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PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 5, Number 1, 2019

Paper Industry Technical Association

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Dynamic soft sensing of organic pollutants in effluent from UMIC anaerobic reactor for industrial papermaking wastewater

Yajuan Xing[1], Zhong Cheng[2],*, Shengdao Shan[3].

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1. Introduction

The paper-making industry is a major water consumer and also a major wastewater discharger. According to the statistics of the Ministry of Ecology and Environment, In 2015, the total water consumption of the paper-making industry and the paper product industry (4,180 enterprises involved in the statistics) was 11.835 billion tons, and the wastewater discharge was 2.367 billion tons,

accounting for 13.0% of the total industrial wastewater discharge. The chemical oxygen demand (COD) in the discharged wastewater is 335,000 tons, accounting for 13.1% of the total industrial COD emission. In recent years, with the increasing shortage of water resources, production water has become a problem that restricts the development of paper-making enterprises. At present, in order to solve the environmental pollution due to paper-making wastewater and realize resource utilization, biogas production through anaerobic digestion has become a main method. The anaerobic digestion process under the action of microorganisms is featured as multi-factor influence, dynamic variability, complex nonlinearity (Yang Hao et al., 2016), etc. and the mechanism model thereof is difficult to construct, so the real-time operation control and optimization and calibration that affect safe production and effluent water production conditions cannot be realized. The production effectiveness of the industrialization process of anaerobic digestion for paper-making wastewater is often measured by the effluent COD. However, the current COD testing of enterprises is mostly realized by timed manual sampling and laboratory analysis. The test results cannot be obtained till several hours later, so the real-time performance is poor (Xu Lisha et al., 2012). In case that a COD on-line analyzer is installed on site, failure often occurs, resulting in loss of data. And also, the maintenance is difficult and the instrument is expensive(Langergraber et al., 2004; Bourgeois et al., 2010). With the improvement of enterprise automation as well as the deep integration of informationization and industrialization, the methods like pivot element regression, partial least squares regression, neural network, support vector machine and fuzzy logic have been used for the data modeling and operational control of the performance indicators including COD concentration, volatile fatty acid (VFA), dissolved oxygen, suspended solids (SS) concentration and gas production in the process of paper-making wastewater treatment (Bourgeois et al., 2010; Haimi et al., 2013) Choi et al., 2001; Wan et al., 2011; Huang et al., 2015 Dürenmatt et al., 2012; Zhou Hongbiao et al., 2017; Liu Lin et al., 2017; Tang Wei et al., 2017). With respect of the method selection, Wan et al. (2011) designed an adaptive fuzzy inference system integrating fuzzy subtractive clustering and PCA technologies, of which the fuzzy subtractive clustering is used to identify the model structure, and PCA is used to reduce the complex collinearity between variables as well as the dimensionality. The model accuracy with this integrated method is higher than that with the BP neural network method in the performance test about the COD and SS concentration prediction of paper-making wastewater. Wang Yao et al. (2017) chose the LSSVM method to predict the COD and SS concentrations. The results show that the soft-sensor model created by optimizing the LSSVM method parameters via the PSO algorithm has a higher prediction accuracy. The LSSVM method based on minimum structural risk is widely used in soft-sensor modeling because of its features of low dependence on sample data, less parameters to be estimated, and strong generalization ability (Souza et al., 2016; Wang et al., 2015; Fortuna et al., 2007; Liu Bo et al., 2015; Zheng Rongjian et al., 2017). However, the prediction accuracy of the soft-sensor model based on the offline sample data architecture, will gradually decline in the face of dynamic changes in continuous production processes. In order to solve the above problem, this paper proposes an OCS-PCA-PSO-LSSVM soft-sensor method integrating data analysis technology and regression modeling, which can eliminate the complex collinearity between variables and achieve dimensionality reduction via PCA technology; then, implement the LSSVM method to establish the nonlinear relationship between input and output variables, and realize the optimization of LSSVM model parameters by means of PSO; and finally, initiate the online calibration strategy (OCS) in case the prediction deviation of the new sample individual exceeds the set error limit, iteratively updating the soft-sensor model in an adaptive manner.

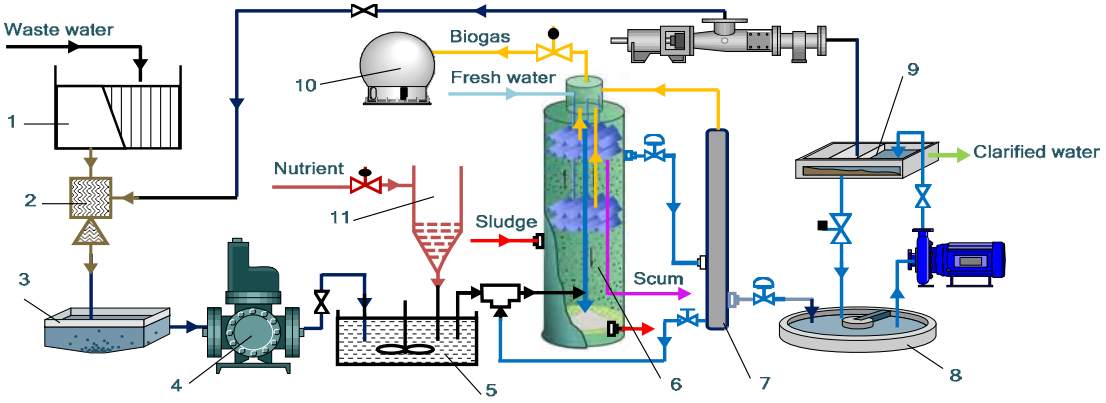
2. Materials and Methods

2.1. Process and Data Collection

With the wastewater anaerobic treatment system of a papermaking mill as the test object of application, the production process is shown in Fig. 1, in which the ascending multistage internal circulation anaerobic reactor UMIC is the main device. The UMIC reactor works based on the principle of granular sludge (Ruggeri et al., 2015; Zhang Yi et al., 2014), namely, the papermaking wastewater is thoroughly mixed with anaerobic microbial sludge after being pumped into the reactor by a lift pump,

and the organics in the mixture are chemically converted into the gases like methane and carbon dioxide, as well as microbial bacterial plastids under the action of the microorganisms.

Based on the analysis of production behavior and process mechanism of the UMIC device, with the combination of experts' experience and knowledge as well as the sensitivity analysis of field data, 8 process variables that affect the COD of the treatment system were selected as the input variables of the model, and they are: influent COD/mg•L^{-1}, influent SS/mg•L^{-1}, influent pH, influent flow/m^3, influent temperature/°C, circulating pool level/%, effluent pH and effluent temperature/°C, while the output variable of the model is effluent COD/mg•L^{-1}. Two sample data collection methods were adopted, one of which was that the mill's distributed control system DCS was used to collect 8 process variables, and the other was that the on-site sampling laboratory obtained effluent COD through offline test (Sun Jun et al., 2017). After the collection of the mill's field operation data from July 2016 to February 2017 was completed, the missing data was directly removed, then the abnormal data was identified and deleted, and finally the initial sample matrix set containing 175 sample individuals was obtained.



1-Bar screener; 2-Blending pond; 3- Preliminary clarifier; 4-Pump; 5- Regulating container; 6-Anaerobic reactor;
7-Cycling wstandpipe; 8- Anoxic pool; 9- The secondary clarifier; 10-Biogas storage tank; 11-Nutrient auto-count pipette

Fig 1. Flow chart of anaerobic degradation for paper mill wastewater

2.2. OCS-PCA-PSO-LSSVM Soft-sensor Method

2.2.1. PCA Technology

The independent variable matrix $\boldsymbol{X}_{n\times p}$ of the obtained initial sample data was recorded, where n is the number of sample individuals, i.e. the sample size, and p is the number of process variables. PCA technology (Jolliffe et al., 2002) was namely to project $\boldsymbol{X}$ from the Euclidean space to the latent vector space of the pivot element.

$$\boldsymbol{X} = \boldsymbol{T}\boldsymbol{Q}^{\mathrm{T}} + \boldsymbol{E} = \sum_{k=1}^{d} \boldsymbol{t}_k \boldsymbol{q}_k^{\mathrm{T}} + \boldsymbol{E} \quad (1)$$

Where, $\boldsymbol{t}_k$ is the k^{th} extracted pivot element, $\boldsymbol{q}_k$ is the load vector used to extract the pivot element, and $\boldsymbol{E}$ is the final residual matrix. In essence, the construction of the PCA latent vector space is to represent most of the dynamic information in the initial process variables in the sample data by extracting d pivot elements ($d \le p$) (Sun Jun et al., 2017), of which, the information contribution of the k^{th} pivot element can be calculated according to Formula (2).

$$\eta_k = \lambda_k / \sum_{k=1}^{p} \lambda_k \quad (2)$$

2.2.2. Soft-sensor Optimization Model PSO-LSSVM

The least square support vector machine (LSSVM) is an extension of the standard SVM method (Cristianini et al., 2000), and the main ideas of the algorithm are summarized as follows:

Suppose the modeling sample data set is $\{(\boldsymbol{t}_i, y_i)\}_{i=1}^{n}$, where, $\boldsymbol{t}_i \in R^d$ is the input vector of the i^{th}-dimension pivot element in the latent vector space expanded by the d^{th}-dimension pivot element, and $y_i \in R$ is the target output variable of effluent COD of the papermaking wastewater. In the high-dimension feature space constructed by the nonlinear mapping function $\varphi(\boldsymbol{t})$, the model establishment between the output variable and the input variable is to find the best fitting function:

$$y(\boldsymbol{t}) = \boldsymbol{w}^{\mathrm{T}}\varphi(\boldsymbol{t}) + b \tag{3}$$

Where, $\boldsymbol{w}$ is the weight coefficient vector to be estimated in the high-dimension feature space, b is the constant deviation term. For the LSSVM method, the parameter estimate in the above formula can be transformed to satisfy the constraint of Formula (4):

$$y_i = \boldsymbol{w}^{\mathrm{T}}\varphi(\boldsymbol{t}_i) + b + \xi_i, i = 1, 2, \cdots, n \tag{4}$$

The minimization optimization problem was solved as below:

$$\min_{\mathbf{w},b,\xi} J(\boldsymbol{w}, b, \boldsymbol{\xi}) = \frac{1}{2}\boldsymbol{w}^{\mathrm{T}}\boldsymbol{w} + \frac{1}{2}\gamma\sum_{i=1}^{n}\xi_i^2 \tag{5}$$

In the formula, γ is a penalty factor, used to balance the complexity and approximation accuracy of the model, ξ_i is the training error of the i^{th} sample point. The Lagrange multiplier α_i is now introduced to transform the above-mentioned constraint optimization problem of the formula into an unconstrained optimization problem:

$$\begin{aligned} &L(\boldsymbol{w}, b, \boldsymbol{\xi}, \boldsymbol{\alpha}) \\ &= J(\boldsymbol{w}, b, \boldsymbol{\xi}) - \sum_{i=1}^{n}\alpha_i(w^T\varphi(\boldsymbol{t}_i) + b + \xi_i - y_i) \end{aligned} \tag{6}$$

Using the KKT optimization condition to solve the above formula (Zhou Xinran, 2012), that is, to solve the partial derivatives of $\boldsymbol{w}$, b, ξ_i and α_i, we can obtain:

$$\begin{cases} \dfrac{\partial L}{\partial \boldsymbol{w}} = 0 \rightarrow \boldsymbol{w} = \sum_{i=1}^{n}\alpha_i\varphi(\boldsymbol{t}_i) \\ \dfrac{\partial L}{\partial b} = 0 \rightarrow \sum_{i=1}^{n}\alpha_i = 0 \\ \dfrac{\partial L}{\partial \xi_i} = 0 \rightarrow \alpha_i = \gamma\xi_i, i = 1, 2, \cdots, n \\ \dfrac{\partial L}{\partial \alpha_i} = 0 \rightarrow \boldsymbol{w}^{\mathrm{T}}\phi(\boldsymbol{t}_i) + b + \xi_i - y_i = 0, i = 1, 2, \cdots, n \end{cases} \tag{7}$$

Eliminating the elements from the above equation set, we will obtain the following linear equation set:

$$\begin{bmatrix} 0 & 1_v^{\mathrm{T}} \\ 1_v & \mathbf{K} + \gamma^{-1}\boldsymbol{I} \end{bmatrix}\begin{bmatrix} b \\ \boldsymbol{\alpha} \end{bmatrix} = \begin{bmatrix} 0 \\ \mathbf{y} \end{bmatrix} \tag{8}$$

Where, $1_v = [1, 1, \cdots, 1_n]^{\mathrm{T}}$, $\boldsymbol{\alpha} = [\alpha_1, \alpha_2, \cdots, \alpha_n]^{\mathrm{T}}$, $\boldsymbol{y} = [y_1, y_2, \cdots, y_n]^{\mathrm{T}}$, $K_{ij}(\boldsymbol{t}_i, \boldsymbol{t}_j) = \varphi(\boldsymbol{t}_i)^{\mathrm{T}}\varphi(\boldsymbol{t}_j)$, $i, j = 1, 2, \cdots, n$, and $\boldsymbol{I}$ is the unit matrix. After solving the parameters of α_i and b in Formula (8) and via the least square method, the LSSVM model will be obtained as below:

$$\hat{y} = f(\boldsymbol{t}) = \sum_{i=1}^{n}\alpha_i K(\boldsymbol{t}, \boldsymbol{t}_i) + b \tag{9}$$

If the LSSVM model uses the RBF kernel function $K(\boldsymbol{t}, \boldsymbol{t}_i, \sigma) = \exp(-\|\boldsymbol{t} - \boldsymbol{t}_i\|^2 / \sigma^2)$, the different values of the kernel function width σ and the penalty factor γ in Formula (5) will affect the actual performance of the LSSVM model (Zhao et al., 2000). To this end, this paper completes the optimization of the two parameters by taking the minimum of the sum of squared error

$\sum_{l=1}^{n_v}(y_l-\hat{y}_l)^2$ between the experimental value y_l and the predicted value of the model of the effluent COD as the objective function, through the particle swarm optimization (PSO) (Kennedy et al., 1995), based on the validation sample set.

2.2.3.Model Parameter Adaptive Correction

In order to track the dynamic changes of the production process and maintain the prediction performance of the soft-sensor model in real time, an online calibration strategy (OCS) has been designed to iteratively update the soft-sensor model parameters in an adaptive manner. The basic idea of OCS is that if the established soft-sensor model is applied to the prediction of COD for a new sample individual, when the deviation between the experimental value y_{new} of the new sample individual and the predicted value $\hat{y}_{new}$ of the model exceeds the set error limit $maxe$, namely:

$$|y_{new}-\hat{y}_{new}|>maxe \qquad (10)$$

To Initiate the iterative update of the soft-sensor model parameters. The specific method is as follows: firstly, the sample individuals with the largest fitting deviation are retrieved from the training sample set and deleted; then, the sample individuals with the highest ranking in the monitoring sample set are transferred into the training sample set; next, the vacancy of the validation sample set is filled, namely, the sampled individuals with the highest ranking among the accumulated predicted sample individuals are transferred into the validation sample set; and finally, the soft-sensor model is re-established based on the newly formed training sample set and the validation sample set, which is namely the OCS - PCA-PSO-LSSVM model.

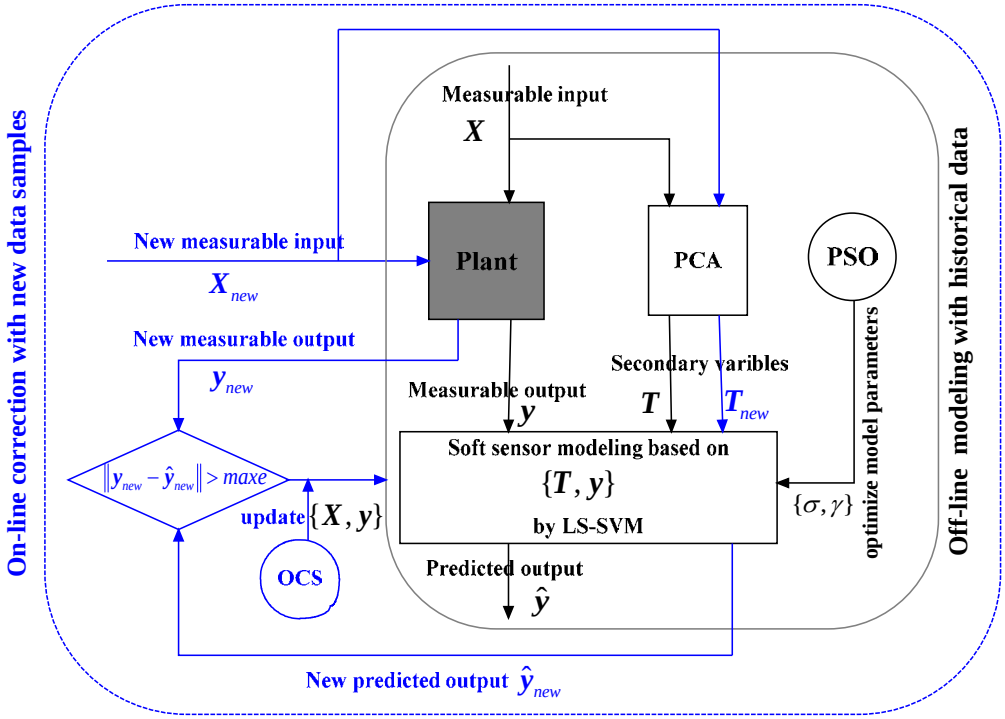


Fig 2. Structure of the OCS-PCA-PSO-LSSVM soft sensor model

With this, the implementation flow of the OCS-PCA-PSO-LSSVM method is shown in Fig. 2. Firstly, the PCA pre-processing of $\boldsymbol{X}_{n\times p}=[\boldsymbol{x}_1,\boldsymbol{x}_2,\cdots,\boldsymbol{x}_p]^{\mathrm{T}}$ was performed and the pivot element matrix $\boldsymbol{T}_{n\times d}=[\boldsymbol{t}_1,\boldsymbol{t}_2,\cdots,\boldsymbol{t}_d]^{\mathrm{T}}$ was obtained after the number d of pivot elements had been selected; then, based on $\boldsymbol{T}_{n\times d}$ and the output variable matrix $\boldsymbol{y}_{n\times 1}=[y_1,y_2,\cdots,y_n]^{\mathrm{T}}$ of the effluent COD, the nonlinear mapping relationship between them was established with the LSSVM method, while the values of

model parameters σ and γ were determined by PSO optimization; and finally, the OCS would be initiated to iteratively update the model in case the prediction deviation of the new sample individual was beyond the set error limit.

3.Results and Discussion

3.1. Model Performance Evaluation Indicator

To objectively and independently evaluate the performance of the OCS-PCA-PSO-LSSVM soft-sensor model, the initial sample data set was divided into a training sample set, a validation set, and a test set in time order, of which the training sample set contained 100 sample individuals, used for parameter estimation of the model; the validation sample set contained 50 sample individuals, used for parameter optimization of the model; and the test sample set contained the remaining 25 sample individuals, used for performance evaluation of the model. The performance evaluation indicators include: maximum deviation (MAXE)/mg•L^{-1}, maximum relative deviation (MAXRE)/%, mean absolute deviation (MAE)/mg•L^{-1}, mean relative deviation (MRE)/% ,root mean square error (RMSE) / mg • L^{-1}, standard deviation (STD) / mg • L^{-1}, etc., and their respective definition formula are as follows:

$$\mathrm{MAXE} = \max_{i\in\{1,2,\cdots,n\}}\{|y_i - \hat{y}_i|\} \tag{11}$$

$$\mathrm{MAXRE} = \max_{i\in\{1,2,\cdots,n\}}\{\frac{|y_i - \hat{y}_i|}{y_i}\}\times 100\% \tag{12}$$

$$\mathrm{MAE} = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i| \tag{13}$$

$$\mathrm{MRE} = \frac{1}{n}\sum_{i=1}^{n}\frac{|y_i - \hat{y}_i|}{y_i}\times 100\% \tag{14}$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} \tag{15}$$

$$\mathrm{STD} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(e_i - \overline{e})^2} \tag{16}$$

Where, $e_i = y_i - \hat{y}_i$, $\overline{e} = \frac{1}{n}\sum_{i=1}^{n}e_i$, while y_i and $\hat{y}_i$ denote the experimental value and predicted value of the model regarding COD of the i^{th} sample individual, respectively. Among the above statistical performance indicators, MAXE, MRE, RMSE and STD are absolute accuracy indicators, of which, MAXE measures the limit boundary conditions of the model according to the maximum predicted deviation of the sample individuals, and MRE and RMSE measure the accuracy of the model according to the average prediction accuracy of the sample individuals. while STD measures the stability of the model according to the degree of dispersion of the prediction deviation of the sample individuals. Considering the objective difference between the magnitudes of different physical quantities, MAXRE and MRE are relative accuracy indicators. The former measures the deviation of the prediction results based on a single sample individual, and the latter does the same based on the average of sample individuals. The smaller the values of these statistics are, the better the performance of the model will be indicated.

3.2. Experimental Results and Analysis

As described in Section 2.2.1 above, in order to satisfy that the pivot element under the OCS-PCA-PSO-LSSVM method contain enough initial variable information, and the cumulative information contribution rate of the d^{th} extracted pivot element is now required to be above 85%. Based on the information of the eight latent roots of the correlation matrix for the training sample set

of papermaking wastewater, when the $6t^h$ pivot element is extracted during calculation, namely, $d = 6$, the cumulative information contribution rate is 92.63%. Thus, the six pivot element are determined as the input vectors of the subsequent PSO-LSSVM model.

As described in Section 2.2.2 above, the optimization process for the algorithm of parameters γ and σ PSO under the LSSVM method is shown in Figs. 3 and 4 after the RBF radial basis kernel function was selected, and the population particle number was set at 30, the minimum inertia weight was $w_{\min}$ =0.01, the maximum inertia weight was $w_{\min}$ =0.99, the particle maximum velocity was $v_{\max} = 2$, the particle minimum velocity was $v_{\min} = -2$, and the learning factor was $c_1 = c_2 = 2$ and the maximum number of iterations was 100. When γ =0.3356 and σ =2.2026, the RMSE of the objective function observation sample set reached the minimum, thereby it was determined as the optimal value of the parameter under the LSSVM method.

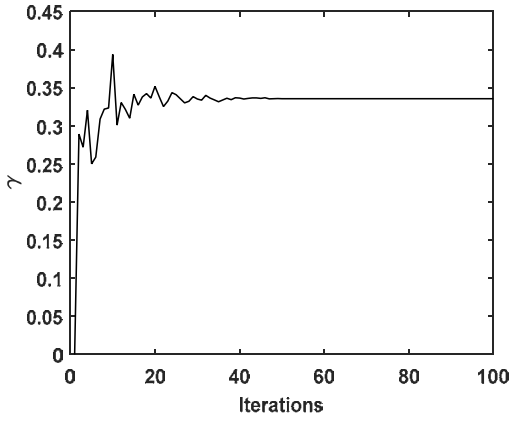


Fig 3. Regularization factor optimizing curve using PSO

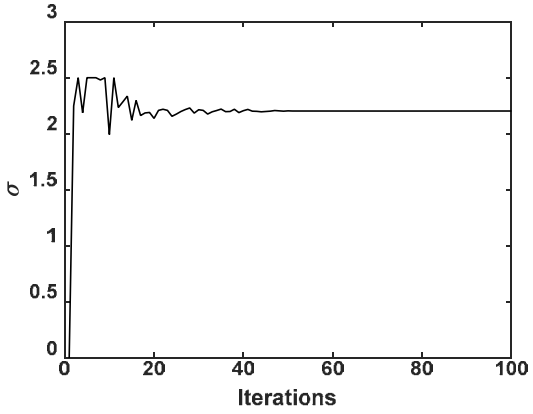


Fig 4. Kernel parameter optimizing curve using PSO

After the optimization for the input variable and parameter of the model was completed, the OCS-PCA-PSO-LSSVM model was applied to the test sample set to detect the model's generalization ability. Table 1 shows the test results of different performance indicators for the three models of OCS-PCA-PSO-LSSVM, PCA-PSO-LSSVM and SVM. It may be observed from the table that the values of the maximum deviation, the maximum relative deviation, the average absolute deviation, the average relative deviation, the root mean square error, and the standard deviation of the OCS-PCA-PSO-LSSVM model are significantly lower than the corresponding results of the PCA-PSO-LSSVM model and the SVM model. Where, compared with the PCA-PSO-LSSVM model, the MAXE of the OCS-PCA-PSO-LSSVM model decreased by 39.15%, the MRE decreased by 25.00%, and the STD decreased by 29.89%. The reason for this is that when the PCA-PSO-LSSVM model predicted the 2nd, 10th, 20th, and 21st sample individuals in the test sample set, their prediction deviations were greater than their respective maximum fitting deviation the training sample set, so the OCS strategy was initiated 4 times to perform the iterative update of the model, therefore, from the 2nd

sample individual of the test sample set containing 25 sample individuals, and the predicted value of the model was different from the predicted value of the PCA-PSO-LSSVM model without the OCS strategy integrated, which was generally reflected as the deviation tends to be small, thus achieving dynamic adjustment and optimization of the model.

Tab. 1 Model performances comparison on the testing data set

Methods	MAXE /mg·L^{-1}	MAXRE /%	MAE /mg·L^{-1}	MRE /%	RMSE /mg·L^{-1}	STD /mg·L^{-1}
SVM	54.39	7.82	18.62	2.58	22.96	13.71
PCA-PSO-LSSVM	51.09	7.53	17.37	2.40	21.57	13.05
OCS-PCA-PSO-LSSVM	31.09	6.26	12.31	1.80	15.23	9.15

To visually compare the prediction performance of the above three model methods, the experimental values and predicted values of COD of 25 sample individuals in the test sample set are plotted in Fig.5. Through observation of the figure, it can be seen that compared with the PCA-PSO-LSSVM and SVM model methods, the COD results on each sample individual predicted with the OCS-PCA-PSO-LSSVM model method are more closely to their respective experimental values, thereby indicating that the OCS- The PCA-PSO-LSSVM model method has better generalization prediction ability and stronger dynamic stability.

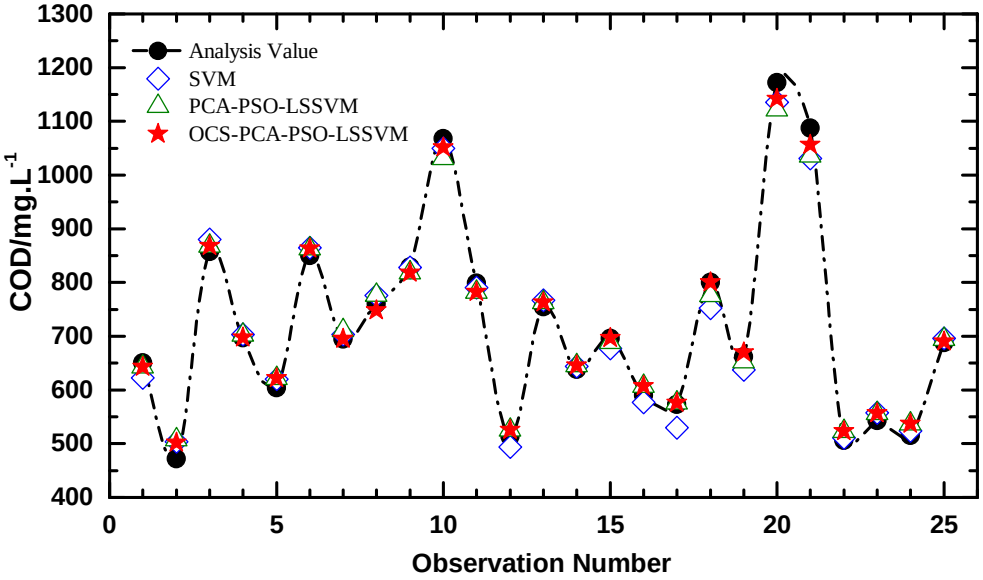


Fig 5. Prediction results of COD on the generalization data set

4. Conclusions

Made in China 2025 clearly pointed out "taking the deep integration of informatization and industrialization as the main line." Based on the safe and healthy management and high-efficiency production requirements in the anaerobic treatment process of papermaking wastewater, this paper focuses on the study of the soft-sensor prediction and dynamic optimization of the model based on the data-driving effluent COD as the water quality indicator, to promote the transformation of the paper industry from extensive development to sustainable development, from the end treatment to the resource utilization, promoting the intelligent management and control of the production process, the main conclusions are as follows:

1) In order to adapt to the structure of anaerobic reactor and the multivariable, nonlinear, time-varying features of the parameters, as well as the special complexity of papermaking wastewater process and the uncertainty of production behavior, the soft-sensor method integrating the modern data analysis technology and intelligent regression model have been developed and designed, which not

only effectively reduces the complex collinearity between variables, but also reduces the spatial dimension of the model, and the prediction accuracy and dynamic stability of the model are significantly improved, achieving the overall improvement and breakthrough of the model performance by virtue of the integration advantages.

2) Data-driving soft-sensor model method: As the time series data continues to increase, the prediction accuracy of the model based on long-term historical data will decrease. Taking the actual industrial process as the background, combined with the dynamic change characteristics of the process, the method can adaptively iteratively update the model parameters through deviation feedback, and maintain the generalization performance of the soft-sensor model in real time, thus ensuring the continuous efficient and stable operation of the equipment, and monitoring the energy conservation and emission reduction as well as sustainable development of the enterprise.

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Biobleaching for pulp and paper industry in India: Emerging enzyme technology

Gursharan Singh, Satinderpal Kaur, Madhu Khatri, Shailendra Kumar Arya.

Indian pulp and paper industry is one of the fastest emerging business sector of the country which has shown tremendous growth in last few years. Governments policies are creating sustain pressure on paper industries to preserve the clean and pollution free environment at any price. As a result industries are pondering to replace the chemical bleaching processes with facile bio-based cost effective technologies. Eco-friendly bleaching enzymes like xylanases and laccases have the potential for biobleaching of wood and agro-based pulps at industrial scale. In India, enzymatic prebleaching of pulp is widely being investigated and has achieved favourable outcomes but at laboratory scales only and commercial application of enzymes for the delignification of pulp is still at budding stage. This article tends to draw the attention on significant efforts which have been continually attributed by indigenous research laboratories and industries to replace the chemical bleaching with enzymes.

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ABSTRACT

Indian pulp and paper industry is one of the fastest emerging business sector of the country which has shown tremendous growth in last few years. Governments policies are creating sustain pressure on paper industries to preserve the clean and pollution free environment at any price. As a result industries are pondering to replace the chemical bleaching processes with facile bio-based cost effective technologies. Eco-friendly bleaching enzymes like xylanases and laccases have the potential for biobleaching of wood and agro-based pulps at industrial scale. In India, enzymatic prebleaching of pulp is widely being investigated and has achieved favorable outcomes but at laboratory scales only and commercial application of enzymes for the delignification of pulp is still at budding stage. This article tends to draw the attention on significant efforts which have been continually attributed by indigenous research laboratories and industries to replace the chemical bleaching with enzymes.

1. Introduction

Currently Indian pulp and paper industrial units account for ~ 3.0% of the world's production of paper. The estimated turnover of the industry is US$ ~ 8.0 billion. The industry provides employment to more than 0.5 million people directly and 1.5 million indirectly. During 2015–16, domestic production of paper was estimated to be 12.2 million tons (http://ipma.co.in). Paper industry in country is becoming more promising as the domestic demand of paper is increasing due to the growing population and literacy rate, growth in gross domestic product (GDP) and lifestyle of the individuals (Sharma et al., 2015a; Sharma et al., 2015b; Sharma et al., 2015c). The focus of paper industry is now shifting towards eco-friendly production of paper. The paper is produced from pulps generated from wood, agricultural residues like wheat straw or from waste paper. The use of wood based technology is constantly on the decline because of capital and raw material availability constraints. The production of pulp and paper involves three important steps viz. pulping, bleaching, and final paper finishing. The removal of recalcitrant lignin from pulp is called bleaching which is necessary for making the bright and white paper. Till the end of 20th century, bleaching of pulps, irrespective of their origin from soft or hard wood, employed large amounts of chlorine and chlorine based chemicals. But now most of the pulp and paper mills worldwide use chlorine dioxide (ClO_2) as the elemental chlorine free (ECF) bleaching agent for the production of high quality white paper (Dwivedi et al., 2010; Bajpai, 2012). The high organic content (especially in the wood based pulp), coupled with chlorine dioxide used in the bleaching process, results in the production of organo-chlorine compounds, which are finally discharged as bleach effluents in water bodies. These organo-chlorine compounds (measured as Adsorbable Organic Halogens, AOX) have been reported to cause genetic and reproductive damages in aquatic as well as terrestrial animals including humans (Sharma et al., 2014). Although more eco-friendly options for bleaching are open to pulp mills in the form of alternatives to ClO_2 like extended cooking or oxygen, hydrogen peroxide or ozone based delignification, but implementation of these alternates needs process modifications and is considered as cost intensive proposition at large scale. Enzymes provide a simpler and cost effective way to reduce the use of ClO_2, chlorine compounds and other bleaching chemicals. Enzymes also offer the simple approach that allows for a higher brightness ceiling to be reached (Abhay et al., 2018). This can all be achieved without major capital investment. The applications of xylanase enzyme as pre-bleaching agent has been established in several laboratories and has also been commercially exploited in Europe, North America and in few Asian countries (Bajpai, 2012).

2. Structure of the Indian paper industry

The Indian paper industry recognized as the aggregation of small, medium and large sized paper mills with different paper making

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capacities, 10–1150 t per day. Paper production in the country is widely based on wood and agricultural waste as the major raw materials. The Indian paper industry prominently produces writing, newsprint and commercial grade paper. Newsprint grade paper is produced by mills utilizing mainly of recycled waste paper as the raw material. In 2012, India recorded the paper consumption of 9.3 kg/capita besides global average was 58 kg/capita. Presently there are 759 paper mills in the country and producing ~10.9 Mt of paper annually (http://psa.gov.in;initiatives-pulp-and-paper-industry-2014). Indian paper manufacturers association (IPMA) representing the platform to project paper industry's views and articulate its strategies. IPMA promoted the interests of paper industry in the country and help it achieve global competitiveness while striving to be an active participant in the policy making process. The important activities of IPMA are following, work as the interface with government, non-governmental organizations (NGOs) and industrial associations so as to present the perspective and interests of Indian paper mills. Promote the excellence in paper manufacturing through presentation of awards, networking with international bodies with a view to gain better visibility for Indian paper industry. IPMA also synchronize the R&D projects in collaboration with academic institutions of India.

3. Manufacturing process of paper in Indian paper mills

The manufacturing process of paper industry can be divided in to three steps, pulping, bleaching and papermaking. Among all of the three steps, bleaching is tedious and combination of chemical and physical treatment of lignin contained pulp (Fig. 1).

3.1. Pulping

Pulping is the first step of paper making procedure in which separation of cellulose fibers from the lignin components. Commonly two different methods of pulping are applying in the Indian pulp and paper industries, chemical pulping and chemi-mechanical pulping.

3.2. Chemical pulping - Kraft sulphate process

In this procedure the wood chips usually cooked at higher temperature, 165–170 °C in the presence of sodium hydroxide (caustic soda) and sodium sulphide to separate the lignin and wood resins from the cellulose. About 92–95% of the chemicals (sodium hydroxide, sodium sulphide and lime) can be recovered and reuse further.

3.3. Chemical pulping – soda process

The soda pulping is used for the conversion of agro residues (like wheat and rice straw and bagasse) to pulp. In this case raw materials usually cooked in the presence of caustic soda at a temperature of 150–160 °C to separate lignin from the cellulosic material.

3.4. Chemi-mechanical pulping (CMP)

In the chemi-mechanical pulping the wood chips initially treated with the mild caustic soda based chemicals to extract resin and lignin from the cellulose prior to mechanical refining.

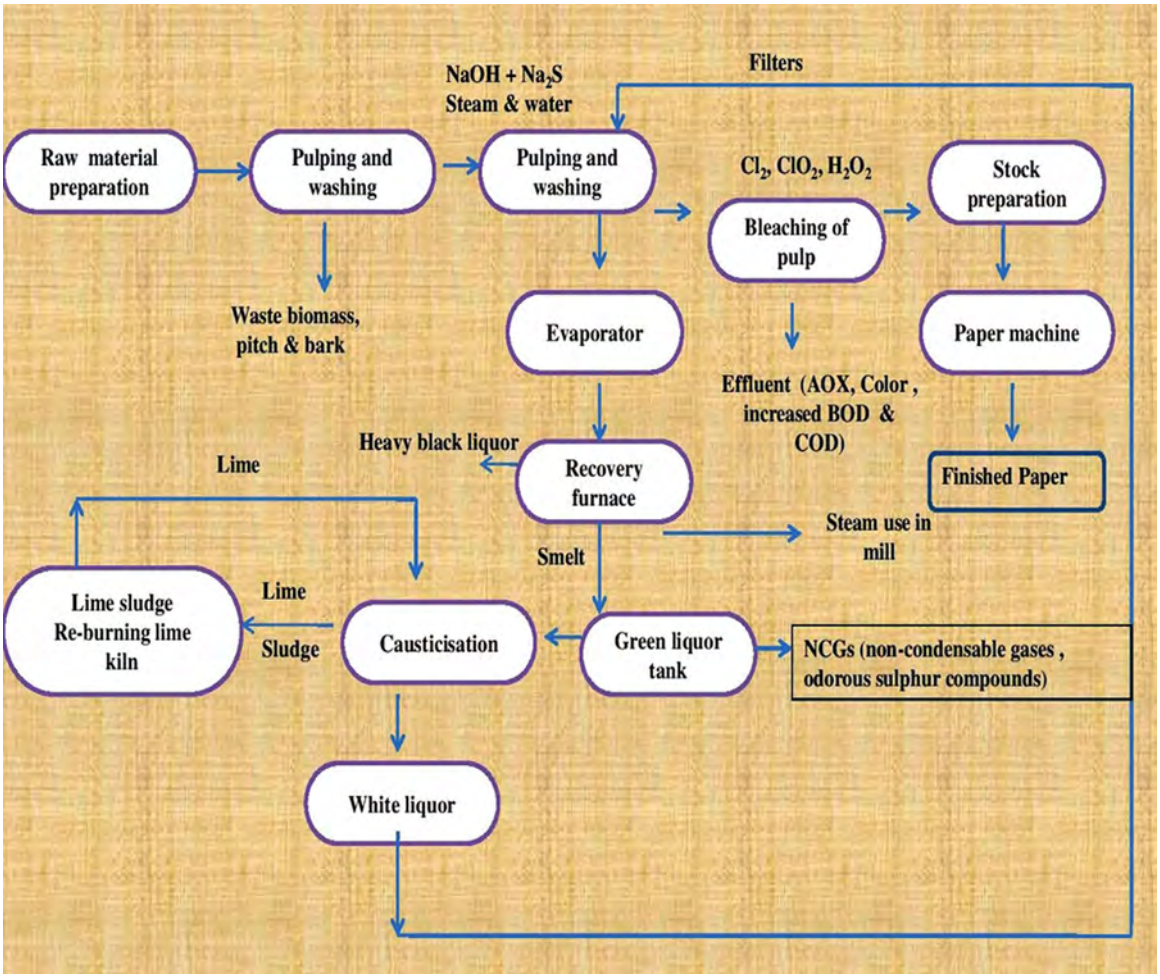

Fig. 1. Common manufacturing process of paper in Indian paper mills.

3.5. De-inking of RCF

Recycled fibers (RCF) dispersion or floatation pulping process is applied for the de-inking of the news papers/print papers. For de-inking, chemicals such as detergents, dispersants and foaming agents added and ink is separated from the pulp.

3.6. Pre-bleaching of pulp with enzymes

The term bleaching is generally referred to the removal of lignin from any kind of the pulp by use of chemicals/gases/steam etc. but prebleaching terminology is used for the enzymatic treatment of the pulp for removal of lignin. Prebleaching is an eco-friendly and cleaner process of lignin removal that can save the chlorine based and other chemicals 10–15% (Bajpai, 2004; Camarero et al., 2007; Garg et al., 2011). Prebleaching of pulp with enzymes is still under trial or at pilot scale in paper mills of India.

3.7. Chlorine bleaching of pulp

The process is used to remove the residual lignin in the range 5–10%. This process is followed by several stages of treatment of pulp with chlorine dioxide or hypochlorite to whiten the pulp. Bleaching process employed in most of the medium and small mills is based on elemental chlorine. However, few of the large sized wood based/agro based mills have introduced elemental chlorine free (ECF) bleaching process making use of chlorine dioxide ClO_2.

3.8. Elemental chlorine free (ECF) bleaching

ECF bleaching technology is being practiced in few large mills of the country where it uses oxygen delignification (ODL), followed by ClO_2 to enhance the brightness of the pulp.

4. Eco-friendly bleaching enzymes (xylanases and laccases) studied by the Indian research laboratories

There are numerous commercially available enzyme cocktails are available, but due to the differences in paper making process in the developed countries and in India, it has been felt to characterize enzymatic pre-bleaching process indigenously with enzymes produced from locally isolated cultures or with commercially available enzymes that match with the interests of Indian pulp industries. One of the major differences is the use of different sort of raw materials for pulp making in India (Sharma et al., 2015a; Sharma et al., 2015b; Sharma et al., 2015c; Dutt et al., 2009; Bajpai et al., 1994; Singh et al., 2008; Singh et al., 2010). Up to the 1980, there was no university or institute was associated in research and development (R&D) that can directly involved for giving the technical guidelines to Indian paper industry. R&D progress on enzymes for paper industry is still in its beginning and only single institute works in a direction to undertake industry related issues and emphasized on applied research, is Central Pulp and Paper Research Institute (CPPRI). There were only a few reports on xylanases for the biobleaching of pulp in country before 2000, e.g. treatment of eucalyptus pulp with commercial xylanases such as Novozyme 473, and Cartazyme HS-10 reduced the chlorine consumption by 31% and increased the final brightness by 2.1–4.9 points (Bajpai et al., 1994). Thermostable cellulase-free xylanase from *Streptomyces* sp. QG-11-3 was produced and applied for delignification of eucalyptus kraft pulp at pH 8.5 and 50 °C for 2 h. There was reduction in kappa number and increase in brightness of pulp by 25% and 20% respectively (Beg et al., 2000). Bajpai, reported, properties of many commercial xylanases make them unsuitable for the real process of pulp bleaching (Bajpai, 2004). So industries need xylanases which can function efficiently in their existing papermaking processes. Xylanase from *Bacillus megaterium* showed 8.1% decrease in kappa number and 13% increase in brightness of eucalyptus kraft pulp with 31% reduction in chlorine consumption (Sindhu et al., 2006). Extracellular cellulase free xylanase produced from *Bacillus subtilis* C01 increased the brightness by 19% of banana pulp Ayyachamy and Vatsala (Ayyachamy and Vatsala, 2007). Purified alkali stable xylanase from *Aspergillus fischeri* was immobilized on polystyrene that reduced the kappa number of paper pulp by 87% (Senthilkumar et al., 2008). A synergistic action of xylano-pectinolytic enzymes from *Bacillus pumilus* was evaluated for the prebleaching of kraft pulp; as a result 8.5% and 25% reduction was noticed in kappa number and chlorine consumption respectively (Kaur et al., 2010). Alkali stable and thermo tolerant xylanase from *B. pumilus* SV-85S showed (at pH 9.0, 55 °C for 2.0 h) the reduction in kappa number by 1.6 points and increased brightness by 1.9 points. The pretreatment of pulp with xylanase resulted in 29% reduction in chlorine consumption (Nagar et al., 2013). First report on a bacterial system involving direct growth of xylanase -producing *B. halodurans* FNP 135 on kraft (eucalyptus) pulp under submerged fermentation conditions, showed 35% reduction in kappa number and 5.8% enhancement in brightness with 20% reduction in chlorine consumption (Gupta et al., 2015). Kumar et al. (2016) emphasized that significant application of thermostable xylanases is biobleaching in pulp and paper industry, where these enzymes acted as delignifying agents, showing clear economic and environmental advantages over chemical alternatives. After xylanases, laccases are the next extensively explored enzymes for biobleaching of pulp; these are oxidative biocatalysts that have influenced the researchers by their numerous merits over any other bleaching enzyme (Singh et al., 2008; Singh et al., 2010; Singh et al., 2009; Singh et al., 2015). Laccases, together with mediators are able to delignify the pulp by the oxidation chain reaction leading to lignin oxidation without the degradation of cellulose. In India pioneering work on alkalophilic laccases was started by Bains et al. (Bains et al., 2003), through isolation of a novel strain named as γ-proteobacterium JB. An alkalophilic cellulase-free laccase from γ-proteobacterium JB was applied to wheat straw-rich soda pulp to evaluate its bleaching potential by optimizing the conditions statistically using response surface methodology based on central composite design in the presence of ABTS at pH 8.0 which enhanced the brightness by 5.8 and reduced the kappa number by 21% within 4 h of incubation at 55 °C. It was noticed that pre-bleaching of eucalyptus kraft pulp with xylanase or laccase individually avoided the ClO_2 by 15% and 25% respectively. When both enzymes were applied together at pilot scale (50 kg pulp), there was reduced organo-chlorine compounds consumption by 34% in bleach effluent (Sharma et al., 2014). Tables 1, 2 shows the year wise isolation of new laccase and xylanase producing organisms and enzyme characterization, but there were very few enzymes either xylanase or laccase evaluated for bioleaching of pulps. Recently, also many reports published on xylanases and laccases from Indian laboratories but none of them studied on delignification of biomass (Sharma et al., 2015a; Sharma et al., 2015b; Sharma et al., 2015c; Desai and Iyer, 2016; Nikam et al., 2017; Afreen et al., 2017; Dharmesh et al., 2017; Raj et al., 2018; Kumar et al., 2018; Ranimol et al., 2018).

5. Commercial use and availability of Indian patents on bleaching enzymes

R&D work on isolation and screening of microbial cultures, capable of producing low molecular weight xylanases was started initially at National Chemical Laboratory Pune in early 1990s. Later, IIT Delhi, Birla Institute of Scientific and Industrial Research Jaipur and few other research and academic institutions began working on culture development for the production of alkaline thermo-tolerant xylanase enzymes. A national research laboratory CPPRI and a premier educational institution in the country, Institute of Paper Technology (IPT) also initiated R&D on xylanase enzyme based pre-bleaching of the pulp. The first ever mill trial of xylanase pre-bleaching in India was conducted in a pulp and paper mill of Ballarpur Industries Ltd. (BILT) in 1992 using

Table 1
Laccase enzymes from different sources studied by the Indian laboratories.

Laccase producing organisms	Optimum conditions for growth		Optimum conditions for enzyme catalysis		Outcome of the study	References
	Temp. °C	pH	Temp. °C	pH		
γ-proteobacterium JB*	37	7.2	55	6.0[a],6.0[b], 6.5[c],6.5[d],7.0[e], 7.2[f]	Molecular weight of the purified laccase was determined (120 kDa), successfully degradation of indigo carmine to anthranilic acid via isatin.	Singh et al. (2007)
γ-proteobacterium JB**	37	7.2	55	8.0	Successfully biobleaching of agro-based wheat straw rich soda pulp in presence of ABTS as a mediator.	Singh et al. (2008)
Cladosporium cladosporioides	37	NA	40–70	3.5[g]	Purified the laccase (71 kDa) up to homogeneity and successfully degradation of 11 structurally different polyaromatic and sulfonated azo dyes.	Halaburgi et al. (2011)
Pleurotus sp.	NA	NA	65	4.5[g]	New organism for laccase production was found and purified (40 kDa)	More et al. (2011)
Escherichia coli AKL2	37	8.5	50	8.5[a]	Study concluded that Cu_2O nanoparticles enhanced the thermostability and activity by 36 and 4.0 fold respectively.	Mukhopadhyay et al. (2013)
Trametes hirsuta (MTCC 11397)	25	5.5–7.5	20–25	2.6[g]	$CuSO_4$ and acetone stimulated the production of laccase up to 2 fold	Dhakar and Pandey (2013)
Streptomycetes sp.	30	7.5	35	6.0[g]	Extracellular laccase producing novel bacteria was isolated from soil	Demissie and Kumar (2014)
Aspergillus nidulans	30	NA	40	6.0[d] and 5.0[g]	Molecular weight of the purified laccase was 66 kDa	Vivekanandan et al. (2014)
Serrtia marcescens	25	5.0	25	5.0[g]	Psychrotolerant laccase producing bacterium was isolated and characterized	Kaira et al. (2015)
Cotylidia pannosa	30	5.0	50	5.0[g]	Laccase was purified (43 kDa), fungal biomass as well as the crude laccase were able to decolorized the congo red, bromophenol blue and coomassie brilliant blue R-250 to different extent.	Sharma et al. (2015a), Sharma et al. (2015b), Sharma et al. (2015c)
Ganoderma lucidum MDU-7	30	5.2	50	4.0[d]	Two laccase isozymes (Glac H1 and Glac L1) were purified from native-PAGE protein purification method and both of the laccase isozymes have same optimum temperature and pH for catalytic activity	Kumar et al. (2015)
Bacillus subtilis MTCC 2414	30	7.0	70	9.0[d]	First report on the maximum production (270 Uml^{-1}) of bacterial laccase.	Muthukumarasamy et al. (2015)
Aspergillus flavus	35	7.0	27	5.0[g]	Optimization of nutritional and cultural paramaters for the laccase production by using statistical method, design of experiment (DOE).	Kumar et al. (2016)
Lysinibacillus and Bacillus Bhargavaea	37	7.0	55	7.0[a,d,g]	Observed the impact of phosphate and other medium components like tryptone and glucose on physiological regulation of laccase production.	Kaur et al. (2016)

*First report from India, alkalophilic bacterial laccase was purified.
**First report on application of alkalophilic bacterial laccase for biobleaching of agro-based pulp.
NA: Not available.
[a] Syringaldazine.
[b] Catechol.
[c] Pyrogallol.
[d] Guaiacol.
[e] L-Methyl DOPA.
[f] *p*-Phenylenediamine.
[g] ABTS.

Table 2
Xylanases enzymes from different sources studied by the Indian laboratories.

Xylanase producing organisms	Optimum conditions for growth		Optimum conditions for enzyme catalysis		Outcome of the study	References
	Temp. °C	pH	Temp. °C	pH		
Streptomyces sp. QG-11-3	37	8.0	60	8.6	Optimization of production media, contained amino acids like L-leucine, DL-isoleucine, L-lysine increased the xylanase production.	Beg et al. (2000)
Emericella nidulans NK-62	45	6.5	60	6.0	Lignocellulosic material, corn cob was used for increasing the cellulase free xylanase production by 318Uml^{-1}	Kango et al. (2003)
Aspergillus fischeri	30	NA	60	9.0	A cellulase free, alkali tolerant xylanase was produced (1024Ug^{-1})	Senthilkumar et al. (2005)
Bacillus megaterium	40	8.0	40	8.0	The use of cellulase free xylanase for biobleaching of kraft pulp, 8.1% increased in brightness and 13% decreased in kappa number of pulp	Sindhu et al. (2006)
Bacillus subtilis	37	7.0	37	7.0	Biobleaching of kraft pulp by using xylanase, increased the brightness by 4.9% and reduced the chlorine consumption by 28%	Sanghi et al. (2009)
Bacillus pumilus	50	9.0	37	8.5	Biobleaching of kraft pulp with xylanase as a result, reduced the 8.5% in kappa number and 25% reduction in consumption of chlorine without any increase in brightness.	Kaur et al. (2010)
Bacillus stearothermophilus	60	9.0	60	9.0	Pretreatment of wheat straw pulp with xylanase, as a result reduction came in kappa number by 7.1% and chlorine consumption by 20% and increased in brightness by 1.7%.	Garg et al. (2011)
Bacillus pumilus SV-85S	37	8.0	50	6.0	Alkali stable xylanase was produced from cost effective and easily available agro-residues.	Nagar et al. (2011)
Bacillus pumilus SV-205	37	7.0	50	7.0	Xylanase was 100% stable at pH 6.0–11 for 24 h.	Nagar et al. (2012)
Cellulosi microbium sp.	40	7.0	40	7.0	Production (4962 ± 45Ug^{-1}) of xylanase was observed in large enamel trays	Goluguri et al. (2016)
Aspergillus lentus	30	NA	70	9.0	Cellulase free xylanase production was more on wheat bran (158 Ug^{-1}) followed by corn cob (153 Ug^{-1}), sugarcane bagasse (129 Ug^{-1}) and wheat straw (49 Ug^{-1})	Kamble and Jadhav (2012)
Sporotrichum thermophile	35	7.0	35	9.5	Useful in food industries, xylan hydrolysis to produce xylo-oligosaccharides i.e. 73 xylotetraose, 15 xylotriose and 10% xylobiose.	Kaushik et al. (2014)
Bacillus sp. *and B. halodurans* (co-culture)	37	10	70	9.0	Xylanase, increased the brightness by 13%, breaking length 49%, viscosity by 11% and decreased in kappa number by 15% of kraft pulp.	Sharma et al. (2015a), Sharma et al. (2015b), Sharma et al. (2015c)
Bacillus halodurans	37	7–12	37	7–12	This study revealed the potential application of *B. halodurans* for biobleaching of hard wood kraft pulp that reduced the cost-intensive steps of enzyme production and extraction before their use in biobleaching.	Chutani and Sharma (2015)
Aspergillus oryzae	28	8.0	60	6.0	Xylanase increased the brightness by 57% during the deinking of newspaper pulp	Boruah et al. (2016)
Thielaviopsis basicola	60	5.0	30	7.2	Alkali and thermostale xylanase was produced (1360Umg^{-1})	Garg et al. (2012)
Penicillium meleagrinum	30	5.5	30	NA	The kappa number was reduced from 13 to 8.5, with increased in brightness by 69% and viscosity 8.9 cP of kraft pulp.	Goswami et al. (2014)

Table 3
Patents reported from the India on bleaching enzymes.

Name of the enzyme	Proposed application	Patent/Application number	Patentee/Institute/Industry	Publication year of patent
Xylanase	Process for the production of xylanase from *Termitomyces clypeatus*	US6569646 B2	Subhabrata Sengupta/Indian Institute of Chemical Biology (CSIR), Calcutta	May, 2003
Xylanase	Process for the production of thermophilic and alkalophilic extracellular xylanase by *Pseudomonas stutzeri*	US6833259 B2	Narayan Baburao Bhosle and Asha Giriyan/ (CSIR), Goa	Dec., 2004
Consortium of xylanolytic bacterium, *Providencia rettgeri*, MTCC 5096 and three ligninolytic bacteria, *Serratia marcescens*, MTCC5094, *Pseudomonas aeruginosa*, MTCC5095 and *Pseudomonas aeruginosa*, MTCC 5098.	Bacterial consortium was capable for biobleaching of kraft pulp up to the 8.0%	US 11/236,819	Rita Kumar and Anil Kumar/CSIR-Institute of Genomics and Integrative Biology at Delhi.	Sep., 2005
Xylanase	A process for the production of cellulase free xylanase	225/DEL/2001	A. Lachke and Chinnathambi Sathivel/ NationalChemical Laboratory, Pune, India.	May,2008
Laccase	Antimicrobial properties of enzyme	IN/PCT/2001/615/CHE	Novozymes A/S, India	March 2009
Xylanase	Process for the xylan-degradation was optimized	389/DEL/2000	Chandralata R and Usha Devi/National Institute of Oceanography Dona Paula, Goa, India.	March 2009
Laccase	Production of polylactide polymers	PCT/IN2010/000010	Venkata R Sonti and group/Praj industries Ltd. India	Aug., 2010
Xylanase	A process for the production of alkalo philic and thermophilic xylanase	491/DEL/1999	Narayan B Bhosle/National institute of Oceanography Dona Paula, Goa, India.	Feb., 2012
Laccase	Invention of process for production of enzyme from *Arthrographis* sp. MTCC5479	WO2012023021 A1	Vijay Sonawane/IMTECH, Chandigarh, India	Feb., 2012

low pH-xylanase, provided by M/s Biocon India Pvt. Ltd. Subsequently, several other trials were organized in different mills by using different types of raw materials and practicing different pulping and bleaching processes, using xylanase enzymes of different qualities (including alkaline and thermo-tolerant) (Singh et al., 2016). According to the news bulletin on pulp and paper R&D, CPPRI Saharanpur (2011), evaluated the potential of bleaching enzymes at pilot and mill scale that was sponsored by the Department of Biotechnology, Govt. of India, New Delhi. Aim of the project was to evaluate prebleaching efficiency of xylanase/laccase biocatalysts produced by Department of Microbiology, South Campus, Delhi University and Kurukshetra University on hardwood pulps at both pilot and mill scale. The outcome of this trial was quite favorable to commercialize the biobleaching process (http://www.cppri.org.in). Through the extensive literature search, there were several patents found on xylanases and laccases on the name of Indian laboratories and industries up to the extent for the production of bleaching enzymes but not yet evaluated for their biobleaching potential. Moreover Biocon India, Bangalore alone is, selling its commercial xyalnase under the name of Bleachzyme F for the delignification of pulps (Table 3).

6. Heterologous expression of xylanase, laccase and protein engineering

Garg et al. (2012) reported the cloning and expression of *Cyathus bulleri* laccase in *Pichia pastoris.* In this study, complete cDNA encoding laccase (Lac) from white rot fungus *C. bulleri* was amplified by RACE-PCR, cloned and expressed in *P. pastoris* under the control of alcohol oxidase (*AOX*)*1* promoter. Later it was also observed, $CuSO_4$ increased the synthesis of laccase up to 12-fold when added in production media. Goswami et al. (2014) reported cloning and heterologous expression of cellulase free thermostable xylanase from *Bacillus brevis.* Xylanase gene was isolated and expressed in *E. coli* BL21. The recombinant xylanase was predominantly secreted to culture medium and showed mesophilic nature (optimum working was at 55 °C, pH 7.0). Both rational design and directed evolution has been widely applied for designing of proteins in technically advanced molecular biology laboratories worldwide. Generally most of the enzymes are produced by mesophilic organisms, like fungi, molds, yeasts and several bacteria. Commonly enzymes produced by these types of organisms have less thermo-stability/pH stability and least consistency in the presence of salts and also less specificity of enzymes towards their substrates. Therefore it is necessary to bring an improvement in the catalytic performance of enzymes by applying the protein engineering that is the vital tool of molecular biology. Verma et al. (2013) reported increased thermostability of xylanase (Mxyl) retrieved from a compost-soil-based metagenomic library. After scrutinizing the structure of xylanase by molecular dynamics simulation exposed more structural fluctuations in β-sheets. The surface of *β*-sheets was enriched with arginine residues by substituting serine/threonine by site-directed mutagenesis; the enzyme with four arginine substitutions (MxylM4) exhibited enhanced thermostability at 80 °C. The Half life ($t_{1/2}$) of MxylM4 at 80 °C, in the presence of birchwood xylan, increased from 130 to 150 min, without any alteration in optimum pH and temperature. The K_m of MxylM4 was also, increased from 8.01 ± 0.56 of Mxyl to 12.5 ± 0.32 mg ml^{-1} but reduced the affinity as well as specific enzyme activity. Both Mxyl and MxylM4 xylanases remained effective for delignification of pulp. Laccase enzyme is metallic biocatalyst unlikely xylanases, it needs mediators (small molecules) for the delignification of pulps. Biobleaching of pulps by laccases in absence of mediator component is not feasible due to the less redox potential (E0) of laccases (470 to ~ 800 mV) than non phenolic structures of lignin (1400 mV) like veratryl alcohol (Camarero et al., 2007; Singh et al., 2015). In the case of laccases, protein engineering may not consider as worthy if there is only increase in enzyme activity not E0. Kenzom et al. (2014) have performed the random mutagenesis to *Cyathus bulleri lcc* gene (WtLcc) by using an error prone

PCR. The 816-bp fragment (toward the C terminus) of the WtLcc was manipulated and enzyme variants (Lcc35, Lcc61, and Lcc62) were chosen best on the criteria of enhanced enzyme activity against ABTS. In this study the mutant laccase variants have the same E0 like the parent WtLcc.

7. Environmental regulations for the paper industry and policy measures

Pulp and paper industry presently consuming the large quantities of fresh water, 80–150 m^3 t^{-1} of paper, depends on the type of raw material being used. Commonly agro based paper mills are expending more water than recycled fibre (RCF) mills for removing the chemicals from processed pulp. Disposal of waste water contained severely environmental toxic compounds (AOX), bleaching (hydrogen peroxide, chlorine dioxide and caustic soda) and whitening agents (kaolin, calcium carbonate and titanium dioxide). Consequences of growing awareness about healthy and clean environment, paper industries facing stringent criticisms from Government as well as from general public due to release of untreated or partially treated effluent (Bajpai, 2012). In response to environmental concerns the paper industry has reacted by making process modifications based on existing and new proven technologies. The Central Pollution Control Board (CPCB) has taken several initiatives for reducing the pollution caused by paper mills, up to 2020. CPCB will make sure that none of the paper industry can discharge untreated industrial effluent to the water bodies like rivers and canals. Some of large paper industries recently upgraded their effluent treatment plant (ETP) with installation of tertiary treatment system for better effluent quality, particularly colour and suspended solids. Some of the medium sized agro-based paper mills have installed the non-conventional chemical recovery system, to incinerate the black liquor, which is one of the major causes of pollution. Effluent from all the operational units is mixed together and collected in effluent treatment plant for a common treatment, this is current practice adopted by most of the small and medium paper industries. This mixing up of all types of wastes poses a problem of handling large volumes of effluents with a variety of effluent parameters. It is suggested that coloured and non-coloured effluents should be segregated and treated separately thereby reducing the overall chemical load and possibly improving the treated wastewater quality. Therefore, mills may initiate actions to reengineer and modernize the existing ETP to phase out unlined lagoons by providing efficient coagulation and flocculation processes and converting the existing anaerobic lagoons into a lined lagoon for active aerobic process, thereby avoiding any groundwater pollution problem, improving the quality of treated effluent as well as reducing the holding time (http://psa.gov.in).

8. Conclusion and future prospects

Irrespective of continuous progress of Indian paper industries, only few of the large wood based paper mills have made progress by adoption of new green technologies but fully fledged, total chlorine free (TCF) bleaching of pulp with cocktail of enzymes is still under observations. ECF and TCF paper production offers opportunities for emerging enzyme technology which provide a simple and cost-effective way to satisfy the consumers and environmental protection agencies' concerns. The day may not be far when paper products manufactured with chlorine compound-based technology will be prohibited for wrapping of food products and other consumer items. If industry will not implement the international standards, as a result paper export market may face the undesirable consequences in future. It is also imperative to generate new technologies for economical xylanase and laccase production. Realistic cost estimate and improvement in process economics shall be the key factors for commercial success of any technology and therefore it must be clearly understood that enzyme-based process for bleaching must be as inexpensive as using chlorine or even organic chlorine compounds.

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Regenerated cellulose from N-methylmorpholine N-oxide solutions as a coating agent for paper materials

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The objective of the presented research was to determine the influence of cellulose coating, obtained from the cellulose solution in N-Methylmorpholine N-oxide (NMMO), on the structural and mechanical properties of paper. The effect of heating time of paper samples coated with cellulose dissolved in NMMO was also investigated. Depending on the heating time of the coating, a continuous or porous layer was obtained. Coating without any heating stage yielded a continuous cellulose layer of hydrophobic properties (higher contact angle in comparison to base paper), and paper of higher smoothness and increased tear resistance. Analysis of the paper samples showed that cellulose coating not only changed the surface properties of paper, but also significantly improved paper strength properties, such as the tensile index, elongation, bursting strength index and double folds number. Despite the process' limitations (e.g. necessity of removing the NMMO), this method can be considered as a novel approach for paper property modification.

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ORIGINAL PAPER

Regenerated cellulose from *N*-methylmorpholine *N*-oxide solutions as a coating agent for paper materials

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Abstract The objective of the presented research was to determine the influence of cellulose coating, obtained from the cellulose solution in *N*-Methylmorpholine *N*-oxide (NMMO), on the structural and mechanical properties of paper. The effect of heating time of paper samples coated with cellulose dissolved in NMMO was also investigated. Depending on the heating time of the coating, a continuous or porous layer was obtained. Coating without any heating stage yielded a continuous cellulose layer of hydrophobic properties (higher contact angle in comparison to base paper), and paper of higher smoothness and increased tear resistance. Analysis of the paper samples showed that cellulose coating not only changed the surface properties of paper, but also significantly improved paper strength properties, such as the tensile index, elongation, bursting strength index and double folds number. Despite the process' limitations (e.g. necessity of removing the NMMO), this method can be considered as a novel approach for paper property modification.

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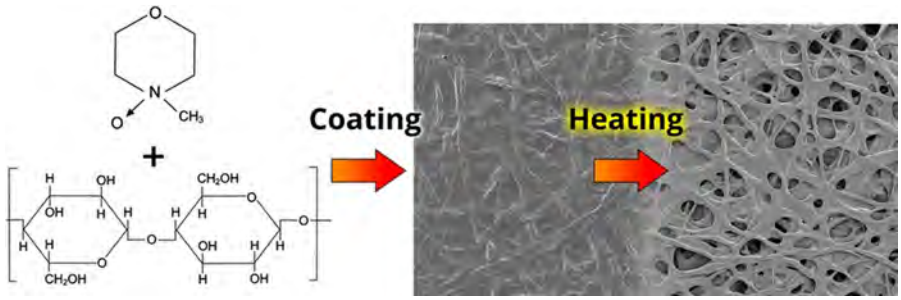
Graphical Abstract



Keywords Paper coating · Regenerated cellulose · *N*-Methylmorpholine *N*-oxide · NMMO · Cellulosic coating · Mechanical properties · Surface modification

Introduction

The coating of paper materials is one of the most commonly applied methods for altering their surface properties. Depending on the coating suspension composition, it is possible to improve paper strength, adhesive, printing, barrier and antibacterial properties, control the coefficient of friction and fire retardancy, modify thermal and electrical conductivity, and also to enhance the many different properties of other end-products (Choi et al. 2002; Tracton 2007; Andersson 2008; Gardner et al. 2008; Liu et al. 2011; Salas et al. 2014; Mngomezulu and John 2017). A lot of substances used for coating purposes are of synthetic origin (e.g. PET, PVC, PP, waxes, latexes). Such compounds—apart from their advantages, i.e. good barrier properties, high strength, low price, easy application—have many drawbacks, especially with regard to their negative environmental impact and recycling difficulties (Andersson 2008). This is one of the reasons for research aiming at reducing the content of synthetic polymers or replacing them by natural polymers (Khwaldia et al. 2010). Nowadays, such reports and their results can be found in the literature discussing the possible application of more environmentally friendly biopolymers, such as whey proteins, chitosan (Gällstedt et al. 2005), starch (Garcia et al. 1999) and alginates (Rhim et al. 2006). Another, but equally important, reason to conduct such research is to seek out truly environmentally friendly substances, which would make it possible to obtain new paper material properties, while at the same time developing novel composite or hybrid biomaterials (Salas et al. 2014; Hubbe et al. 2017). Different forms of cellulose, in particular, microfibrillated, microcrystalline cellulose and nanocellulose, are currently among the substances widely studied to meet these objectives (Lavoine et al. 2014; Nakagaito and Yano 2005). Numerous scientific publications (Zimmermann et al. 2005, 2010; Henriksson et al. 2008; Hansen and Plackett 2008; Fukuzumi et al. 2009; Tingaut et al. 2011; Lavoine et al. 2012; Dufresne 2012, 2013; Siró and Plackett 2010; Savadekar et al. 2015; Spence et al. 2010; Kangas et al. 2014; Mngomezulu and John 2017) indicate the possible application of these forms of cellulose in the production of new, environmentally friendly materials. Those researchers determined, among other things, that the addition of micro- and nanocellulose significantly influenced the material structure. Therefore, it is possible to modify the mechanical and barrier properties of fibrous materials. For example, Ferrer et al. (2012) and Fall et al. (2014) reported that nanocellulose-based materials had the following major features: high specific surface area, high density (1100–1560 kg/m^3) and high strain at break (up to 10%). Additionally, the elastic modulus of cellulose nanocrystals could be as high as 143 GPa (Šturcová et al. 2005). From a practical viewpoint, the hydrophilicity of microcrystalline cellulose and nanocellulose is a significant advantage, as it enables them to be applied in water-based systems and/or in mixtures with other hydrophilic substances. The presence of the –OH groups in the cellulose macromolecule may contribute to the ordered structures of the cellulose chains. As a result, these structures possess hydrogen bonding potential and, thus, they may be combined with other polymer materials (Gardner et al. 2008; Erdman et al. 2016). This makes

it possible to produce new, biodegradable composites of exclusive characteristics, e.g. barrier properties (Hubbe et al. 2017) or even substrates for printed electronic products (Lee et al. 2009; Peresin and Rojas 2014). Moreover, using the same polymer for the surface modification as that present in the natural fibers may result in strong adhesion between the coating layer and the base paper. Despite being a hydrophilic and hydrogen-bonded substance, cellulose neither dissolves in water nor in many popular volatile polar and non-polar organic solvents (e.g. ethanol, methanol). The lack of simple dissolving systems is a direct outcome of the complex chemical structure of cellulose. The cellulose macromolecule contains a high number of hydroxyl groups prone to the formation of a strong and highly structured intra- and intermolecular hydrogen-bonding network, which resists water and most organic solvents. Therefore, cellulose solubility depends on the ability of the solvent to break these interactions (Yamane et al. 2006; Lindman et al. 2010; Medronho and Lindman 2014, 2015). Cellulose contains multiple hydroxyl groups on the glucopyranose ring and, therefore, its insolubility in water is rather unexpected. It might be explained—according to recent investigations—by its amphiphilic nature. This means that the glucopyranose ring exhibits both a hydrophobic and hydrophilic character. The axial direction of the ring is hydrophobic as a result of the location of C–H bonds along the axial position. Hydrogen atoms connected directly to the carbons do not contribute to the hydrogen bonding. According to simulations carried out by Mazeau (2011), the surface energy of the layer of C–H moieties is the lowest and, as a consequence, the attachment energy, which is mainly of van der Waals type, is less favourable than that of other surfaces of the cellulose. Hydrophobic interactions obviously limit cellulose solubility in polar solvents. The equatorial direction of the ring is hydrophilic since the hydroxyl groups—responsible for hydrogen bonding—are located along this direction. Hence, cellulose macromolecules exhibit differences in polarity (Yamane et al. 2006; Medronho et al. 2012). The situation is more complex due to the presence of various crystalline phases in native cellulose. There are three principal phases: type Iα (triclinic), Iβ (monoclinic) and type II (Biermann et al. 2001). Affinity of all these phases to water and to many organic solvents has not yet been fully investigated. Some authors also link cellulose insolubility with its crystallinity (Cao et al. 1994; Medronho et al. 2012). The chemical structure and properties of cellulose may suggest that amphiphilic solvents would be the most suitable for cellulose dissolution. Ionic liquids (Kosan et al. 2008) and some organic solvents exhibit such properties (Kalashnikova et al. 2012; Lindman et al. 2010; Medronho and Lindman 2014). It should be emphasised that, even though many different systems that dissolve cellulose are described in the scientific papers, not all of them are amphiphilic (Alves et al. 2016). *N*-Methylmorpholine *N*-oxide (NMMO) is an example of such a system. The mechanism of cellulose dissolution in NMMO systems has been described in the literature (Medronho and Lindman 2014). The proposed mechanism, however, does not fully explain the occurring changes. For instance, it does not include the impact of water molecules, which are crucial for the NMMO cellulose dissolving system. Experimental practice indicates (Lindman et al. 2010) that lack of water results in cellulose insolubility in NMMO. Conversely, at too high water content, cellulose would not dissolve either. This emphasises the water-sensitivity of the process. Nonetheless, among different cellulose solvents, NMMO seems to be the most interesting and promising from the viewpoint of paper material modifications. This solvent has been the subject matter of research for many years (Kulpinski 2007; Kulpinski et al. 2011; Erdman et al. 2016). Nowadays, it is applied on an industrial scale for the production of cellulose fibers, known under the brand name of Lyocell or Tencel. Low toxicity is one of the most important advantages of this solvent. The possibility to obtain cellulose solutions in a wide range of concentrations, from less than 1% to approximately 28% by weight, is another advantage. No less important is the fact that—in the case of NMMO—the cellulose solidification process is carried out in water baths. So far, methods for modifying paper with the application of NMMO have been scarcely studied. Johnson (1969) patented a method in which only NMMO (without cellulose) was used for paper mechanical property improvement. In another patent, Melville et al. (2014) applied a mixture of NMMO, water and fluorinated polymer particle suspension to modify paper surface so that its abrasion resistance would be increased and, simultaneously, its friction coefficient decreased. Paper with an applied wet layer was heated at a temperature of 100 °C to ensure good

adhesion to paper fibers. Afterwards, NMMO was washed out from the paper with water. The NMMO cellulose solution, containing dispersed kaolinite, was applied in research conducted by Se Young Yoon (2007). Such a system was used to form paper-based composite materials of improved strength properties. In the literature, one may find information into the properties of membranes, made of cellulose dissolved in NMMO, which afterwards were used to filtrate, e.g. gases (Jie et al. 2005). The above-mentioned patents and scientific articles did not include the experiments presented in this publication, i.e. in neither was the cellulose solution in NMMO used to coat the surface of paper. The method applied in this research is safe because the solvent is both non-toxic and non-flammable. Furthermore, NMMO is considered environmentally friendly. It can be reused with a percent recovery of 98% or even higher (Rosenau et al. 2001; Chen et al. 2015). This technology also significantly reduces problems related to post-consumer material recycling.

The objective of the research was to determine the interactions between the NMMO cellulose solution and paper, whose surface had been coated by that solution. In particular, the impact on the structural and strength properties of paper was investigated. This study is part of a larger research project on fibrous material modification by means of a surface treatment operation, namely by coating the substrate with the solution containing cellulose dissolved in NMMO.

Materials and methods

Cellulose solution preparation

Bleached beech kraft pulp of Degree of Polymerisation (DP) of 655 and α-cellulose content of 92.3% was used for the cellulose solution preparation. This type of pulp was selected because of its relatively low degree of polymerisation and short fibers that enabled the dissolution of such cellulose under mild conditions. According to the authors' experience, it is very difficult to run a coating operation using solutions of higher than 5% cellulose concentration due to high solution viscosity, resulting in runnability problems. Conversely, the application of significantly lower concentration solutions results in insufficient deposition of cellulose on the base paper. Therefore, for the coating solutions used here, cellulose content of 3% was selected as the most effective from a practical point of view. The cellulose solutions were obtained in a high efficiency laboratory-scale IKAVISC kneader type MKD 0.6-H60. The mixture of 50/50 water and NMMO with an addition of 3% of cellulosic material (based on NMMO weight) was heated at a temperature of 95 °C and under low pressure (of about 6.7 kPa), and the excess of water was removed from the system. The process was continued until a homogeneous and transparent cellulose solution in NMMO was obtained.

Base paper preparation

Commercial, bleached softwood pine kraft pulp (BSK) was used to prepare laboratory handsheets. Pulp parameters were as follows: initial moisture content 93.78%; α-cellulose content 86.6%; DP 1081; Schopper-Riegler value SR-12. Pulp samples were prepared according to standard ISO 5263-1:2004. Unbeaten pulp was examined and laboratory sheets of 70 g/m^2 were formed in Rapid-Köthen apparatus according to standard ISO 5259-2:2001. The obtained laboratory sheets were used as base paper for a subsequent coating.

Unbeaten pulp was used in order to eliminate the influence of the beating process on the paper mechanical properties. Consequently, it was possible to evaluate the full development of strength properties, resulting only from the applied modifications.

Coating

The application of cellulose-NMMO solution on the paper surface was conducted using the standard coating process. This operation was carried out with the use of an automatic coater ('Control Coater') of IPP/TUL, Poland, at the speed of 16 cm/s and with the use of a standard Mayer rod No. 3 (K-bar), which gave a wet film thickness of 24 μm and, hence, a dry coating thickness of about 0.8 μm. Prior to the coating process, the cellulose solutions were melted and kept at a temperature of 80 ± 2 °C. Solidification of the coating occurred as a result of washing out the solvent (NMMO) and—afterwards—drying the coated papers.

Post-treatment

Two post-treatment methods were employed. In the first one, marked as NH (No Heating), the solvent was washed out immediately after the coating application. In the second method, marked as HA (Heating Applied), before the washing out operation, coated papers were subjected to heating at a temperature of 80 ± 2 °C for a time period of 5, 10, 20, 40 or 60 min. The applied procedures are shown in Fig. 1.

Heating stages were added in order to keep the cellulose solution in a liquid state to observe possible effects related to the further interactions between paper and NMMO. In particular, it was expected that cellulose from the solution would migrate in the presence of NMMO, and that the solvent itself could also interact with cellulosic fibers.

The samples of coated paper were exposed to heat treatment in a KBC-32 drier of WAMED, Poland. NMMO removal from the cellulose coating was carried out by means of immersing a sample of coated paper in a water bath at a temperature of 37 °C ± 2 °C for 120 s.

The duration and temperature of the washing bath was selected based on the conducted experiments. According to the study, under the chosen conditions, it was possible to remove all NMMO in a relatively short time and to obtain reproducible sample properties.

Structural and mechanical properties testing

Paper samples were conditioned according to ISO 187:1990 standard. All properties were determined in accordance with adequate ISO standards:

- Thickness and apparent density (ISO 534:2005)
- Tensile index and elongation (ISO 1924-2:2008)
- Elmendorf tear resistance (ISO 1974:1990)
- Bendtsen surface roughness (ISO 8791-2:1990)
- Bendtsen air permeance (ISO 5636-3:1992)
- Folding endurance (Schopper device—ISO 5626:1993)
- Bursting strength (ISO 2758:2001)

PG-X Goniometer of Testing Machines Inc. was used for contact angle measurements. The tests were carried out according to TAPPI T 458 standard method.

SEM analysis

The observation of the paper surface was performed with the use of Scanning Electron Microscope (SEM) VEGA3-SBU. The samples for SEM examination were gold- and palladium-coated using 'Mini' Sputter Coater/Glow Discharge System SC7620.

Results and discussion

The influence of cellulosic coating on the properties of paper products was studied. Additionally, the effect of the coating post-treatment (heating), carried out before the solvent washing-out operation, was investigated.

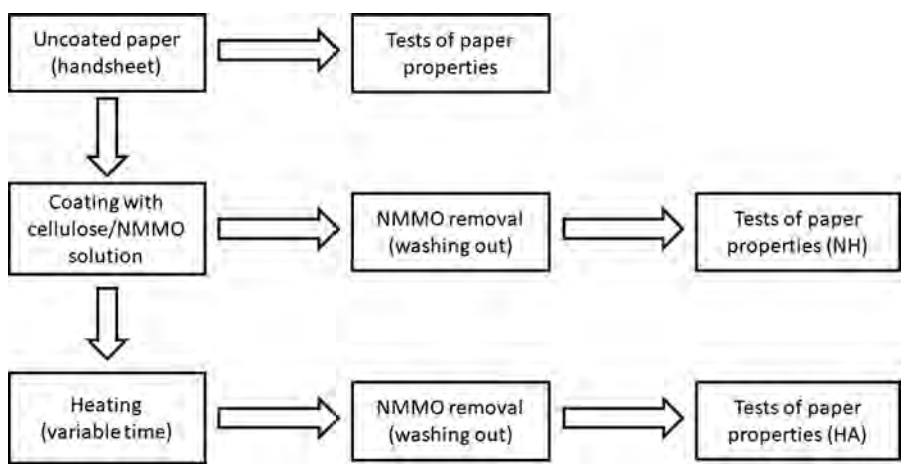


Fig. 1 Diagram of the research

The most important structural and mechanical parameters of all paper samples were determined. The results are presented in Table 1, and also shown in Figs. 2, 3, 4, 5, 6, 7, 8 and 9.

The basic statistical analysis is presented as a coefficient of variation (given in Table 1) and as error bars, based on standard deviation values (given in figures).

Structural and surface properties

The microscopic observations of the surface of paper samples constituted the first stage of the research. Figure 2 presents: (a) surface of reference paper without coating, (b) surface coated with cellulose dissolved in NMMO, where solvent was removed immediately after a coating operation, (c) surface with coating, where solvent was removed after 10 min of heat treatment of the coated paper, (d) coated paper surface, where solvent was removed after 40 min of heat treatment. The presented pictures show that, depending on the applied methodology of modifying a surface by means of the same kind of cellulose solution, it is possible to obtain different coating structures. If the solvent is removed immediately after coating, a continuous coating layer is obtained (Fig. 2b).

When the heat treatment was applied, the continuous layer disappeared (Fig. 2c, d). This effect suggests that the cellulose solution penetrated the structure of the material when the samples were heated. As a result, not only the surface but also the structure of paper was modified. Based on the property measurements and SEM images it could be concluded that, as heat treatment time was extended, the degree of penetration of the paper structure by the cellulose solution increased. Therefore, modification not only of the paper surface, but also of the entire structure of the paper was possible. The results presented below show to what extent the modifications influence the most important properties of paper. The surface roughness values are shown in Fig. 3. The lowest roughness level was found for paper with a continuous regenerated cellulose layer (NH—without further heating). When heat treatment was applied, roughness increased quickly up to the value comparable with that for uncoated paper. For the longer heat treatment times (over 20 min), a certain decline in the roughness of the surface was observed. This decrease might be explained by possible partial swelling and/or

Table 1 Structural and mechanical properties of investigated papers (COV, %—coefficient of Variation is given inside the parentheses)

Heat treatment time (min)	Apparent density (g/cm^3)	Surface roughness (ml/min)	Tensile index (N m/g)	Elongation (%)	Double folds number	Tear resistance index (mN m^2/g)	Bursting strength index (kPa m^2/g)	Air permeance (ml/min)
0	0.555	289	23.81	3.50	37	8.80	0.80	181
	(2.66%)	(9.9%)	(3.21%)	(8.72%)	(7.3%)	(4.58%)	(5.32%)	(9.3%)
5	0.593	605	61.28	4.96	1527	5.94	4.45	4900
	(1.03%)	(9.2%)	(6.73%)	(9.82%)	(8.1%)	(5.93%)	(6.41%)	(4.6%)
10	0.594	623	61.09	5.48	1228	5.80	6.22	4980
	(1.09%)	(9.1%)	(5.09%)	(3.12%)	(9.0%)	(4.32%)	(6.29%)	(2.9%)
20	0.595	634	59.77	5.76	1176	3.34	4.65	> 5000
	(1.72%)	(8.6%)	(4.17%)	(8.83%)	(4.4%)	(5.0%)	(4.90%)	(3.3%)
40	0.599	587	64.47	5.48	1248	2.07	4.83	> 5000
	(2.41%)	(8.5%)	(3.91%)	(9.03%)	(8.1%)	(3.68%)	(5.19%)	(2.7%)
60	0.617	563	58.93	4.57	1251	2.05	5.28	>5000
	(2.59%)	(8.7%)	(4.21%)	(8.12%)	(6.4%)	(4.12%)	(6.28%)	(3.1%)
Uncoated (reference) paper	0.521	611	20.21	1.86	7	7.14	0.79	4500
	(3.13%)	(5.4%)	(3.52%)	(8.33%)	(7.31%)	(6.18%)	(4.78%)	(10.4%)

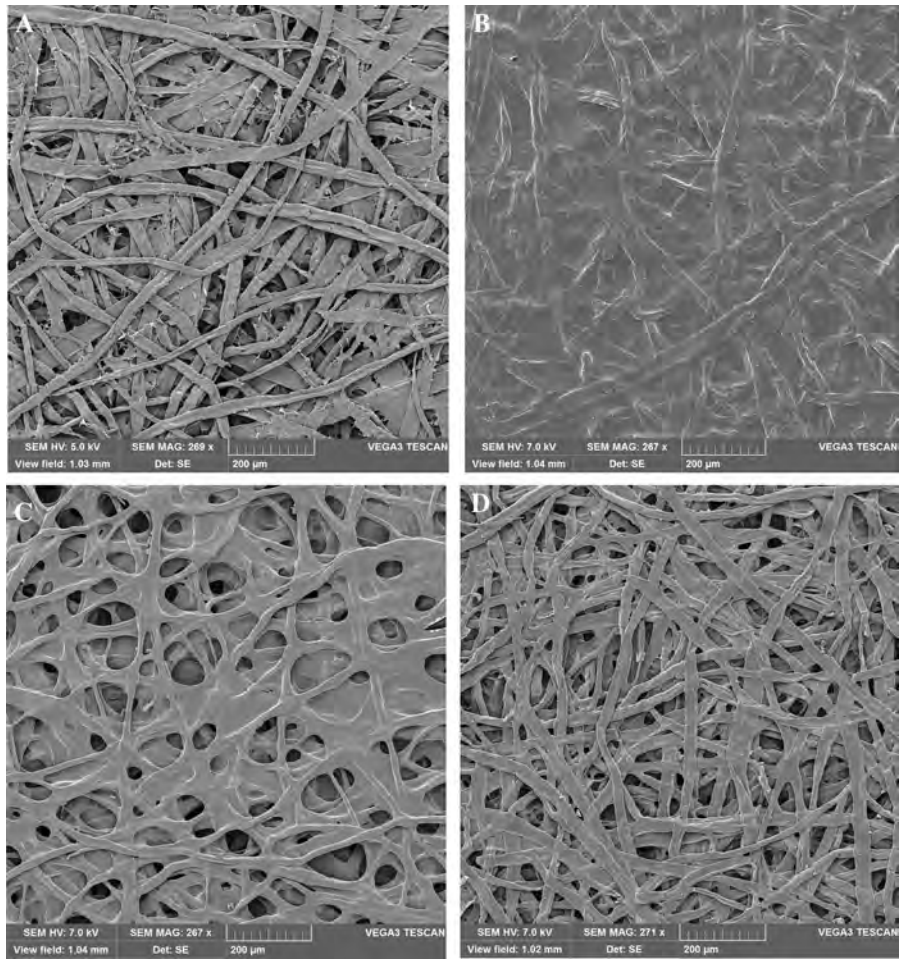


Fig. 2 Comparison of the surface of laboratory paper samples made from BSK pine pulp **a** uncoated (reference sample), **b** coated (NH), **c** coated (HA)—10 min of heat treatment, **d** coated (HA)—40 min of heat treatment

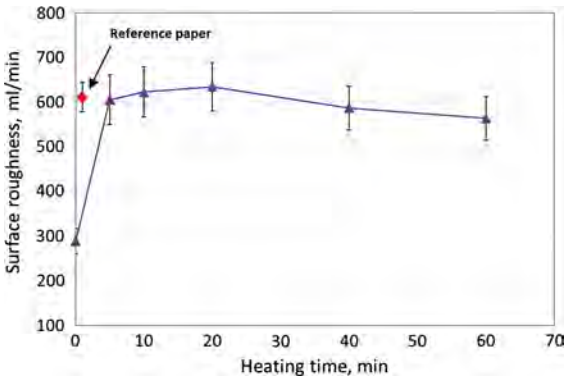


Fig. 3 Effect of heat treatment time on the surface roughness of coated papers (the value for base paper is given as a reference)

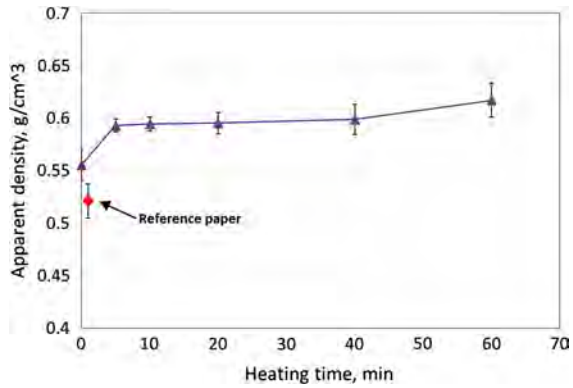


Fig. 4 Effect of heat treatment time on the apparent density of coated papers (the value for base paper is given as a reference)

dissolution of the base paper cellulose by the concentrated NMMO solution.

In Fig. 4, changes in the apparent density of studied samples of paper depending on the duration of heat treatment of the coating are presented. Time equal to

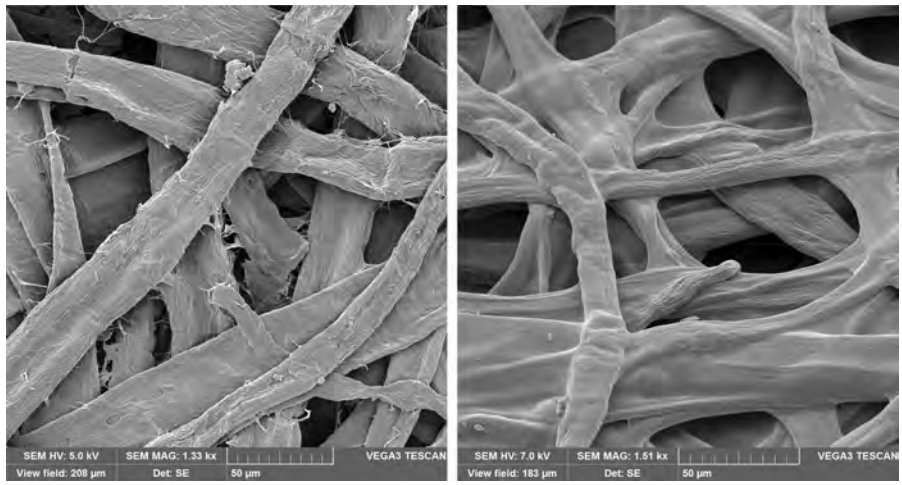


Fig. 5 Close view of the surface of the reference paper (left) and the coated paper after 10 min of heat treatment (right)

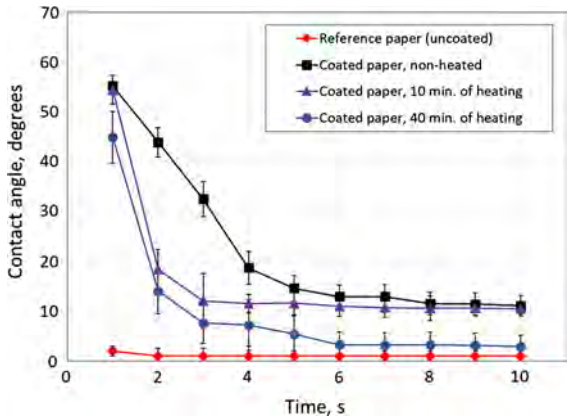


Fig. 6 Comparison of the changes in contact angle with water for uncoated (reference) paper, coated paper—immediately washed out—and coated and heated papers

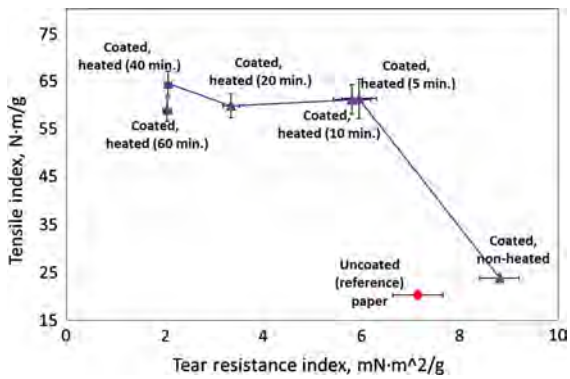


Fig. 7 Comparison of the changes of tensile index versus tear resistance index for coated papers (the value for base paper is given as a reference)

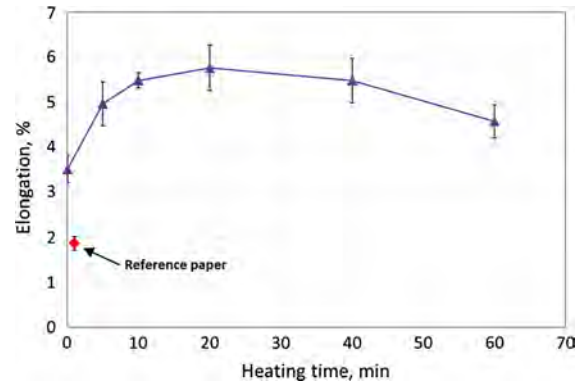


Fig. 8 Effect of heat treatment time on the elongation of coated papers (the value for base paper is given as a reference)

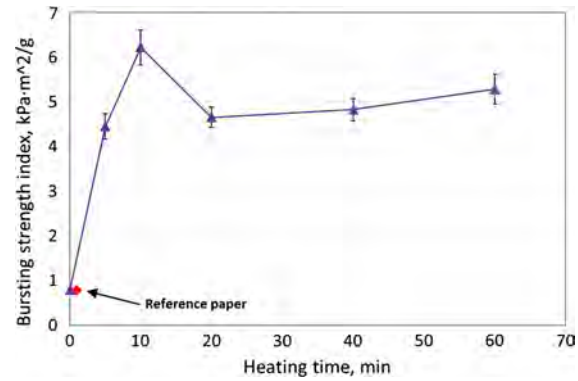


Fig. 9 Effect of heat treatment time on the bursting strength index of coated papers (the value for base paper is given as a reference)

'0' means that no heat treatment was applied (sample NH), and that the solvent was removed immediately after the coating was applied. A single red rhombus point represents the value of the discussed parameter for the reference uncoated paper. The reference papers were not heated either. The data in Fig. 4 indicate that the apparent density of the studied samples of paper with a cellulose coating was higher than the apparent density of the base paper itself. In the case of the constant thickness of a coating and, thus, the same amount of deposited cellulose, it was expected that the average apparent density of the coated paper would be similar, regardless of the post-treatment method. It was revealed, however, that apparent density was increasing when heat treatment duration was prolonged.

These results could suggest that heat treatment of cellulose coating modifies the internal structure of the entire material. This is evidenced as well by the results of the measurement of air permeance (Table 1 and images presented in Fig. 5). A close view of the heat-treated samples reveals the lack of continuous layer on the surface. Moreover, the fiber network is tightly surrounded by the regenerated cellulose. The lack of fibrils suggests that the small particles (e.g. fibrils, fines) could have been partially dissolved and absorbed by the cellulose-NMMO solution. This could result in higher permeance of the whole structure.

The range of changes of apparent density depended on the method of sample post-treatment. The most significant changes were already observed for short heat treatment times. After 5 min of heat treatment, the apparent density of the tested sample increased by approximately 0.5 g/cm^3, whereas change by barely 0.006 g/cm^3 in apparent density was observed when heating time was increased from 5 to 40 min. Evidently, the major changes in the structure of the paper occur during the first 5–10 min of heating. Further data analysis demonstrated that the change of apparent density was caused by changes in the thickness of the samples. This implies that the increase of apparent density results from the increased shrinkage of the whole structure. A similar observation can be found in the literature (Ferreira et al. 2015).

The hydrophobic properties of applied coatings were tested for four cases: reference paper without a coating, paper with a continuous coating (NH), and papers with a coating heated for 10 and 40 min before solvent removal. It is commonly accepted that native cellulosic fibers are mainly hydrophilic, and a paper structure is of a capillary-porous nature. The contact angle for such materials is usually equal to 0 (i.e. water immediately penetrates the paper structure if no hydrophobic additive has been used). In the case of the applied cellulose solution in NMMO, cellulose dissolution and regeneration cause the reorganisation of the intra- and inter-molecular hydrogen bonds. Other scientists (O'Sullivan 1997; Zimmermann et al. 2016) determined that conversion from cellulose I to cellulose II occurs during the cellulose regeneration process.

Furthermore, Biganska and Navard (2009) found also that the regeneration process may influence the final properties of cellulose. Cellulose regenerated in a water bath after the crystallisation of solutions exhibited a uniform and compact structure. Conversely, regeneration from the molten solution resulted in a porous structure surrounded by dense "skin". Depending on the final organisation of the structure, part of the –OH groups may not be available for interactions with liquid located at a cellulosic surface (Hubbe et al. 2015). Yamane et al. (2006) proved that regenerated cellulose can exhibit increased hydrophobic properties. The results of measurements presented in Fig. 6 demonstrated that paper without a cellulosic coating had a contact angle equal to 0.

It was already noticed that, during the solvent removal process, the presence of cellulose coating increased the samples' resistance to water. A sample of paper without a coating, immersed in a water bath, quickly disintegrated into individual fibers. The coated samples easily survived a 2-min immersion in water, preserving their structure. This proved that the cellulose introduced into the paper bonded the fibers and made the structure more hydrophobic.

Measurements of the contact angle for a continuous regenerated cellulose coating showed an increase in the initial contact angle to more than 50°. This effect, however, disappeared quickly and after approximately 6 s, the contact angle reached the constant value of *circa* 10°. The final value corresponds to the value of contact angle for micro-crystalline cellulose found in works by Yamane et al. (2006). For the sample of paper coated with cellulose and heated for 10 min, the initial contact angle was about 50° as well but it decreased more rapidly to the same value as that for continuous regenerated cellulose coating. For longer times of heat treatment (40 min), the layer of cellulose

was not continuous. As a consequence, the initial contact angle was lower (about 45°), and its decrease in time was faster, reaching a constant value equal to approximately 4°. On the basis of the measurements conducted, it can be stated that the papers with a layer of regenerated cellulose exhibited higher contact angle as compared to the samples not treated with the cellulose solution. Apparently, the observed changes might have been affected by various factors, i.e. different hydrophobicity of regenerated cellulose, surface roughness and capillary structure of the material. Therefore, full explanation is difficult and requires further investigations.

Mechanical properties of paper coated with a cellulose solution

Tensile strength and tear resistance were measured as the key functional parameters of paper materials. The classic method of improving papermaking ability applied on an industrial scale (process of beating) causes an increase in tensile strength and, simultaneously, a decrease in tear resistance. For this, both of these parameters are often presented together. Figure 7 shows a comparison of changes in tensile strength as a function of tear resistance. A single red rhombus point represents the properties of uncoated paper. On the basis of the obtained results, it is possible to conclude that a continuous cellulose layer causes an increase in the tear resistance of paper (from 7.14 to 8.8 mN m^2/g), and also a small increase in tensile strength (by approximately 3.6 N m/g). Additional heating operation applied to coated papers resulted not only in penetration of the paper structure by the cellulose solution but also could have caused changes of the paper structure, since the hot NMMO-water system (containing about 16% of water) has an ability to swell or partially dissolve cellulose fibers. The structural changes of the samples resulted in quick and significant increase in tensile strength. Just after 5 min of heating operation, tensile strength increased by more than 40 N m/g in comparison to uncoated, reference paper. The observed increase of the tensile strength correlated with the decreasing value of tear resistance when the heat treatment time of the coating was prolonged. These results were the basis for quantifying the optimum time of coating heat treatment as no longer than 10 min—exceeding this time resulted in excessive loss of paper tear resistance.

Interesting results were obtained while studying changes in the elongation of the samples of uncoated paper and of paper with regenerated cellulose coating (Fig. 8). The initial elongation of uncoated paper amounted to 1.86%. The application of cellulose coating (without heat treatment) caused an increase in this parameter to 3.5%. Heat treatment caused a further increase in elongation to approximately 5% (after 5 min of heat treatment), and the maximum value was reached after 20 min of heating (approximately 5.8%). Longer heat treatment times caused a decrease in this parameter. It is worth pointing out that the obtained maximum elongation was comparable with values typical of beaten cellulose pulps. An increase in both tensile strength and elongation of paper coated with cellulose indicate the high binding properties of the regenerated cellulose from the solution in NMMO. The relatively long heat treatment time (measured in minutes) required for the elongation increase was the shortcoming of the process.

Figure 9 presents the changes in bursting strength of the studied samples of paper. The results indicate that cellulose coating itself is rather weak. The bursting strength of base paper and coated paper without heat treatment was almost the same. The heat treatment applied caused a large and quick increase in bursting strength. The highest value of this parameter was obtained after 10 min of heat treatment, and then it decreased (up to 20 min). After that time, bursting strength remained almost unchanged. These results confirm earlier observations that an increase in paper strength properties results mainly from the interactions of the regenerated cellulose with the entire matrix of the fibrous structure of paper. Longer heating times causeed the deeper penetration of a cellulosic solution into a paper structure. As a result, fibers became surrounded by a layer of cellulose, which contributes to an increased bonded area of fibrous network (this effect can be seen in photographs—Fig. 2c, d).

The double folds number, the only fatigue test conducted on paper, was the last property studied. This parameter is particularly important for materials exposed to multiple deformations, such as banknote paper, map paper or book cover paper. The number of double folds is frequently identified—not quite correctly—with paper fracture resistance while folded. The results obtained in this research are presented in Fig. 10. It is well known that the number of double

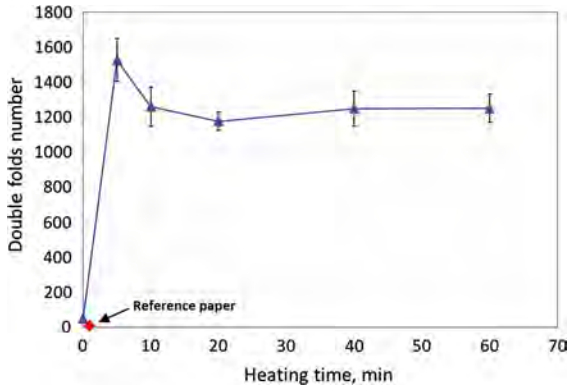


Fig. 10 Effect of heat treatment time on the double folds number of coated papers (the value for base paper is given as a reference)

folds depends mainly on the length of fibers, but also on the degree of their mutual contact area (i.e. bounded area) in the paper structure. It is also for this reason that paper made of unbeaten pulp, quickly breaks while folded. In the discussed case, the reference paper (without coating) demonstrated a number of double folds amounting to 7. Cellulose coating applied on the surface of the paper increased the value of this parameter to 37. In turn, the relatively short heat treatment time applied (5 min) caused an increase in the number of double folds to more than 1500. Longer heating time resulted in a decrease of this parameter to the constant value of approximately 1200. This means that cellulose coating itself is not very resistant to folding. Yet again, these results indicate the significant bonding abilities of regenerated cellulose.

Considering the changes in strength properties of all coated papers it can be concluded that the highest values of these properties were found when coated papers were subjected to heat treatment for about 5–10 min. Longer treatment caused decrease in these properties. This allows the argument that this negative effect could be caused by exceedingly long NMMO-fibrous material interactions at high temperatures, which may have resulted in the excessive dissolution of fiber structural elements (e.g. cellulose, hemicellulose) within the paper. Consequently, it could have led to partial damage of the fibrous network and overall loss in material mechanical strength. This effect will be further investigated.

Conclusion

On the basis of the conducted research, it can be concluded that it is possible to use regenerated cellulose from an *N*-Methylmorpholine *N*-oxide solution to coat paper materials. The obtained results showed that regenerated cellulose-based coatings changed the surface, structural and strength characteristics of paper. Additional heat treatment enabled the modification of those properties even more significantly. Heat treatment proved to be most effective in terms of strength properties improvement when applied for 5–10 min. Coated papers subjected to that optimal "thermal conditioning" exhibited an increase in tensile index, elongation, bursting strength index and double folds number. It is believed that heat treatment enhanced the penetration of the NMMO cellulose solution into the paper structure resulting in the higher number of contacts between paper fibers and regenerated cellulose chains. Therefore, the bonded area within the fibrous matrix was increased, which reinforced the coated papers. When heat treatment was not applied, penetration of the coating solution into the paper structure was limited and, thus, regenerated cellulose interacted mostly with surface fibers, covering them with a continuous coating film. As a result, additional bonding did not form deep inside the paper fiber network and the internal structure of the material was not mechanically strengthened. Such surface modification, however, contributed to the highest smoothness and hydrophobicity out of all the examined papers. The measurements of the contact angle for continuous regenerated cellulose coating showed an initial contact angle of about 50°. This value, however, decreased quickly and, after approximately 6 s, the contact angle reached the constant value of about 10°, which corresponds to the value of contact angle for micro-crystalline cellulose. In general, the contact angle decreased as heat treatment time increased. It should be mentioned that the necessity of subjecting a coated paper to the process of solvent removal stage (washing out) is a shortcoming of this method, which limits its wet-end applications in the classical process of paper production. An increase in strength properties, however, and also (as previously reported in the literature—Yoon 2007) the possible use of various substances as additives to such coating solutions, may lead to the development of innovative products. As a result, the

presented method may be beneficial for the production of specialty materials for which quality and specific properties play a decisive role in relation to the efficiency of the production process and also to the price of the final product.

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Warehouse Design and Operation using Augmented Reality technology: A Papermaking Industry Case Study

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In modern, high competitive markets, efficient warehousing is critical as it accounts for a great part of logistics costs. Companies try to adopt highly adaptive and flexible warehouse design that may support the integration of novel technologies such as Augmented Reality (AR). This paper proposes a framework for warehouse design which minimizes inventory cost while keeping a high degree of service by supporting the integration of an AR warehousing system. The AR system will support the effective management of operations, by providing meaningful information. The proposed methodology is tested and validated in a real-life case study of a papermaking industry.

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Abstract

In modern, high competitive markets, efficient warehousing is critical as it accounts for a great part of logistics costs. Companies try to adopt highly adaptive and flexible warehouse design that may support the integration of novel technologies such as Augmented Reality (AR). This paper proposes a framework for warehouse design which minimizes inventory cost while keeping a high degree of service by supporting the integration of an AR warehousing system. The AR system will support the effective management of operations, by providing meaningful information. The proposed methodology is tested and validated in a real-life case study of a papermaking industry.

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Keywords: Warehouse design; Augmented reality; Warehouse simulation; Manufacturing

1 Introduction

Warehouses are a key aspect of modern supply chains and play a vital role in the success, or failure, of businesses today, since they: a) provide storage for raw materials, components, work-in-process, and finished goods b) operate as distribution and order fulfilment centres and c) perform localized and value-added warehousing [1]. For these reasons, warehouses have to be highly adaptive to the production rate so as to reach optimal operation level. Inventory management and control is the key to warehouse design and optimization. The main goal of inventory management and control is to optimize three targets: customer service, inventory costs, and operating costs. Service level must be kept at high levels while inventory and operation costs must be minimized [2].

Warehouse design demands a very methodical and well-structured approach due to warehouse complexity. Warehouse design is highly complex as it is a multi-criteria problem, with interconnected functions and parameters. Warehouse simulation is a commonly used approach to improve its design [3]. Novel digital solutions have been proposed in the literature and also the market that support effective warehouse design, considering different criteria [4] so as to support decision making while offering simulation features that may visualize the functionality of the designed warehouse.

Additionally, novel technologies that shape manufacturing have found fertile ground in different fields [5]. Starting from simpler combinations on laser scanners and barcodes, contemporary warehouses try to integrate new technologies to facilitate managing warehouse available stock and effective product localisation, especially in larger facilities [6]. Utilizing wearables, such as smart watches and head-mounted displays, the operators may easily report product input/ output in the warehouse, while also retrieve the position of a stored product [7]. Using advanced visualization techniques, such as Augmented Reality, the operators may intuitively be guided to find a stored product and easily report stock updates [8].

This paper proposes an adaptive methodology for warehouse design while integrating Augmented Reality. Logistics and statistical analysis has been used and the final is designed according to Economic Order Quantity (EOQ) model, aiming to minimize inventory cost. Additionally, an

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Augmented Reality based system to support warehouse management, connecting the operators with a central inventory management platform. To verify the proposed design, it is applied in papermaking industry.

2 State of the art

According to ELA (2004), the capital and operating costs of warehousing in Europe represent about 25% of logistics costs, whilst figures for the USA show that warehousing contributes to about 10% [9]. In spite of warehouse significance in supply chain, there is limited effort in the literature towards that direction [10]. Although, publications show that there is an abundance of information written on analyzing particular aspects of warehouse designing problem, it is the combination of all these aspects that has to be taken into consideration and classified in a strict order so as act as a basis for a successful approach to warehouse design [11].

Warehouse design problems have been early reported in the literature. Oxley [12] presents a comprehensible list of steps which are based on the key features of the previous authors, while also defining the overall system requirements of the supply chain. He emphasizes that the warehouse design should be focused on the storage and handling requirements and that the building should then be designed around these. This basic framework of steps is also enhanced by Rowley [13] with Oxley's contribution.

Simulation models have been applied since the early 1980's through basic simulation packages as presented by Ashayeri, et al. [14]. Most of the research done in simulation field is due to the need for optimal warehouse design and planning, where novel technologies could be early adopted. For example, Automated Guided Vehicle (AGV) transport systems where soon adopted in warehouse applications [15]. Gu et al. provided an extensive overview of warehouse performance analysis models, claiming that simulation models are typically used for evaluating one design alternative, but that they are less suited for design-space exploration [4]. Andriansyah et al. presented a layered warehouse simulation model built from reusable components that considers varying number of storage aisles and workstations in a miniload-workstation order-picking system [16].

A further step has been added to the former publication which has to do with the use of computer simulation. Rouwenhorst et al. stated that a design process runs through a hierarchical framework, identifying strategic, tactical and operational decisions [11]. Rushton et al. (2006) have made a refinement of steps in their earlier edition so as to recognize the importance of flexibility in warehouse design issue [17]. The iterative nature of design process is clarified by the equipment and staffing calculations now being presented after the layout design rather than before, as with most other frameworks. Baker and Canessa explored the current literature on the overall methodology design, validated and refined the general results from the literature with reference to warehouse companies [18]. Accorsi et al. applied an integrated decision-support system for the design and management of a storage system [19]. Mital and Krejci presented a modelling framework and an effective algorithm to design material handling systems and warehouses by the identification of the possible system configurations [20]. Thomas and Meller presented a statistical-based methodology to develop guidelines, used to design a manual and case-picking warehouse [21]. The aforementioned publications make apparent warehouse design follows a structure sequence of interdependent steps.

Nevertheless, there are many differences among the various approaches described above, which steam from the various combinations of design process activities when they are grouped into steps [18]. The past few years, warehouse planning was considered to be a very complex issue due to the absence of the simulation and computing power [3]. In many cases, it was not feasible to experiment on real environment as production rate did not allow to make changes. Nowadays, there are many simulation tools that make warehouse design and planning easier and give to the industry the opportunity to test different scenarios, supporting decision making [22].

A technology that starts to gain ground in industrial applications is Augmented Reality. From knowledge distribution through technical instructions in assembly tasks [23] to remote maintenance support [24], AR is tested in different applications, until it becomes mature enough (both from hardware but also from technical knowledge side) to be fully integrated into manufacturing. Its applicability, as it may be used through various host device, and its mobility has proven to be a great advantage that allows it to be easily used in the production line [25]. Additionally, it has proven to be useful for providing positioning instructions, both in maps navigation but also in large warehouse facilities for inventory management and package retrieval, facilitating the operators to efficiently manage large facilities with changing stocks (such as the case of logistics warehouses) [8].

Based on the aforementioned literature review, it becomes apparent that simulation modelling, in terms of warehouse design, is a one-way selection [26]. This happens due to the fact that simulation models can be extremely valuable, timely and cost-effective means to study the performance characteristics of a proposed warehouse layout. Additionally, novel technologies that may improve inventory management and increase the efficiency of product retrieval in vast warehouses are welcome. Towards that end, this paper suggests a method for warehouse design, considering the integration of mobile devices and Augmented Reality to support product location retrieval by the warehouse operators and efficient inventory management. The developed approach is applied in a papermaking industry for validation.

3 Warehouse design to support Augmented Reality package retrieval

This paper presents an innovative and easy to adapt methodology which can give a reliable solution to the problem of warehouse design and simulation that seems to concern the majority of the industries in our days. This methodology aims to keep a high service level while minimizing the inventory costs.

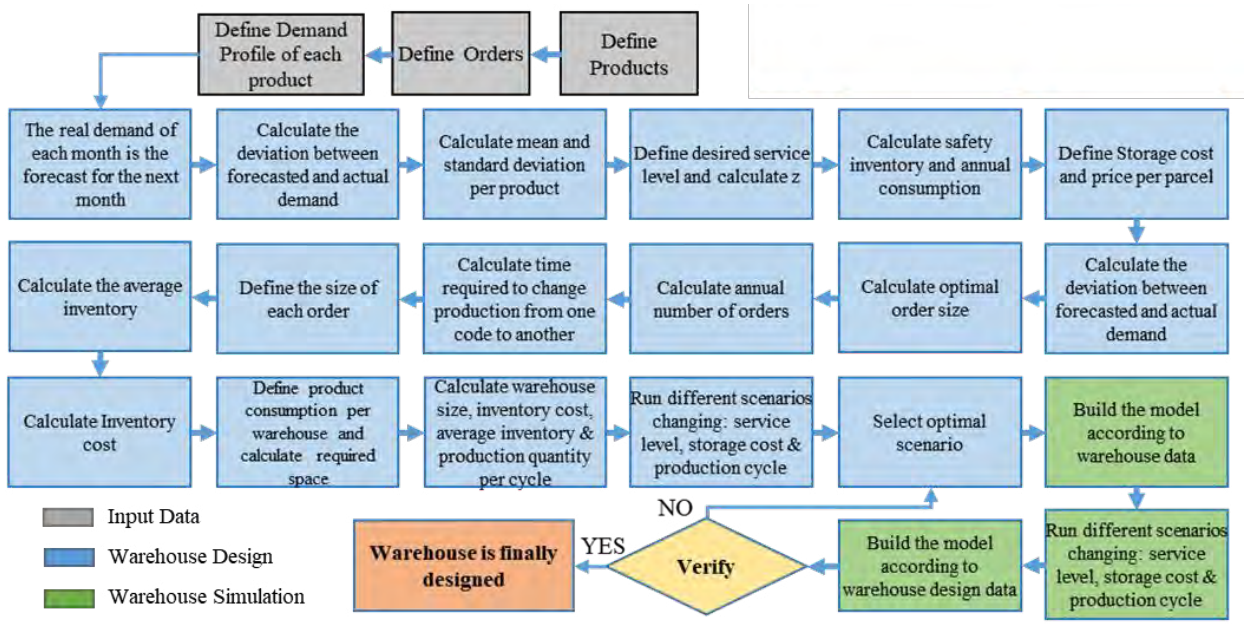

Fig. 1. Workflow of the proposed methodology.

It has to be pointed out a set of assumptions have been made to tackle the obstacles in the following categories: a) demand uncertainty, b) Constant Order Quantity, c) Constant Re-Order Point, d) Suppliers/Production Inconsistency and e) Economic Order Quantity model. The methodology consists of two basic parts with a total number of 23 steps; warehouse design (18 steps) and warehouse simulation (5 steps) as presented in Figure 1.

3.1 Warehouse Design

The design of a well-structured warehouse system concerns a large number of interrelated decisions/ steps which have to be placed in a hierarchical framework. Input data are crucial for reaching a viable verdict on the proper operation. In our methodology, three input data are inserted: products, orders and demand profiles. Then, the proposed methodology is followed to define the warehouse design requirements. The steps of the proposed methodology are listed below (also presented Figure 1 in blue color):

1. Based on the real demand, the forecast for the next month is created
2. its deviation from the real demand is calculated
3. The mean and standard deviation for each product is calculated
4. Define the desired service level and based on that, the z value
5. Calculate safety inventory and the annual consumption
6. Calculate storage cost and parcel price
7. Calculate the deviation between forecasted and actual demand
8. Calculate Economic Order Quantity
9. Define the number of annual orders
10. Calculate time for inventory re-ordering
11. Define the size of order
12. Calculate average inventory
13. Calculate the inventory cost
14. Define product consumption and required warehouse size
15. Calculate final warehouse metrics (size, inventory costs, productivity)
16. Re-run for different values for service level, storage cost and production cycle
17. Define the optimal scenario, which minimizes inventory costs and warehouse size
18. Design the warehouse layout.

3.2 Warehouse simulation

Warehouse simulation is a way of testing different scenarios in real life without any interruption in the production rate. As a result, it gives the opportunity to compare and select the best scenario which will cover warehouse demands. According to warehouse design data, the warehouse model is built. The warehouse model includes: a source for each product, a queue before and after each palletizing station, forklifts according to warehouse capacity which carry pallets to warehouse, the calculated warehouse area where products are stocked, forklifts according to warehouse capacity which carry pallets from warehouse area to each loading area/ exit and a queue to each loading area-exit.

All the above are properly linked and programmed so as to simulate a virtual warehouse environment and operation, while the parameters of each testing scenario are defined. Then, the possible warehouse layouts are defined and run, while their performance is compared and the optimum solution is selected. The result is then verified, comparing the results from the simulation and the design methodology, and if valid, is applied in the warehouse.

3.3 Augmented Reality application for inventory management

Together with the new layout that will be suggested, an application that will support inventory management and

warehouse operators' guidance to the position of the product is developed. The application allows the operator to have constant connection with the database of the available stock, record product entries or exits, while also being able to ask for navigation instructions inside the warehouse. The application targets mobile devices, so as to be easy to use in the warehouse, offering increased mobility and enabling access from everywhere to the available stock.

The application hosts a user-friendly interface, which aims to be used by warehouse operators and/or warehouse vehicles drivers. The application offers three functionalities: monitor available stock, manage product (un-)loading and navigation. To visualize current stock, a top-down depiction of the warehouse is used. The operator may select one storing department and see what is stored there. Additionally, a list option is also available. To (un-)load products, QR codes are placed on each pallet of products but also on all the storage shelves, so that the operator may easily scan the QR codes and update the inventory management database for product input and output. Finally, to facilitate the retrieval of products, Augmented Reality navigation instructions are available. The operator provides the product that needs to be retrieved and the application navigates him to it.

4 Case Study and results

This methodology has been applied to a papermaking industry in order to give a solution to warehouse design problem. Targeted industry has to cope with a very high inventory cost which stems from the bad warehouse design and management systems that is currently applied. The developed methodology has been adapted on the warehouse of final products, in close collaboration with experts from the papermaking industry production line.

There are four basic categories of final products which are taken into consideration: 1) kitchen paper 2) rough toilet paper 3) 3-plies toilet paper and 4) 4-plies toilet paper. The demand profile for each product is generated based on actual 8 months demand, as given by the industry. The main targets were to minimize the storage costs while keeping a high service level of about 95% and 98%. Adjusting the proposed methodology to the industrial use case needs, we assumed that the cost of production stems only from the cost of machines' set up. All the methodology has been based on Fixed Order Quantity System with no-constant demand and order time.

4.1 Warehouse Design

Twelve scenarios have been run for 53 final products following real industrial specifications. The scenarios come from the combinations of the possible storage levels (95 or 98%), the storage costs (16, 18 or 20%) and the production cycle duration (1 or 2 months). The selection is based on two basic criteria:

- Minimum inventory cost (first priority)
- Minimum warehouse size (second priority)

Regarding all the above results for twelve scenarios, the one with 95% Service level, 18% storage cost and 1 month production cycle seems to fulfil industry's expectations. The main decision making criteria are highlighted in bold.

Table 1. Results for 1 months, 18% storage cost and 95% Service level

Criterion	Unit	Proposed solution
Safety Inventory	Parcels	30185
Average Inventory	Parcels	55010
Inventory Cost	Euro/ Year	179449
Warehouse Size	M^2	1802
Production Quantity (per month)	Parcels	44983

After selecting the optimum scenario, the CAD of the warehouse layout is created, considering some basic criteria:

a) First-In-First-Out must be served as often as possible so as to limit the possibility for the products to spoil (≥2 columns unless we have access from both sides).
b) The existing space must be used as efficiently as possible.
c) There are two types of pallets: the dimensions of each is either 1,40m*1,40m*0,15m or 1,2m*0,8m*0,15m.
d) Integer number of columns and rows must be used for each code.
e) Stack support must be secured at all times. That means that single columns must not have more than 2 pallets.
f) Warehouse surface must be as small as possible.

The layout has been based in real dimensions taken from the existing warehouse storage area and are used for placing inside these limits the existing and the new warehouse layout. The main disadvantage of the existing layout, which is presented in Figure 2, is that bulky storage areas are created for each product, which prevents from FIFO serving and make products reachability a tough issue. Another disadvantage that makes current layout has is that products are not supported so well.
The proposed layout indicates a new way to store the products (Figure 3). This scenario allows FIFO to be served to a greater extend and offers a better reachability for most of products due to the fact that smaller spaces are created. Moreover, following this layout warehouse achieves higher structural support of the piles and increased functionality.

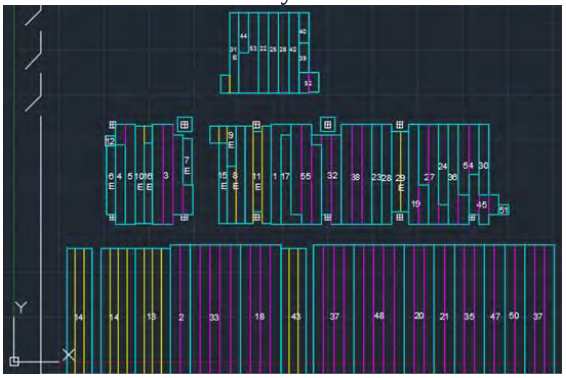

Fig. 2. Existing warehouse layout.

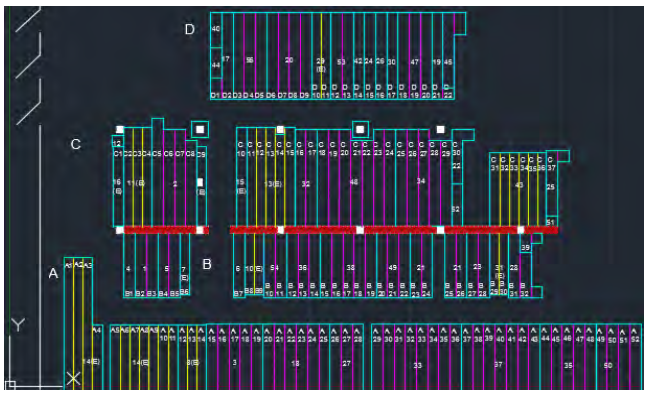

Fig. 3. New warehouse design.

4.2 Warehouse simulation

In our case, in order to as to simulate the warehouse operation and verify the proposed design a simulation tool named Enterprise Dynamics® 10 has been used. The two aforementioned design scenarios (existing and proposed) have been inserted in the simulation tool.

The two models have identical modelling resources: i) 53 different products generated from 53 sources, ii) 3 different queues where all products hold before they pass from the palletizing stations, iii) 3 different assemblers which represent the 3 palletizing stations, iv) 2 different kinds of pallets with two different sources, v) 1 queue after each palletizing station where products wait until the forklift comes and dispatches them to the warehouse, vi) 1 forklift for transporting products, vii) The warehouse area where products are stored, viii) 1 queue for each exit where products hold to leave the warehouse and ix) 3 exits. All of them are properly linked and programmed so as to simulate the real industrial environment. The programming language used is 4D-Script. In Figure 4 a 3D screenshot of the simulation model is presented.

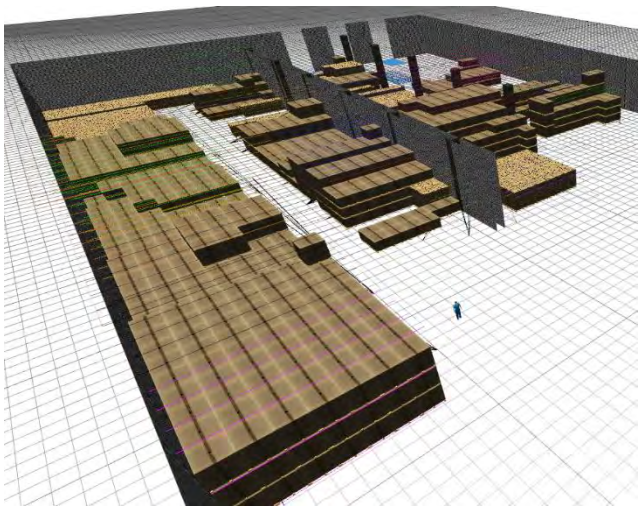

Fig.4. 3D representation of the suggested layout in Enterprise Dynamics.

4.3 Augmented Reality application for inventory management

Together with the new layout design, an application that will support inventory management and warehouse operators' guidance to the position of the product is suggested. Its functionalities are presented in Figure 5. The suggested layout facilitates and also necessitates the integration of the developed AR application, as more storage partitions are created so as to smoothen the transition to the new layout for the operators. To digitalise the process of registering input and output of products, QR codes are placed in the warehouse compartments and each pallet or product. With the new QR code-based system, inventory management is simplified and enables constant awareness of the available stock. Using the developed application, the operators can navigate and act more efficiently whenever a request is sent to the warehouse. The application offers three features: view available stock, find a product in the warehouse and report a new entry.

In the first option, the operator or the warehouse manager may monitor the available stock. A top-down layout of the warehouse is presented, where a compartment may be selected to see what is stored in it. The two other functionalities aim to

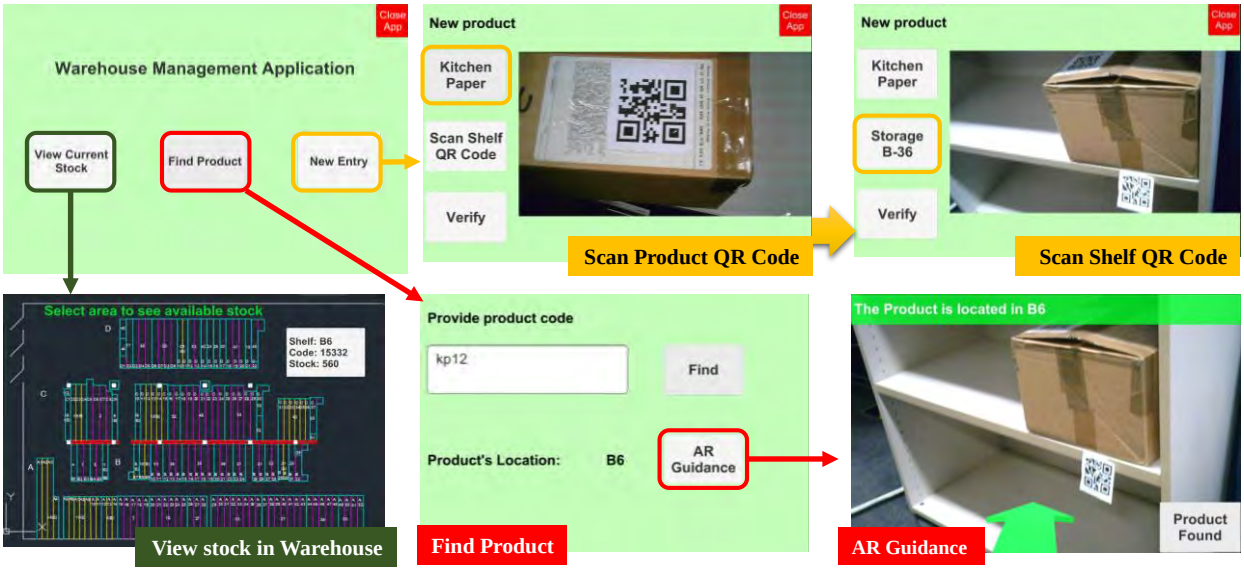

Fig. 5. Augmented reality-based application for warehouse management support.

support product input and output registration. In the case of new product entry to the warehouse, the operator may scan the QR code on the product and on the storage shelf/ compartment so as to quickly register a new product in the warehouse database.

The last functionality helps to retrieve a specific product in the warehouse. As a new warehouse layout is suggested, and also because the operators tend to change what product is stored in each compartment, an Augmented Reality based guidance is introduced. The operator may provide, through the mobile application, a request to retrieve a product's position from the database and be guided to it. Using device's GPS and the corresponding warehouse compartment's position, as stored in the database, the operator is guided to find it. This application may be used by operators, using either handheld equipment or pallet transfer vehicles.

5 Conclusion

To sum up, warehouse design and planning is an ever-existing challenge in manufacturing that highly affects the efficiency of the warehouse. Many solutions have been proposed in the literature but it still seems to be an open issue for research. The developed methodology presents a step-by-step way to design and plan a warehouse which initiates from inventory control and management and is completed with a warehouse simulation so as to verify warehouse design. Additionally, an Augmented Reality based mobile application is introduced. The application aims to facilitate warehouse management, supporting efficient navigation and product retrieval, which could be extended to logistics warehouse, where there the product stock is constantly changing, thus finding it becomes more difficult for the operators.

For future work, a more throughout analysis of the fluctuating customer demand will be performed, in order to improve the design of the stock levels. Moreover, lost sales cost analysis due to low inventory level and the cost from the unpredictable changing of the production line in order to serve some large orders. Additionally, the developed Augmented Reality application will be extended to other warehouse management use cases.

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In-situ analysis of polyelectrolyte complexes by flow cytometry

Anders Strand. Lari Vãhãsalo. Annika Ketola. Kristian Salminen. Elias Retulainen. Anna Sundberg.

Polyelectrolyte complexes (PECs) from common papermaking additives were prepared at different cation/anion ratios, resulting in colloidal light scattering particles. The polycations were cationic starches and polyDADMACs, while the polyanions were different carboxymethyl celluloses. The PECs were studied by turbidity measurements, as well as by flow cytometry (FCM). Turbidity maxima were detected close to the theoretical neutralization point of the polycation and polyanion. The turbidity response of the PEC mixtures varied with polyelectrolyte charge density. The PECs were in most cases quite stable over 24 h, but certain combinations resulted in unstable particles over time. Flow cytometry of PECs revealed clear populations of hydrophilic particles. The light scattering properties of PECs in side direction (SSC) and forward direction (FSC) were recorded for the different PEC combinations. The determined FSC and SSC offered information about very different PEC properties, and a new term was suggested for better understanding the mechanisms behind PEC formation; FSC/SSC. It was suggested that the determined FSC/SSC values were connected to the structural density of different particles. The premise was tested by analyses of solid, dense particles as well as swollen, soft particles. In addition to this, the hydrophobicity of PECs was determined by FCM. It was seen that the PECs were quite hydrophilic overall and that the measured hydrophobicities were lowest around the theoretical point of neutralization. Finally, the behavior of a coagulating PEC mixture as a function of contact time was studied with FCM.

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ORIGINAL PAPER

In-situ analysis of polyelectrolyte complexes by flow cytometry

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Abstract Polyelectrolyte complexes (PECs) from common papermaking additives were prepared at different cation/anion ratios, resulting in colloidal light scattering particles. The polycations were cationic starches and polyDADMACs, while the polyanions were different carboxymethyl celluloses. The PECs were studied by turbidity measurements, as well as by flow cytometry (FCM). Turbidity maxima were detected close to the theoretical neutralization point of the polycation and polyanion. The turbidity response of the PEC mixtures varied with polyelectrolyte charge density. The PECs were in most cases quite stable over 24 h, but certain combinations resulted in unstable particles over time. Flow cytometry of PECs revealed clear populations of hydrophilic particles. The light scattering properties of PECs in side direction (SSC) and forward direction (FSC) were recorded for the different PEC combinations. The determined FSC and SSC offered information about very different PEC properties, and a new term was suggested for better understanding the mechanisms behind PEC formation; FSC/SSC. It was suggested that the determined FSC/SSC values were connected to the structural density of different particles. The premise was tested by analyses of solid, dense particles as well as swollen, soft particles. In addition to this, the hydrophobicity of PECs was determined by FCM. It was seen that the PECs were quite hydrophilic overall and that the measured hydrophobicities were lowest around the theoretical point of neutralization. Finally, the behavior of a coagulating PEC mixture as a function of contact time was studied with FCM.

Keywords Polyelectrolyte complex · Cationic starch · CMC · Flow cytometry · Light scattering · Hydrophobicity · Structural density

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Introduction

Lately, materials research has focused more and more on multi-composites. The potential of combining two or more desirable properties by tailoring the material

opens up a vast array of new possibilities (Decher 1997; de Vasconcelos et al. 2006). The use of polyelectrolyte complexes (PECs), or polyelectrolyte multilayers (PEMs) have received quite a lot of attention in the field of research (Philipp et al. 1989; Dautzenberg 1997; Decher 1997; Dautzenberg and Karibyants 1999). Multi-layered structures on surfaces can be formed from a wide variety of components, either from solutions or dispersions.

The most common approach for PEC or PEM formation is the electrostatic attraction between oppositely charged groups. The formation of PECs is driven by the increase in entropy when counter ions are liberated from the oppositely charged polyelectrolytes during associative phase separation into colloidal particles (Piculell and Lindman 1992; Kekkonen et al. 2001). Strong ionic binding between the opposite charges of the polyelectrolytes results in kinetically frozen structures (Dautzenberg and Karibyants 1999). It has been reported that the core of PEC particles consists of a neutralized polyelectrolyte core, while the outer shell consists mainly of excess polyelectrolyte, which stabilizes the colloids against aggregation (Dautzenberg and Karibyants 1999).

The use of PECs and PEMs have also found their way into the field of pulping and papermaking (Petzold and Lunkwitz 1995; Petzold et al. 1996; Gernandt et al. 2003; Hubbe et al. 2003, 2005; Gärdlund et al. 2005; Lofton et al. 2005; Torgnysdotter and Wågberg 2006; Myllytie et al. 2009; Renneckar and Zhou 2009; Lin and Renneckar 2011; Granberg et al. 2012; Ankerfors and Wågberg 2013; Marais et al. 2014). The use of PECs and PEMs in papermaking is somewhat expected, since the properties of paper and retention of fillers commonly have been tailored by additions of polyelectrolytes, in single or dual systems, for a long time (Hubbe 2006). Additionally, surfaces of pulp fibers carry anionic charges that are convenient anchor points for polyelectrolytes and PECs. In papermaking applications, the size of the PECs can be tailored to exceed the average pore radius of pulp fibers, to ensure that the PECs are retained mainly on fiber surfaces. In papermaking, surface-specific strengthening agents are especially interesting, since the additive should be adsorbed within the cross-over region of two fibers in order to enhance paper strength (Stratton 1989).

The properties and behavior of PECs in suspension has previously been studied by measurements of turbidity, static light scattering, dynamic light scattering, polyelectrolyte titration, viscosity, surface charge analysis, FTIR spectroscopy, and electrophoretic mobility (Buchhammer et al. 1995; Dautzenberg 1997; Dautzenberg and Karibyants 1999; Dragan and Cristea 2001; Kekkonen et al. 2001; Hubbe et al. 2005; de Vasconcelos et al. 2006). It has been reported that the formation of PECs is sensitive towards the nature of the cationic polyelectrolyte (Hubbe et al. 2005). It is known that the formation of PECs is path dependent, which means that all aspects of the PEC formation will influence the result (Kötz 1993; Feng et al. 2008). Due to the wide variety of available polyelectrolytes, additional information about their interactions and the complexes they form is still needed.

Adsorption experiments and modeling have been used to gain information about formed layers of polyelectrolytes (Van de Steeg et al. 1992; Fleer et al. 1993). Adsorption studies using QCM-D and SPR techniques have revealed that polyelectrolytes adsorb differently depending on their chemical properties, such as molar mass and charge density, onto model cellulose or silica surfaces (Tammelin et al. 2004; Kontturi et al. 2008; Strand et al. 2017). A polyelectrolyte with a high charge density will adsorb as a stiffer and more rigid layer, compared to a polyelectrolyte with a low charge density (Kontturi et al. 2008). The charge density of the surface itself in adsorption studies is also of great importance, which was shown by adsorption experiments onto cellulose and silica surfaces. While the QCM-D and SPR methods provide information about adsorption of polyelectrolytes onto surfaces, the behavior of unretained polycations and polyanions is an open question. An analysis method that could bridge the gap between the previously used analyses for PECs and the techniques used in adsorption studies would be helpful for gaining additional insight into the behavior of polyelectrolyte mixtures.

Flow cytometry (FCM) is a relatively new technique in the field of pulping and papermaking. The technique was adapted from medical science, where it is used mainly for the counting of cells (Shapiro 2003). FCM also measures the light scattering properties of particles in suspension in forward and side direction. Further, FCM can be used to measure the fluorescence of particles at different wavelengths, which is very useful when combined with addition of selective dyes to samples. In the field of pulping and papermaking,

FCM has so far been used to analyze colloidal wood pitch, bacteria, coated broke, precipitated oxalate, and filler particles (Vähäsalo et al. 2003; Lindberg et al. 2004; Vähäsalo and Holmbom 2005; Strand et al. 2013; Häärä et al. 2014). With FCM techniques, it is possible to analyze particles in suspension directly without complicated pre-treatments. The strengths of the FCM technique are short analysis times, as well as insight into the behavior and interactions of particle populations in aqueous suspension.

The aim of this work was to gain additional knowledge about PECs formed from commonly used papermaking additives, by analysis with flow cytometry. The light scattering properties of these particles might reveal important information about their properties and structure. The additives chosen for the study were different cationic starches, polyDADMAC and carboxymethyl cellulose (CMC). Cationic starches are the most commonly used additive in papermaking (Fornue et al. 2011). Studies have shown that CMC greatly increases both the strength and stiffness of paper, which makes it a very interesting papermaking additive (Beghello et al. 1997; Strand et al. 2017). An additional aim of this work was to determine the hydrophobicity of PECs, and to study the time dependent stability of different PEC mixtures, since contact times between polyelectrolytes in papermaking can vary between fractions of a second to several hours.

Materials and methods

Materials

Three different cationic starches were received from Chemigate as pre-boiled slurries; Raifix 01015 SW, Raifix 25035, and Raisabond 15. The cationic starch slurries were diluted with distilled water to 0.1% solutions under agitation. Sodium carboxymethyl cellulose (CMC), M_w 700 kDa and DS 0.80–0.95, was obtained from Aldrich as dry powder. Additionally, three 250 kDa CMCs of varying DS were obtained from Acros Organics as dry powders. The different CMCs were dissolved in distilled water to a concentration of 0.1% with the aid of agitation and boiling, until clearly dissolved. Two different polydiallyldimethylammonium chloride (PolyDADMAC) solutions were obtained from Aldrich. The polyDADMACs were received as viscous solutions with dry contents of about 26% and molar masses of 100–200 and 200–350 kDa, respectively. The polyDADMAC was diluted with distilled water to a concentration of 0.1% under agitation. Poly(vinyl sulfate) potassium salt (KPVS) was obtained from Wako. The KPVS salt was dissolved in deionized water under agitation. Hexadimethrine bromide (polybrene) was obtained from Sigma. The polybrene was dissolved in deionized water under agitation. Nile red was obtained in dry form from from Sigma-Aldrich, USA. The Nile red was dissolved in methanol to a concentration of 10 ppm.

A variety of commercially available mineral particles was obtained. Prismatic precipitated calcium carbonate (PCC p) was obtained from Specialty Minerals, New York, USA, as a slurry, which was diluted with pH-adjusted distilled water (pH 8). Scalenohedral precipitated calcium carbonate (PCC s) was obtained from Specialty Minerals Nordic, Anjalankoski, Finland as a slurry, which was diluted with pH-adjusted distilled water (pH 8). Commercially available ground calcium carbonate (GCC) was obtained as a slurry, and was diluted with distilled water. Kaolin was obtained from Imerys Minerals, Par Cornwall, UK, in powder form and was dispersed in distilled water. Three different grades of commercially available bentonites were obtained from Clariant Produkte, Germany, and dispersed in distilled water. Cellulose nanocrystals (CNC) were prepared by H_2SO_4 hydrolysis of birch kraft pulp, with subsequent purification steps (Beck-Candanedo et al. 2005). Cellulose nanofibrils (CNF) were produced by TEMPO oxidation of birch kraft pulp followed by mechanical defibration (Shibata and Isogai 2003).

Methods

Charge titration

The anionic or cationic charge of the different polyelectrolytes was analyzed by polyelectrolyte titration with a particle charge detector (Mütek PCD 03, Mütek Analytic GmbH, Germany; BTG, Switzerland) coupled to a titration device (736 GP Titrino, Metrohm Ltd., Switzerland). The cationic polyelectrolytes were titrated with KPVS, and the anionic polyelectrolytes were titrated with polybrene with an M_w of approximately 8 kDa (Sundberg et al. 2000).

The amount of titrant needed for charge neutralization was used to calculate the total charge of the analyzed polyelectrolyte (Tables 1 and 2).

Formation of polyelectrolyte complexes

Different volumes of 0.1% polycation solution were pipetted into glass bottles. A fixed volume of 0.1% polyanion solution was pipetted into the polycation solution under vigorous magnetic stirring. To simplify and standardize the procedure, the polyanion was always added to the polycation. Polyelectrolyte complexes (PECs) started forming immediately when the polyanion came in contact with the polycation, which was evident as increasing opacity of the mixture upon visual inspection. The PEC mixtures were diluted to a total volume of 30 mL with distilled water within a few seconds of contact time, prior to analyses. All experiments were performed at room temperature.

Turbidity measurements

The initial turbidity of the PEC mixture was analyzed within 1 min after PEC formation using a turbimeter (Hach 2100AN IS, ISO 7027) equipped with a LED light source (870 ± 30 nm). In order to assess the long-term stability of the PECs, the mixture was stored in closed glass bottles at room temperature for 24 h before the turbidity was measured again using the same device. The mixtures were stirred for a short time prior to the turbidity measurements.

Flow cytometry

Flow cytometry (FCM) was used to analyze the PEC mixtures, using a Partec CyFlow Blue apparatus, equipped with a blue Argon laser (488 nm). The light scattered by the PEC particles were recorded in forward direction (FSC) and side direction (SSC, 90°). The apparatus was also equipped with three different fluorescence channels, which recorded the scattering intensity in the green (512–542 nm), orange (575–605 nm), and red (615–645 nm) spectra. Filtered distilled water was used as sheath fluid in the analyses. Nile red (Tamro, Vantaa, Finland) was used as a fluorescent dye to stain the particles prior to FCM analysis, as in previously published studies (Vähäsalo et al. 2003; Vähäsalo and Holmbom 2005; Strand et al. 2013). Nile red is an environment-sensitive fluorophore that exhibits a blue-shift proportional to the hydrophobicity of its environment (Greenspan and Fowler 1985). It was expected that the added Nile red mainly stained the surface of the PEC particles, since the migration of Nile red into the PECs, and the solubility of Nile red in water, are both negligible effects.

PEC samples were diluted 3–100 times with filtered distilled water prior to FCM analysis, depending on the concentration of particles in the sample. Methanol solution of Nile red (10 ppm) was added to stain the PEC particles, and the fluorescence intensity in the red spectrum was used as an indicator of particle hydrophobicity. FCM analysis was used to count the number of particles in the sample, and group the particles together as populations based on their recorded light scattering properties. Particle populations were gated using Partec FloMax software, in order to calculate the average scattering of particles in side and forward direction, as well as particle hydrophobicity (Vähäsalo et al. 2003).

Results and discussions

Turbidity measurements

Solutions of polycations were mixed together with solutions of polyanions, forming nearly clear solutions or turbid suspensions depending on the cation/anion ratio (Fig. 1). The increase in turbidity was caused by

Table 1 Properties of the polycations used in the experimental series

Polycation	Charge density [μeq/g]	Molar mass [kDa]	Source
Raifix 01015 SW	+ 831	Low	Waxy maize
Raisabond 15	+ 882	Medium	Potato
Raifix 25035	+ 1870	Medium	Potato
PolyDADMAC	+ 3978	100–200	–
PolyDADMAC	+ 4949	200–350	–

Table 2 Properties of the polyanions used in the experimental series

Polyanion	Charge density [μeq/g]	Molar mass [kDa]
CMC, Aldrich, DS 0.80–0.95	− 4176	700
CMC, Acros Organics, DS 0.7	− 3351	250
CMC, Acros Organics, DS 0.9	− 3892	250
CMC, Acros Organics, DS 1.2	− 4513	250

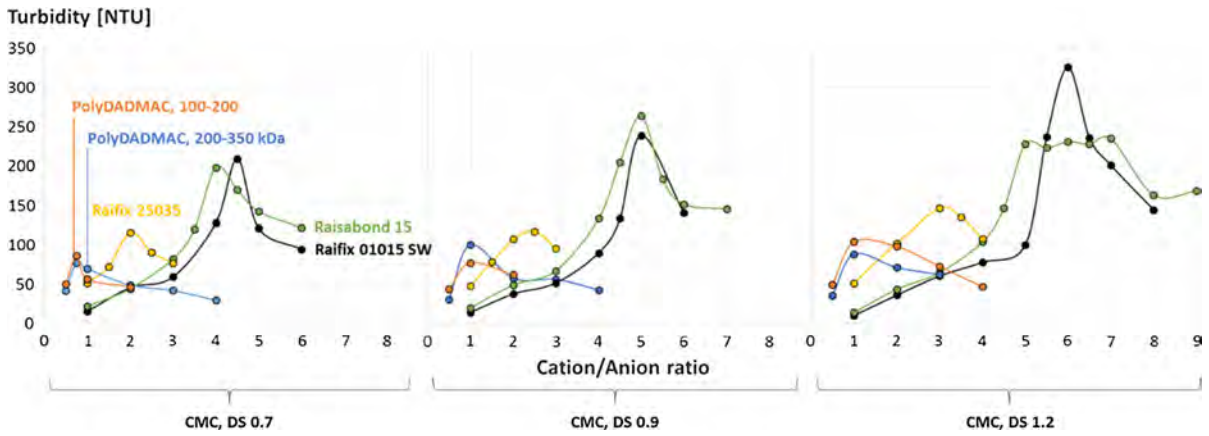

Fig. 1 The measured turbidity values of polyelectrolyte complexes (PECs) of polyDADMACs or different cationic starches with CMCs (250 kDa) of DS 0.7, 0.9, and 1.2. The presented turbidity values were determined within 1 min of PEC formation

associative phase separation of the oppositely charged polyelectrolytes into colloidal particles (Piculell and Lindman 1992; Kekkonen et al. 2001). The turbidity increased up to cation/anion ratios close to the theoretical neutralization point of the polyelectrolytes, and decreased after this ratio was exceeded. The calculated theoretical neutralization points between the different polyelectrolytes are presented in Table 3. In order to illustrate that the turbidity maxima were connected to charge neutralization, the polycations were mixed together with CMCs of different charge density, or degree of substitution (DS). Using a CMC with higher charge density shifted theoretical point of neutralization towards higher cation/anion ratios, since a larger amount of polycation was needed in order to neutralize the anionic charge. The turbidity curves in these experiments were similar to previously published results using other polyelectrolytes (Dragan and Cristea 2001; Hubbe et al. 2005; Lofton et al. 2005).

It has been shown that PECs coexist with dissolved polyelectrolyte species at cation/anion ratios above and below the direct vicinity of the neutralization point (Kekkonen et al. 2001). However, PEC mixtures close to the neutralization point only contain low residual amounts of dissolved polyelectrolytes. Excess

Table 3 Theoretical cation/anion ratio for charge neutralization

	CMC DS 0.7, 250 kDa	CMC DS 0.9, 250 kDa	CMC DS 1.2, 250 kDa	CMC DS 0.8–0.95, 700 kDa
PolyDADMAC 200–350	0.7	0.8	0.9	0.8
PolyDADMAC 100–200	0.8	1.0	1.2	1.0
Raifix 25035	1.8	2.1	2.4	2.2
Raisabond 15	3.8	4.4	5.1	4.7
Raifix 01015 SW	4.2	4.7	5.4	5.0

of one of either anionic or cation polyelectrolyte results in a stabilizing shell around a neutralized polyelectrolyte core (Dautzenberg and Karibyants 1999). The PEC particles carry either negative or positive net charge due to the cation/anion ratio of the mixture. Measurements have shown that the sign of the PEC particles charge changes sharply within a quite narrow cation/anion ratio (Kekkonen et al. 2001).

The maximum turbidity for these mixtures appear close to the theoretical neutralization point, but not necessarily precisely on the neutralization point. Similar observations have been reported earlier in several studies (Chen et al. 2003). It was reported that a slight excess of polyDADMAC was needed to completely neutralize the polyanion used (Kekkonen et al. 2001). Similarly, it was reported that the near-zero electrophoretic mobility of PECs from polyDADMAC and CMC was achieved at a ratio of 8:10 of cationic to anionic groups (Hubbe et al. 2005). Deviations from a 1:1 when using irregularly branched polyelectrolytes are quite common (Kötz 1993). This was noticeable in the determined turbidity values when cationic starches Raifix 01015 SW and Raisabond 15, which both contain a high amount of branched amylopectin, were mixed together with the different CMC grades (Fig. 1). Steric factors, differences in chain lengths, and differences charge densities have previously been used to explain deviations from 1:1 stoichiometric neutralization points between polyelectrolytes of opposite charge (Philipp et al. 1989; Buchhammer et al. 1995; Kekkonen et al. 2001). It has previously been reported that the maximum turbidity decreases with increasing molar mass of the polyelectrolyte (Hubbe et al. 2005). This correlation was not apparent in these experiments, but instead it was noted that the maximum turbidity depended on the charge density of the cationic polyelectrolyte, when the amount of anionic charges were kept constant in all trial points.

Long-term stability of PECs

The long-term stability of PEC mixtures was evaluated by turbidity measurements 24 h after PEC formation. The measured turbidity values after 24 h were lower than the previously measured values for almost all of the tested PEC combinations (Fig. 2). Only small changes in turbidity were expected for PEC mixtures that contained an excess of either polycation or polyanion, due to electrostatic stabilization of the particles. It is known that the PEC particles consist of a core of neutralized polyelectrolytes, and an outer shell is formed from the polyelectrolyte in excess (Dautzenberg and Karibyants 1999). It was clear that some changes occurred in the PEC particles over time, and that these changes were most likely an effect of secondary aggregation of particles. Decreases and increases in turbidity over time have previously been reported for other PEC mixtures (Hubbe et al. 2005). Others have reported colloidally stable PECs over time periods of 48 h, and in some cases even 2 months (Gernandt et al. 2003).

However, some very noticeable decreases in turbidity took place at certain cation/anion ratios. Combinations of Raifix 01015 SW with the different CMCs resulted in unstable PEC mixtures at cation/anion ratios close to the theoretical point of neutralization. In these experiments, Raifix 01015 SW was the only tested cationic starch produced from waxy maize, i.e. it consisted approximately of 98% branched amylopectin, unlike the other cationic starches from potato (Fredriksson et al. 1998). This low-molar mass and branched structure seemed to form unstable aggregates effectively, given enough time. Also a 5.5:1 ratio of Raisabond 15 and DS 1.2 CMC also resulted in unstable aggregates over time, i.e. once again close to the theoretical point of neutralization. An incomplete, and less noticeable turbidity decrease was seen for Raisabond 15 with DS 0.7 CMC at the ratio of 4:1, which also was close to the theoretical neutralization point at 3.8.

Flow cytometry

Polyanion was mixed together with polycations under agitation. The PECs were diluted, a small amount of staining agent for hydrophobic components (Nile red) was added, and the mixture was analyzed by flow cytometry. The Argon laser in the FCM instrument scanned the PECs. The light scattered by each colloidal particle was recorded in the forward direction (FSC), side direction (SSC), and in the red spectra. The different light scattering properties of the PEC particles were plotted against each other, in order to create particle populations in FCM density plots. The PEC particle populations were quite visible when FSC was plotted versus SSC, as illustrated in Fig. 3a of a

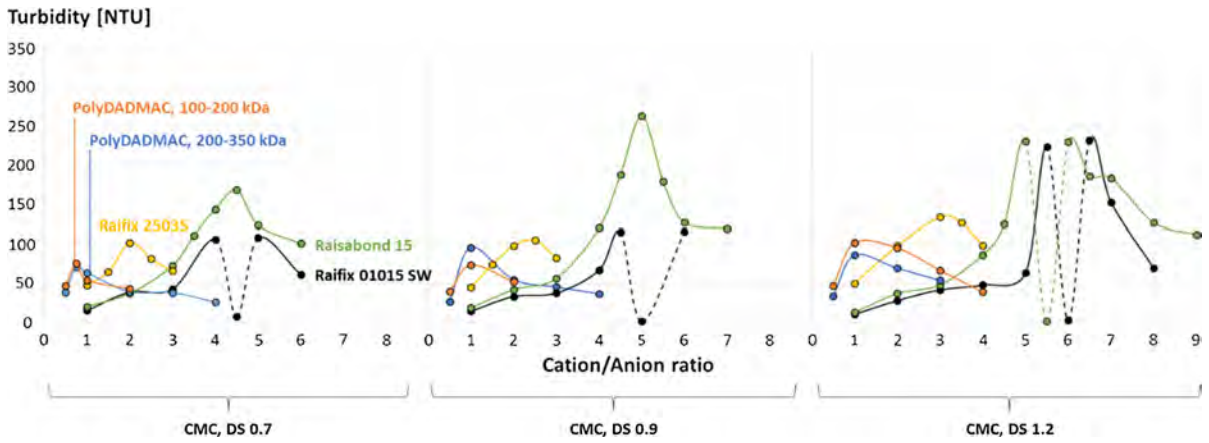

Fig. 2 The measured turbidity values of polyelectrolyte complexes (PECs) of polyDADMACs or different cationic starches with CMCs (250 kDa) of DS 0.7, 0.9, and 1.2. The presented turbidity values were determined after 24 h of PEC formation

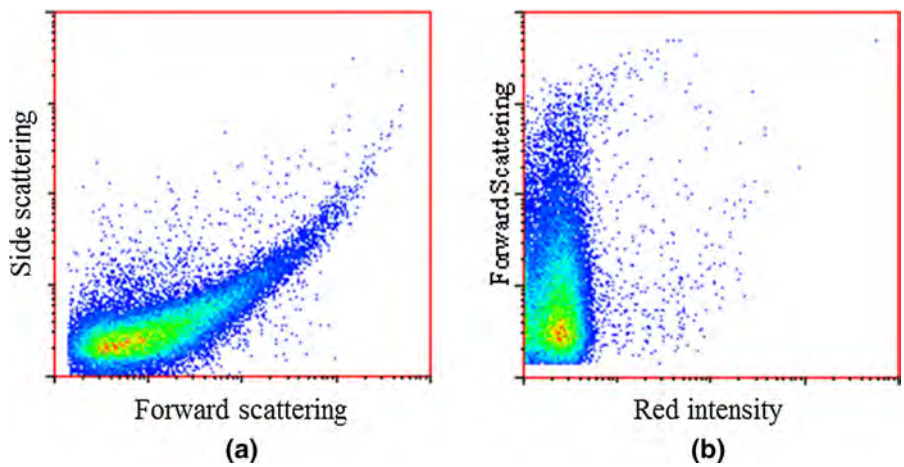

Fig. 3 Two logarithmic flow cytometry dot plots of PECs in aqueous media, using a mixture of polyDADMAC (100–200 kDa) + CMC (250 kDa, DS 0.9) with a cation/anion ratio of 0.5:1. The properties of the measured particles are plotted as **a** their side scattering (SSC) versus forward scattering (FSC), and **b** their FSC versus intensity in the red spectrum (hydrophobicity)

0.5:1 mixture of polyDADMAC (100–200 kDa) with CMC (250 kDa, DS 0.9).

The colloidal PEC particles interacted with the added hydrophobic dye, which was seen in the recorded intensities of the particles in the red spectra (Fig. 3b). The added Nile red was most likely adsorbed on the surface of the PECs. Nile red is an environment-sensitive fluorophore, which is almost non-fluorescent in hydrophilic environments, while it undergoes a fluorescent enhancement and large absorption and blue shifts in hydrophobic environments. The fluorescence in the red spectrum has commonly been used as a measurement of particle hydrophobicity (Vähäsalo et al. 2003; Strand et al. 2013). The PECs were quite hydrophilic; the low intensities of the PEC particles in the red spectra indicated that the particles were hydrophilic, even though the chemical environment could activate the hydrophobic dye to some extent. A hydrophilic nature of the PECs was very much suspected, since these consist of kinetically frozen structures of polyelectrolytes that were previously soluble in water (Dautzenberg and Karibyants 1999).

Particle count

PECs of polyDADMAC or three different commercially available cationic starches with CMC of 250 and 700 kDa were prepared at different cation/anion ratios. Noticeable variations in the number of particles per µL was seen when 250 kDa CMC was used as polyanion, while the particle count remained more stable when 700 kDa CMC was used (Fig. 4a, b). Adsorption experiments have previously shown that

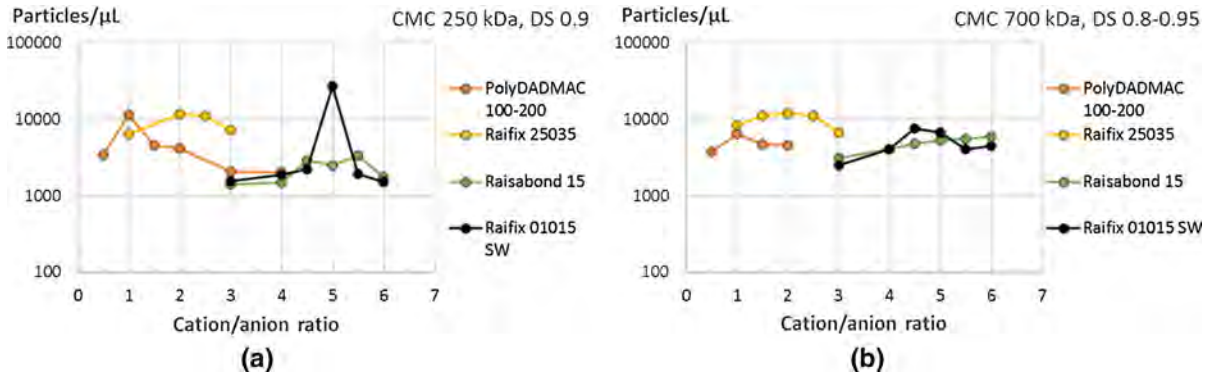

Fig. 4 Number of particles per µL versus cation/anion ratio, for combinations of different polycations with **a** 250 kDa and **b** 700 kDa CMC

increasing the molar mass of cationic starch results in a larger hydrodynamic thickness of the adsorbed layer on quartz surfaces (Tammelin et al. 2004). The M_w of PEC particles have previously been shown to increase with increasing molar mass of the used polyDADMAC (Dautzenberg 2000). It would be expected that increasing the molar mass of CMC in these experiments also would lead to thicker, more compact particles in suspension.

It is important to remember that particles smaller than 0.1 µm were not analyzed in the FCM measurements, and are not included in the results. This phenomenon is highlighted when combining Raifix 01015 SW with 250 kDa CMC at a cation/anion ratio of 5:1, which resulted in a coagulating combination of polyelectrolytes (Fig. 4a). Close to the neutralization point, the large number of particles below the detection limit were suddenly elevated into the detection range of the FCM, which resulted in a large spike in particles per µL.

Light scattering properties

PEC mixtures were analyzed by flow cytometry at different cation/anion ratios. The scattering of light in side direction (SSC), and scattering of light in forward direction (FSC) was recorded for the particles. Average values were calculated for the different PEC populations, and these values were plotted as a function of cation/anion ratio. Mixing together polyDADMAC with CMC resulted in PEC particles with quite high SSC values (Fig. 5a). The SSC of particles consisting of cationic starches and CMC were considerably lower at all measured cation/anion ratios. Overall, the changes in the determined SSC values were quite small as function of cation/anion ratio for all of these PEC mixtures.

Larger and more noticeable changes took place in the average light scattered in forward direction (FSC) of the PEC mixtures. The FSC of PECs formed from polyDADMAC and CMC decreased dramatically as the cation/anion ratio increased between 0.5 and 2, even though this type of behavior was not reflected in the determined SSC values (Fig. 5b). The FSC for PECs formed from Raifix 25035 and CMC also decreased noticeably after the theoretical neutralization point. The FSC of PECs from Raisabond 15 and Raifix 01015 SW were overall significantly higher than for the other mixtures. Large differences in the FSC values as a function of cation/anion ratio, that were not reflected in the SSC values, indicated that FSC and SSC were connected to very different properties of the PEC particles. Available explanations from medical science about FCM of cells may be useful for understanding the scattered light in different directions of these PEC particles.

In medical science, SSC is commonly used as an indicator of the granularity of cells, i.e. the amount of granular components within a cell that are able to scatter light in the side direction (Shapiro 2003). Therefore, SSC is not a direct measurement of particle size, but can be used to distinguish cell types from each other. Degranulation of cells and membrane ruffling following activation are known to decrease the SSC of cells. On the other hand, FSC is commonly used as an indicator of cell size, but is not a direct measurement of cell size (Shapiro 2003). It is known that many factors influence the FSC of a cell, such as

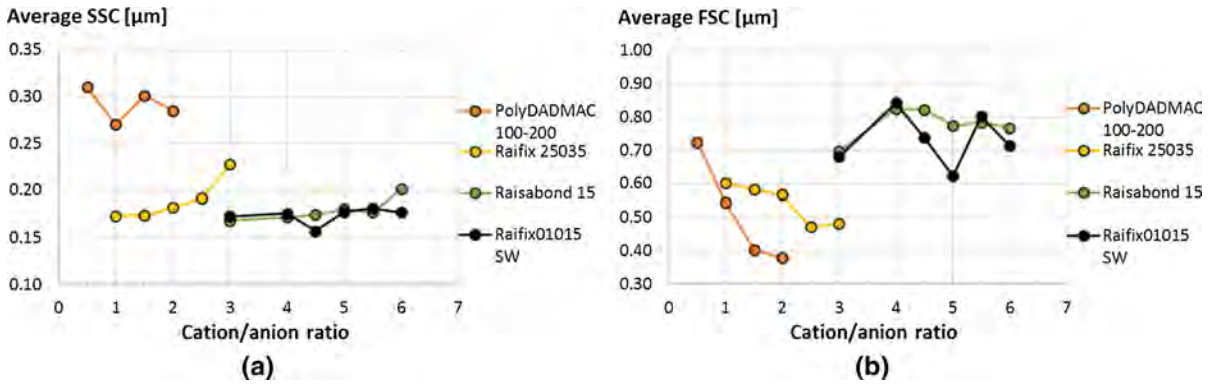

Fig. 5 Average **a** side scattering and **b** forward scattering of PEC particle populations at different cation/anion ratios of polycations with 700 kDa CMC and DS 0.8–0.95

the wavelength of the incoming light, the precise angle that the light is collected, the internal structure of the cells, the presence of strongly absorbing materials within the cell, and refractive index of the cell. It has been shown that osmotic swelling of cells, as well as damages from freezing and thawing of cells will lower their measured FSC. Especially interesting is the fact that changes in lipid packing within a cell can affect the FSC, without changes in cell volumes. It has also been reported that highly textured surfaces or internal structures lower the FSC of a cell.

With the explanations of FCM data from medical science, it is clear that SSC and FSC give information about very different properties of the PEC particles. The SSC of a particle gives information about the amount of dense and light scattering surfaces. The FSC of a particle gives information about the transparency of a particle, as well as the complexity of its external or internal texture. The light scattering in both side and forward direction are still connected to particle size, even though the dependence is indirect. An attempt to diminish the influence of particle size by combining the SSC and FSC of PEC particles into one single term, in the form of FSC/SSC values, gave new correlations.

The FSC/SSC values of PECs formed from polyDADMAC and CMC at low cation/anion ratio was 2.4, but decreased to about 1.1 with increasing cation/anion ratio (Fig. 6). The size estimation of these PEC particles from SSC and FSC were almost the same at the highest examined cation/anion ratio. The FSC/SSC of PECs from Raifix 25035 and CMC were slightly higher at low cation/anion ratio, but also decreased after the theoretical neutralization point was

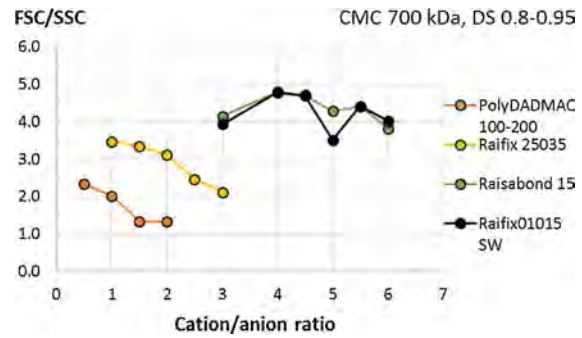

Fig. 6 Determined FSC/SSC values of particle populations from different cation/anion ratios of polycations with 700 kDa CMC

exceeded. The FSC/SSC values of PECs formed from Raifix 01015 SW or Raisabond 15 with CMC were higher throughout the studied cation/anion interval, yet similar to each other. PolyDADMAC, with a charge density of about 4 meq/g, gave lower FSC/SSC values than Raifix 25035 (1.9 meq/g), which in its turn gave lower values than Raifix 01015 SW and Raisabond 15 (0.8 and 0.9 meq/g, respectively). The results indicated that the FSC/SSC values decreased with increasing charge density of the polycation, while the properties of the polyanion was kept constant. Furthermore, the results indicated that for most combinations the FSC/SSC values seemed to decrease after the theoretical point of neutralization.

In order to understand these results, available literature about the adsorption behavior of polyelectrolytes onto model surfaces need to be considered, since the interactions between two dissolved polyelectrolytes may exhibit similar mechanisms.

Adsorption experiments with QCM-D have previously shown that polyelectrolytes adsorb differently onto model surfaces depending on their charge density and molar mass (Tammelin et al. 2004; Kontturi et al. 2008). Adsorbed polyelectrolyte layers consist of the polymer, electrolyte (if present), and solvent that is imbibed inside the layer (Kontturi et al. 2008). The amount of water moving with the polyelectrolyte can be quite substantial, if the polyelectrolyte forms extended loops, trains, or tails. It was previously shown that adsorbed layers of CMC and these cationic starches onto nanocellulose surfaces contained between 52 and 66% of coupled water by weight at adsorption equilibrium (Strand et al. 2017). Cationic starches with high DS onto cellulose surfaces results in a significantly more rigid layer, compared to cationic starches with a low DS, because polyelectrolytes with high DS are more strongly attracted to surfaces of opposite charge.

There are some similarities between adsorption of polyelectrolytes onto model surfaces and the creation of PECs, since both are driven by attraction of oppositely charged groups. Instead of adsorbing the polyelectrolyte onto an existing surface, it is adsorbed onto another polyelectrolyte in order to create a completely new colloidal phase. The FCM results indicate that similar rules apply in the formation of PECs as in the adsorption studies; A polyelectrolyte with higher charge density will have higher affinity to the oppositely charged polyelectrolyte, creating a more dense structure. In these experiments, both polyDADAMAC and CMC consisted of linear and highly charged polyelectrolyte chains, that resulted in FSC/SSC values as low as 1.1. The dense PEC structure was able to scatter light more effectively in SSC, and the increasing complexity of the particle structure caused less effective light scattering in FSC. A determined FSC/SSC value approaching 1.0 indicated that quite dense PEC particles were formed. It has previously been reported that higher structure density of PECs was obtained when CMC of DS 1.3 was mixed with amine-epichlorhydrin resin (PAE), compared to when CMC of DS 0.7 was used (Gernandt et al. 2003). Different models for explaining the degree of PEC particle swelling/density as a function of polyelectrolyte chain length and charge density have been theorized upon, and it was shown that the density of the PEC core is influenced by polyelectrolyte charge density (Dautzenberg 1997; Mende et al. 2002).

In mixtures of cationic starches and CMC, the FSC/SSC values indicated that the PECs were less dense than the PECs formed with polyDADMAC (Fig. 6). The determined FSC/SSC values increased with decreasing charge density of the polycations, indicating that less dense PECs were formed with the cationic starches of lower charge density. It has been reported that large differences in charge density between the polycation and polyanion may lead to less dense, and more swollen PEC structures (Dautzenberg 1997). The cationic starches originated either from potato or waxy maize, that contain about 77 and 98% of branched amylopectin respectively (Fredriksson et al. 1998). Less well-ordered packing of the cationic starches in the PEC particles would be expected, compared with the linear and highly charged polyDADMAC.

FCM analysis of various particle types was performed in order to gain more insight about FSC/SSC values. The available particles were kaolin, scalenohedral and prismatic precipitated calcium carbonates (PCC s, PCC p), ground calcium carbonate (GCC), three different bentonites, cellulose nanocrystals (CNC), and cellulose nanofibrils (CNF). The FCM analyses were performed in similar fashion, and the calculations were performed in the same way as for the PECs. Theoretically, solid particles should have FSC/SSC values close to 1.0 in the FCM setup. This was seen for both of the PCC particle types, GCC, and kaolin (Table 4). The bentonites, which are known to swell in water, had FSC/SSC values between 2.8 and 4.6. The FSC/SSC of cellulose nanocrystals, which are known to be dense and crystalline cellulose particles,

Table 4 Determined FSC/SSC values for a variety of different inorganic and organic particles analyzed by FCM

Particle type	FSC/SSC
PCC p	1.0
PCC s	1.1
GCC	1.3
Kaolin	1.4
Bentonite A	2.8
Bentonite B	3.2
Bentonite C	4.6
CNC	1.4
CNF	6.6
PECs	1.1–8.7

The reported FSC/SSC values are not absolute for each particle type, and may vary with various particle properties to some extent

was low. The FSC/SSC of cellulose nanofibrils, which are known to be very swollen in water, was 6.6. The obtained results indicated that the determined FSC/SSC values could in fact be connected to particle density or swelling. By mixing together different types of polyelectrolytes into PECs, FSC/SSC values of 1.1–8.7 have so far been obtained, indicating that the choice of polyelectrolytes and the ratio between them will results in very different populations of PEC particles.

The hydrophobicity of PEC particles was determined by FCM analyses with the added hydrophobic staining agent Nile red. A small volume of Nile red dissolved in methanol was added to the different water samples. It was expected that the added Nile red mainly adsorbed onto the surface of the different PEC particles, since the solubility of Nile red in water is negligible and the migration of Nile red into the PECs is unlikely (Greenspan and Fowler 1985; Jose and Burgess 2006). Once activated, Nile red emitted fluorescent light that was detected in the red spectra of the FCM apparatus. The PEC particles interacted and activated the added Nile red, but the detected red intensities were quite low, which indicated that the PECs were ultimately hydrophilic in nature (Fig. 7). The average hydrophobicity of the PEC particles were of the same size range for all of the measured polyelectrolyte combinations at different cation/anion ratios. The average hydrophobicity of the PECs was lowest around the theoretical point of neutralization for all of the PEC combinations, and increased once this cation/anion ratio was exceeded. The results showed that the added Nile red was activated to a lesser extent close to the neutralization points, which

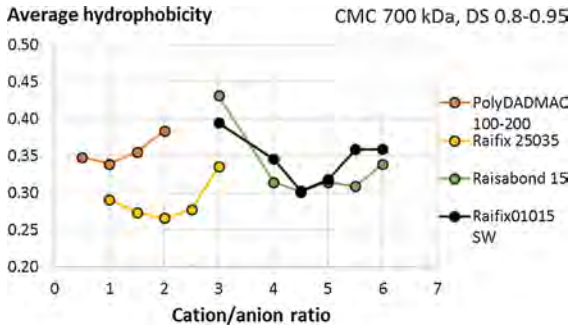

Fig. 7 Determined average hydrophobicity of particle populations from different cation/anion ratios of polycations with 700 kDa CMC

indicated that the particles were slightly less hydrophobic.

It has been reported that the hydrophobic domains exist within polyelectrolytes, and that these tend to vary with the conformational changes (Abe et al. 1977). It was reported that a polyelectrolyte with many hydrophilic ionic sites will show a hydrophobic atmosphere, or a low-polar solvent-like environment, within its domains. The hydrophobicity of a dense polyelectrolyte conformation is higher than for a polyelectrolyte with extended conformation. The presented FCM results would indicate that the polyelectrolyte chains on the surfaces of the PEC particles were less dense around their neutralization points, due to the slight decrease in hydrophobicity. More extended conformations of the polyelectrolytes may have been favored around the neutralization point. Additionally, the determined hydrophobicities of the PECs followed their FSC/SSC values to some extent; increases in structural density of the PECs seemed to be connected to increases in hydrophobicity.

Time dependency: coagulation

To study the time dependency of PECs over a short time scale, a coagulating PEC mixture was chosen for FCM analysis. From the preliminary turbidity measurements, it was known that a mixture of Raifix 01015 SW and 250 kDa CMC, DS 0.9, at a ratio of 5:1, was unstable over time. The two polyelectrolytes were quickly mixed together and diluted. The first sample was collected after 6 s of polyelectrolyte contact time, and it was quickly fed into the FCM apparatus. The initial number of particles in suspension was about 41000/μL, and the measured FSC/SSC value of the PEC population was 3.4 (Fig. 8). The number of particles per μL decreased quite rapidly within the first 5 min of contact time, from 41000 to about 10000/μL, most likely due to secondary aggregation of the initial particles. Within the first 5 min, the FSC/SSC value of the particle population also increased from 3.4 to 8.7, indicating the formation of large, swollen PEC particles with low structural density. The particle count continued to decrease over time, and only about 500/μL remained at 53 min. From the FCM density plots, it was visible that the largest, and most unstable aggregates disappeared over time. The largest aggregates formed macroscopic flocs, that were either left in suspension or attached to the glass beaker walls.

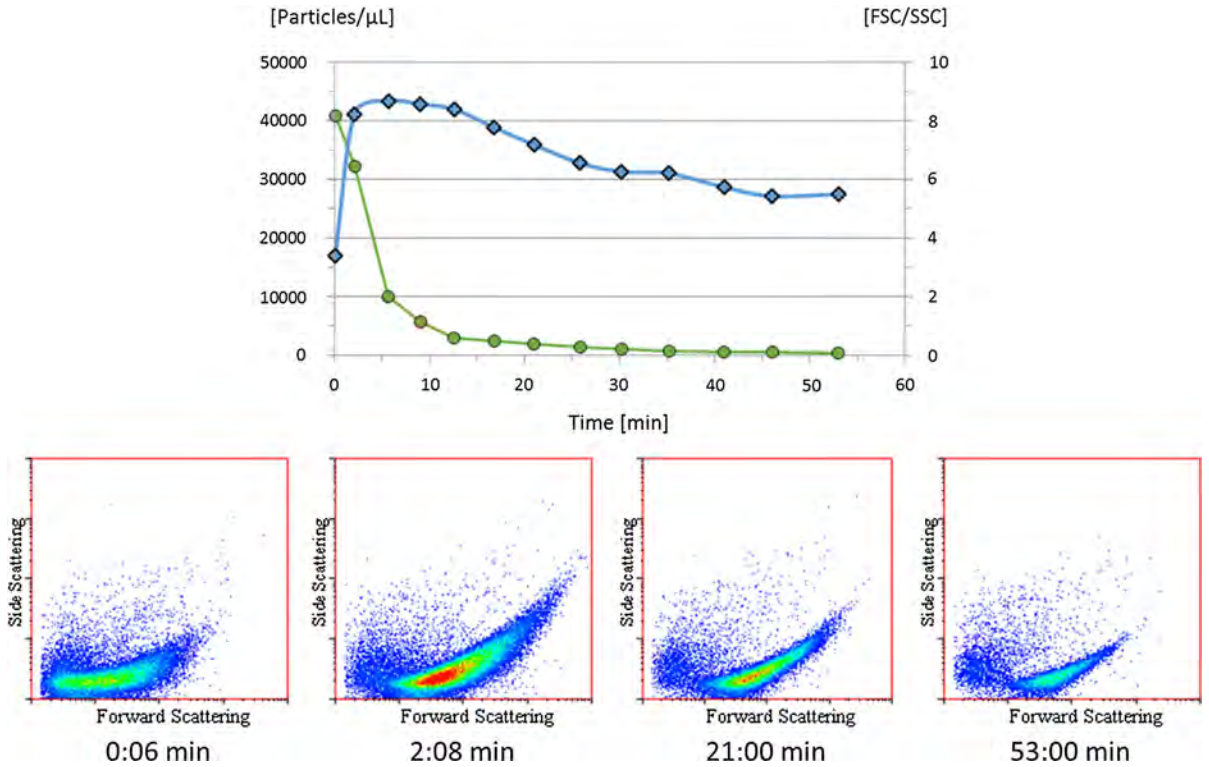

Fig. 8 Determined number of particles per µL (Open circle, green) and FSC/SSC values (Diamond, blue) of a coagulating PEC mixture as a function of contact time. FCM density plots of the PEC population after different contact times, plotted as SSC versus FSC, are also presented. (Color figure online)

The FSC/SSC value of the particle population seemed to stabilize at about 5.5 after 53 min, but the number of particles remaining in suspension was only about 1% of the initial amount.

The large change in the observed PEC population should be of special interest in wet-end chemistry, where the contact times between polycations and polyanions can be extremely short. These studied additives required a short contact time before large, swollen, and easily retainable PEC particles were formed. In adsorption studies at high flux, an initial over-adsorption of polymer has been noted, and the over-adsorption was corrected by partial desorption over time (Fleer et al. 1993). In a previous study, it was noted that the response to additions of salt took up to 60 min for some PEC systems (Dautzenberg and Karibyants 1999). In another study, the PEC mixtures were stirred for 10 min, and allowed to stabilize for 2 h prior to characterization (Mende et al. 2002). Therefore, the time dependency of PECs should be studied in more detail, and also be taken into account when studying mixtures of this nature. The situation at initial polyelectrolyte contact, where a papermaker usually operates, may be very different from the equilibrium states commonly studied at laboratory scale. The salt concentration should also be taken into account, since this will influence the results due to the introduction of screening effects during PEC formation.

It should be mentioned again, that every step of PEC formation will influence the result (Kötz 1993; Feng et al. 2008). Slowly introducing the polycation to its counterpart, which is a common approach in literature, in order to study the cationically stabilized PECs at cation/anion ratios exceeding the neutralization point will cause the interaction path to pass through the unstable region. By suddenly introducing the polycation, it is possible to circumvent this phenomenon and obtain cationically stabilized particles that are not products of secondary aggregation.

Conclusions

Polyelectrolyte complexes (PECs) were prepared from common papermaking additives at different cation/anion ratios. The polycations were different cationic starches and polyDADMACs, while the polyanions were CMCs of various molar masses and charge densities. The colloidal, light scattering PEC particles were studied by turbidity measurements, as well as by flow cytometry (FCM). Turbidity maxima of the different PEC mixtures were located close to the theoretical point of neutralization between the polycation and polyanion. The turbidity response varied with polyelectrolyte charge density. The formed PECs were in most cases stable for 24 h, but certain combinations close to the theoretical point of neutralization resulted in unstable complexes.

The light scattering properties of PECs in side direction (SSC) and in forward direction (FSC) were recorded by FCM analyses. It was seen that the SSC and FSC of the analyzed particles were influenced by very different particle properties, and a new term was suggested to better understand the properties of these particles in suspension; FSC/SSC. It was shown that the calculated FSC/SSC values were connected to the structural density of particles. The hydrophobicity of PECs was also analyzed by FCM. All of the measured PEC combinations were very hydrophilic, and it was seen that the hydrophobicity of the particles was lowest close to the theoretical point of neutralization. Finally, a coagulating PEC mixture was studied by FCM analysis as a function of time. It was shown that the initial particle count decreased by 75% over a short period of time. The PECs were initially of medium density, but quickly formed large, swollen particles due to secondary aggregation amongst the initial particles. After 53 min, only about 1% of the particles remained in suspension.

It is suggested that FCM can be used to study polyelectrolyte complexes in suspension. FCM provides relevant information about the structural density and hydrophobicity of these particles. With FCM it would be possible to simultaneous analyze PEC properties and their interactions with other particles in suspension. When dealing with research or production of PECs, FCM techniques can be very useful for categorizing the formed particles.

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Comparative Studies on the Explosion Severity of Different Wood Dusts from Fiberboard Production

Lu Guo,[a] Qiuping Xiao,[b] Nanfeng Zhu,[a] Yao Wang,[b] Xiulan Chen,[c] and Changyan Xu [a],*

Wood dust samples with different particle sizes were used to investigate the explosion characteristics of wood dust. The dust samples came from Populus alba L., Pinus massoniana Lamb., and Cinnamonum camphora (L.) Pres., species that are commonly utilized in medium density fiberboard production in China. The thermogravimetric characteristics, element composition, and morphology of dust samples were analyzed to help explain the explosion phenomena in a 20 L sphere. The analysis showed that both the maximum explosion pressure and explosion index of wood dust presented a decreasing trend with increasing particle size, and the maximum explosion pressure values were in the range of 7 to 9 bar, regardless of species. For both explosion pressure and explosion index values, the wood dust with similar particle sizes were different, which are ranked as Populus alba > Cinnamonum camphora > Pinus massoniana. In addition, for the explosion pressure of wood dust with similar particle size, the dust concentration had threshold values. Additionally, the particle size and dust concentration had a synergistic effect on the explosion pressure and explosion index. Wood dust with a smaller particle size is more likely to explode at the threshold of concentration.

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Keywords: Wood dust; Particle size; Dust concentration; Maximum explosion pressure; Explosion index

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INTRODUCTION

With the development of modern industry and the extensive application of powder technology, a growing number of industries are becoming involved in the production, processing, transportation, and storage of flammable powder. In recent years, the types and amounts of flammable powder have increased greatly, resulting in a significant increase in equipment abrasion, dust explosion casualties, and serious environmental pollution (Abbasi and Abbasi 2007; Yan and Yu 2012; Yuan *et al.* 2015). As a typical type of flammable powder, biomass dust, especially wood dust, also possesses serious explosive potential (Huescar Medina *et al.* 2013; Calvo Olivares and Rivera 2014). Dust burning is likely to occur in almost all sections involving wood dust processing, transportation, and storage, and such incidents do harm to the human body, equipment, and the environment (Hedlund *et al.* 2014; Krentowski 2015). In the fabrication board production, wood grinding, sawing, milling, planing, carving, and other processing processes will produce shavings, sawdust, sanded wood powder, *etc*. When the wood dust is suspended in the air or scattered on the hot surface of the equipment, the dust is accumulated. If there is a suitable ignition source in the surrounding environment, the

wood dust will be ignited, releasing heat and causing an explosion accident. Yuan *et al.* (2015) examined and analyzed more than 2000 dust explosion accidents that occurred worldwide between 1785 and 2012, and found that 17% of the incidents were caused by wood dust. Wood dust is an important type of combustible dust that accounts for 46% and 27% of all explosion accidents in the US and China, respectively. On January 31, 2015, a wood dust explosion occurred in Jinhe Xingan Wood-based Panel Co. Ltd., Genhe, Inner Mongolia in China killing six, injuring three, and badly damaging the factory building (State Administration of Work Safety of China 2015). According to a preliminary investigation, the accident was caused by an initial wood dust bin explosion in the sanding and dust collecting system, which led to a secondary wood dust explosion in the workshop, triggering a fire in the workshop and storehouse.

Increasing attention has been paid to research on combustible dust explosions in the United States, Britain, France, Germany, Japan, Norway, and other developed countries (Nagy and Verakis 1983; Eckhoff 2005, 2009; Amyotte and Eckhoff 2010). They studied the causes and consequences of dust explosions, mechanisms of dust explosions, physical and chemical experimental methods related to dust cloud generation and combustion, explosion test parameters, and safety improvement procedures to reduce the probability and damage of dust explosions in industry.

The maximum explosion pressure (P_{max}), the maximum rate of explosion pressure rise $(dp/dt)_{max}$, and the explosion index (K_{st}) derived from $(dp/dt)_{max}$ are safety characteristic factors usually used for hazard identification in various industries, suggesting safety improvement procedures, and designing safety measures for the mitigation of destructive effects of dust explosions (BSEN 14034-1(2004) and BS EN 14034-2 (2006)).

Cashdollar (2000) believed that the particle size, shape, and specific surface area of dust were closely related to its explosion characteristics. Amyotte *et al.* (2012) conducted a comparative study on the effects of dust particle size and shape on the maximum explosion pressure as well as the rise in the maximum rate of explosion pressure of wood fibers and polyethylene dust. They deemed that fibrillar particles such as wood dust were more likely to explode because they would remain suspended in air for a long time, increasing their ignition probability. Calle *et al.* (2005) also studied the explosion characteristics of wood dust with different particle size in a 20 L sphere, and confirmed that explosion violence decreases with increasing particle size. The researchers then developed a model based on balances of chemical reactions, kinetics, and thermodynamics during the explosion.

Most studies on dust explosions have focused on coal, metal, and food dust. To date, the reports about wood dust explosion characteristics are still in a fragmentary stage, including the description of the individual explosion characteristics of wood dust, describing common physical laws of various dust types such as explosion incentives, explosive conditions, as well as explosion and explosion factors (Hedlund *et al.* 2014; Krentowski 2015). Minimal attention has been paid to the combustion and explosion dynamics in wood explosions (Calle *et al.* 2005; Huescar Medina *et al.* 2015), mainly because of the considerable variation in wood particle size and morphology, as well as the low density and large specific surface area of wood dust.

The 1990s saw a rapid development of fiber board production as an effective way to comprehensively utilize wood resources in China. However, it is unavoidably accompanied by a lot of dangerous wood dust explosions. In fiberboard production, the equipment that is prone to dust explosion includes the wood fiber drying system, dry

wood fiber or sanding dust silos, dry wood fiber conveying systems, mat forming units, mat or panel cutting units, wood dust collecting systems, as well as the grinding and sanding systems. Combustible dust clouds can be easily formed in the above units and thus could be ignited by heat, fire, or spark. Therefore, more attention should be paid to these units in production. The measurement of $\underline{P}_{max}$ and $(dp/dt)_{max}$ are the basis for designing, constructing, and monitoring critical equipment and protective systems. In this research, wood dust was obtained from *Populus alba* L., *Pinus massoniana* Lamb. and *Cinnamonum camphora* (L.) Pres., which are commonly utilized for fiberboard production in China. The influences of particle size and concentration on the wood dust explosive power were investigated.

EXPERIMENTAL

Preparation of Wood Dust Samples

Wood dust samples from three species of trees, *Populus alba* L., *Pinus massoniana* Lamb., and *Cinnamonum camphora* (L.) Pres., commonly utilized in medium density fiberboard production in China, were used to investigate the explosion characteristics of wood dust. All dust samples were generated by sawing, chopping, and grinding from solid wood supported by Dare Artificial Board Group Co., Ltd., Jiangsu province. Four groups of wood dust samples with different particle size (250 to 500 µm, 125 to 250 µm, 63 to 125 µm, and 0 to 63 µm) for each species were obtained by sieving (Analysette 3 Spartan, Fritsch, Idar-Oberstein, Germany) and particle size analyzing (Mastersizer2000, Malvern Analytical, Malvern, UK).

Experimental Methods

Morphological, thermogravimetric, and elemental characteristics of wood dust from three different species were investigated using a polarizing microscope (Olympus BX51, Tokyo, Japan), a synchronous thermal analyzer (Netzsch STA 449C, Bavaria, Germany), and an elemental analyzer (2400 II, PE, Waltham, MA, USA), respectively. In the thermogravimetric analysis, dust was heated from room temperature to 750 °C using a heating ramp of 20 °C/min in an N_2 environment (20 mL/min). The content of carbon, hydrogen, nitrogen, and sulfur element were determined in an O_2 environment.

Investigation of the maximum explosion pressure (P_{max}) and the maximum rate of explosion pressure rise ($(dp/dt)_{max}$) were carried out with a Siwek 20 L apparatus (Kuhuer, as shown in Fig. 1) in accordance with the standardized test procedures BS EN 14034-1 (2004) and BS EN 14034-2 (2006). This apparatus is comprised of a water-cooled explosion vessel with a volume of 20 dm^3, an ignition source composed of two chemical igniters each with 5 kJ of energy, a control unit sequencing, and a pressure measuring system including at least two pressure sensors and one piece of recording equipment (KSEP 310 and KSEP 332, Kühner, Zurich, Switzerland).

Before starting the test procedure, the moisture content of all dust samples was conditioned to less than 5% using an oven (BPG-9050AH, HASUC, Shanghai, China) and the temperature inside the vessel was 20 °C. For testing, the required amount of dust was placed in the dust container. After being vacuumed to a vacuum of 0.6 bar, the container was pressurized to an over-pressure of 20 bar. The dust sample was dispersed into the sphere from the dust container via the fast-acting valve and a rebound nozzle. The time lag of the outlet-valve (t_d) was outside the acceptable range of 30 to 50 ms. The

delay between the initiation of the dust dispersion and activation of the ignition source (ignition delay t_v) was 60 ms. The pressure was recorded as a function of time. From the pressure/time curve, the explosion pressure (p_{ex}) was determined by taking the arithmetic mean of the values measured by the pressure sensors. The testing procedure was started from a concentration of 250 g/m^3, and the concentration was increased by steps of 250 g/m^3, which is shown as 250 g/m^3, 500 g/m^3, 750 g/m^3, 1000 g/m^3, 1250 g/m^3, and 1500 g/m^3 for each kind of wood dust with different particle size. Then researchers determined the explosion pressure (p_{ex}) under each concentration and found a maximum value P_{max}.

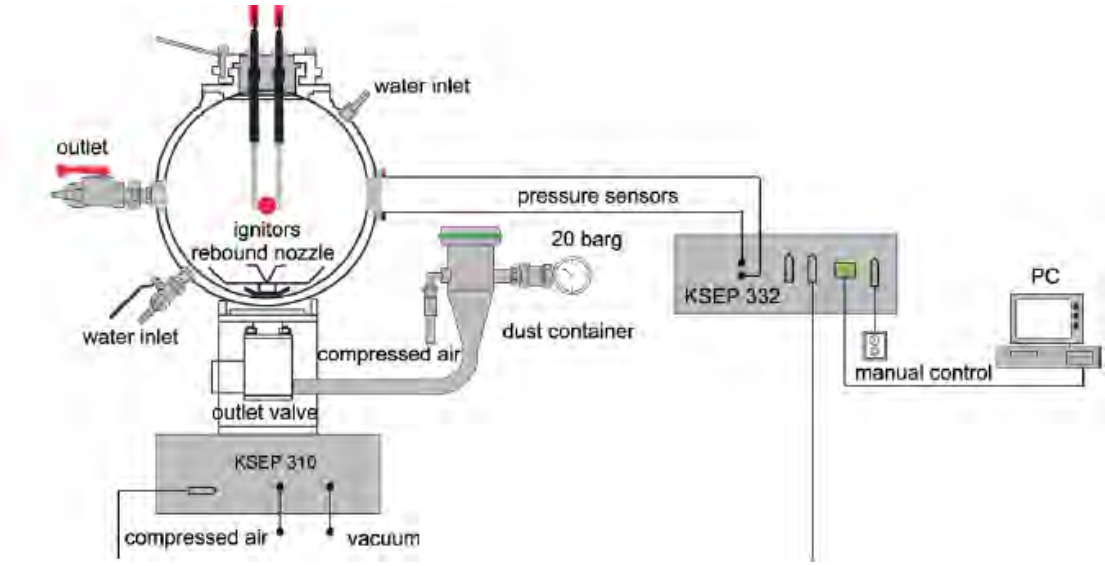


Fig. 1. 20 dm^3 sphere explosion testing system

RESULTS AND DISCUSSION

Particle Size and Surface Morphology of Dust

Tables 1 through 3 show the D_{10}, D_{50}, D_{90} and specific surface area for each fraction of wood dust samples. For all dust samples, the values of D_{10}, D_{50}, and D_{90} gradually increased with increasing particle size, yet the values of specific surface area presented an opposite trend. Generally speaking, the median diameter of dust (D_{50}) should be smaller than the corresponding upper bound value of the particle size, as shown by the particle size of 0 to 63 μm, 63 to 125 μm, 125 to 250 μm, and 250 to 500 μm. *P. massoniana* dust had median diameters of 34 μm, 57 μm, 120 μm, and 219 μm, respectively, and *P. massoniana* dust showed a median diameter of 30 μm, 66 μm, 162 μm, and 303 μm. However, for *P. alba* dust, the median diameters were 38 μm, 89 μm, 180 μm, and 566 μm, respectively. Herein a median diameter of 566 μm was larger than the corresponding upper bound value of the particle size, 250 to 500 μm. This phenomenon can be explained from the morphology of wood dust samples, as shown in Figs. 2 through 4. Dust from *P. alba* had a higher length to diameter ratio, and the long needle shapes can pass through the lengthwise portion of the sieve. In addition, in the same particle size, the D_{10}, D_{50}, and D_{90} values of *P. alba* dust were greater than those of *P. massoniana* and *C. camphora* dust. This is mainly attributed to *P. alba* dust's slender

fiber-like and irregular shape, rough surface, various particle sizes, and uneven dispersion (Lee *et al.* 2016).

Table 1. D_{10}, D_{50}, D_{90} and Surface Area for Each Fraction of *Populus alba* Dust

Size fraction	0-63 μm	63-125 μm	125-250 μm	250-500 μm
Particle size D_{10}(μm)	12.91	30.25	56.84	164.62
Particle size D_{50}(μm)	38.06	89.44	180.78	565.78
Particle size D_{90}(μm)	94.91	204.33	418.62	1402.98
Surface area (m^2/g)	0.27	0.11	0.06	0.02

Table 2. D_{10}, D_{50}, D_{90} and Surface Area for Each Fraction of *Pinus massoniana* Dust

Size fraction	0-63 μm	63-125 μm	125-250 μm	250-500 μm
Particle size D_{10}(μm)	12.77	18.12	29.78	66.67
Particle size D_{50}(μm)	34.16	57.21	120.09	219.04
Particle size D_{90}(μm)	77.90	154.14	279.06	459.90
Surface area (m^2/g)	0.28	0.18	0.10	0.05

Table 3. D_{10}, D_{50}, D_{90} and Surface Area for Each Fraction of *Cinnamonum campora* Dust

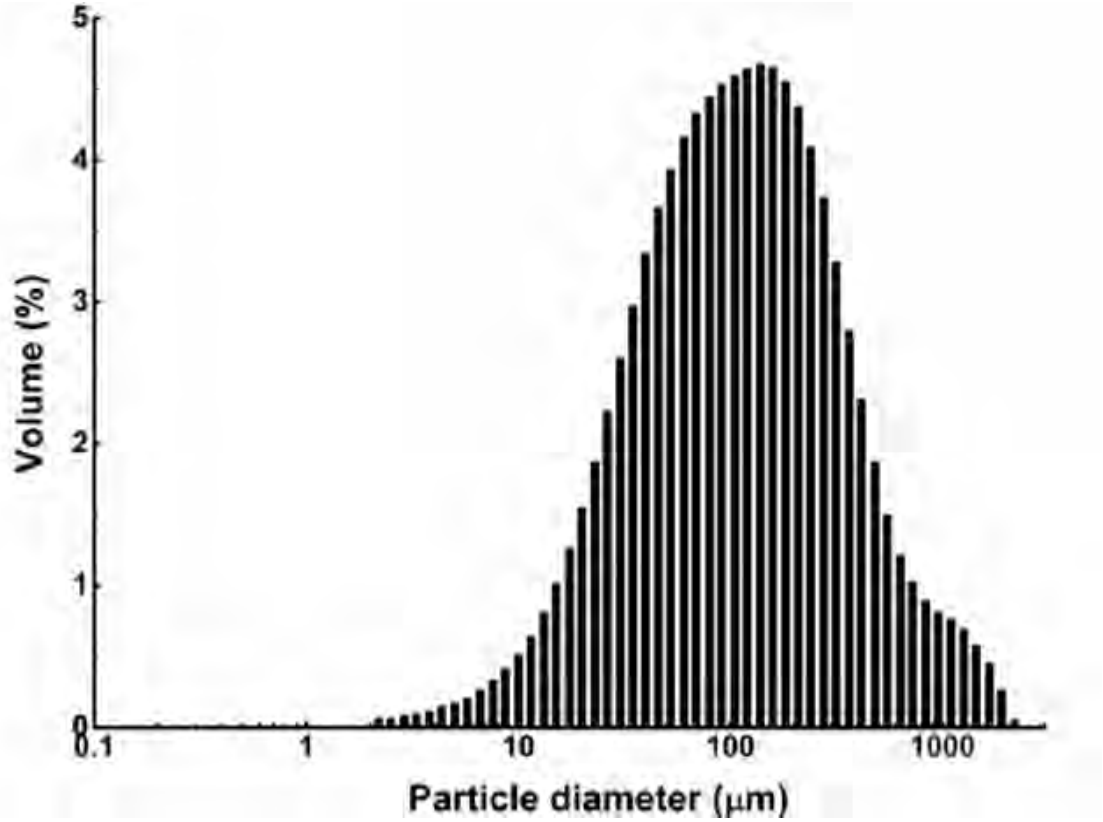
Size fraction	0-63 μm	63-125 μm	125-250 μm	250-500 μm
Particle size D_{10}(μm)	10.29	17.76	52.25	138.30
Particle size D_{50}(μm)	29.76	66.50	161.86	303.23
Particle size D_{90}(μm)	66.78	157.51	313.18	568.19
Surface area (m^2/g)	0.35	0.19	0.07	0.04

Besides, the dust of *P. massoniana* and *C. camphora* had similar shapes, being oval and slender, and the dust of *P. alba* and *P. massoniana* had a relatively uniform and normal particle size. All the samples had particles of 1000 μm, not only *P. massoniana* and *C. camphora*, and even *P. alba* reached the 1500 μm size. National Fire Protection Association (NFPA) Standard 68 defines combustible dust as particles less than 420 μm in diameter and believes that these particles have a potential to cause a fire or explosion when dispersed and ignited in the air. In this paper, wood dust from three species is considered to be combustible dust because the particles less than 420 μm in diameter account for about 50% of all dust samples for each species.

Elemental and Thermogravimetric Analysis of Wood Dust

Table 4 shows the carbon, hydrogen, nitrogen, and sulfur content in the dust of *C. camphora*, *P. alba*, and *P. massoniana*. The H/C ratio of *P. alba*, *P. massoniana*, and *C. camphora* was 9.7%, 8.4%, and 9.1%, respectively. Compared with poplar and pine trees (Liao *et al.* 2004), the chosen wood dust samples in this paper had a lower hydrogen and nitrogen content, and a higher nitrogen and sulfur content.

Figure 5 shows the TG and DTG curves for the wood dust samples. In general, the pyrolysis process of wood dust is divided into three main stages: water loss drying, devolatilization, and carbonization (Xu *et al.* 2010). For all dust samples, the water was dehydrated at 30 °C to 100 °C, and most cellulose and hemicellulose were decomposed at 220 °C to 400 °C (Yan 1997; Yang *et al.* 2000).



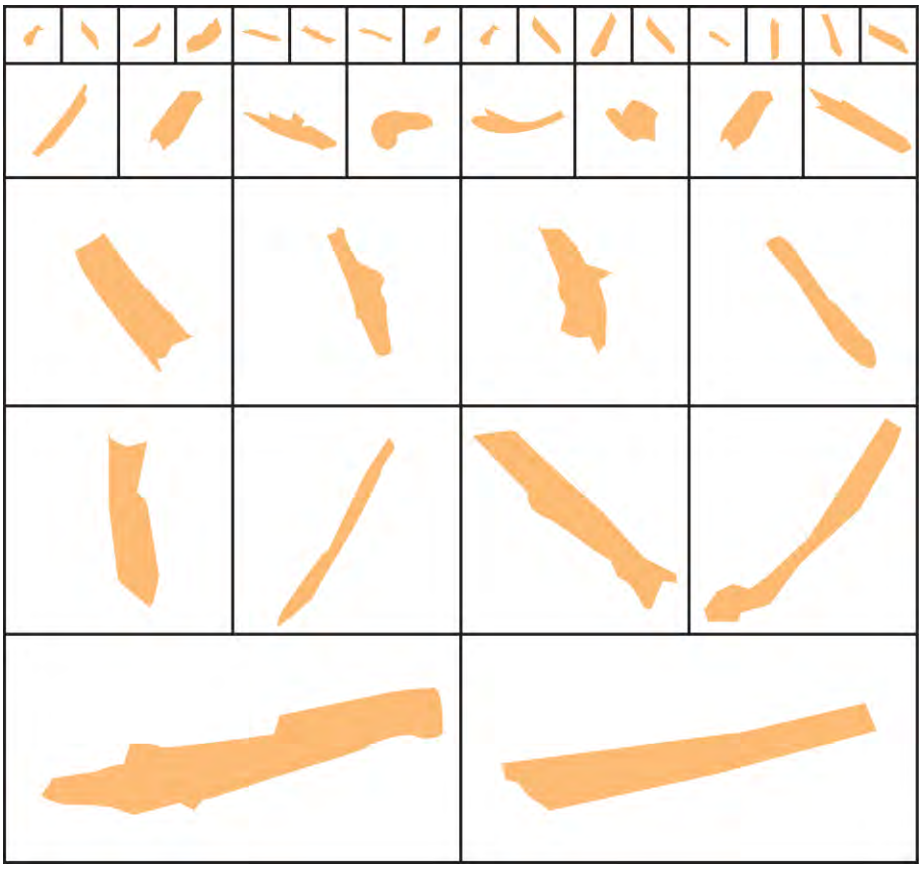


Fig. 2. Particle shape and particle size of unsieved *Populus alba* dust

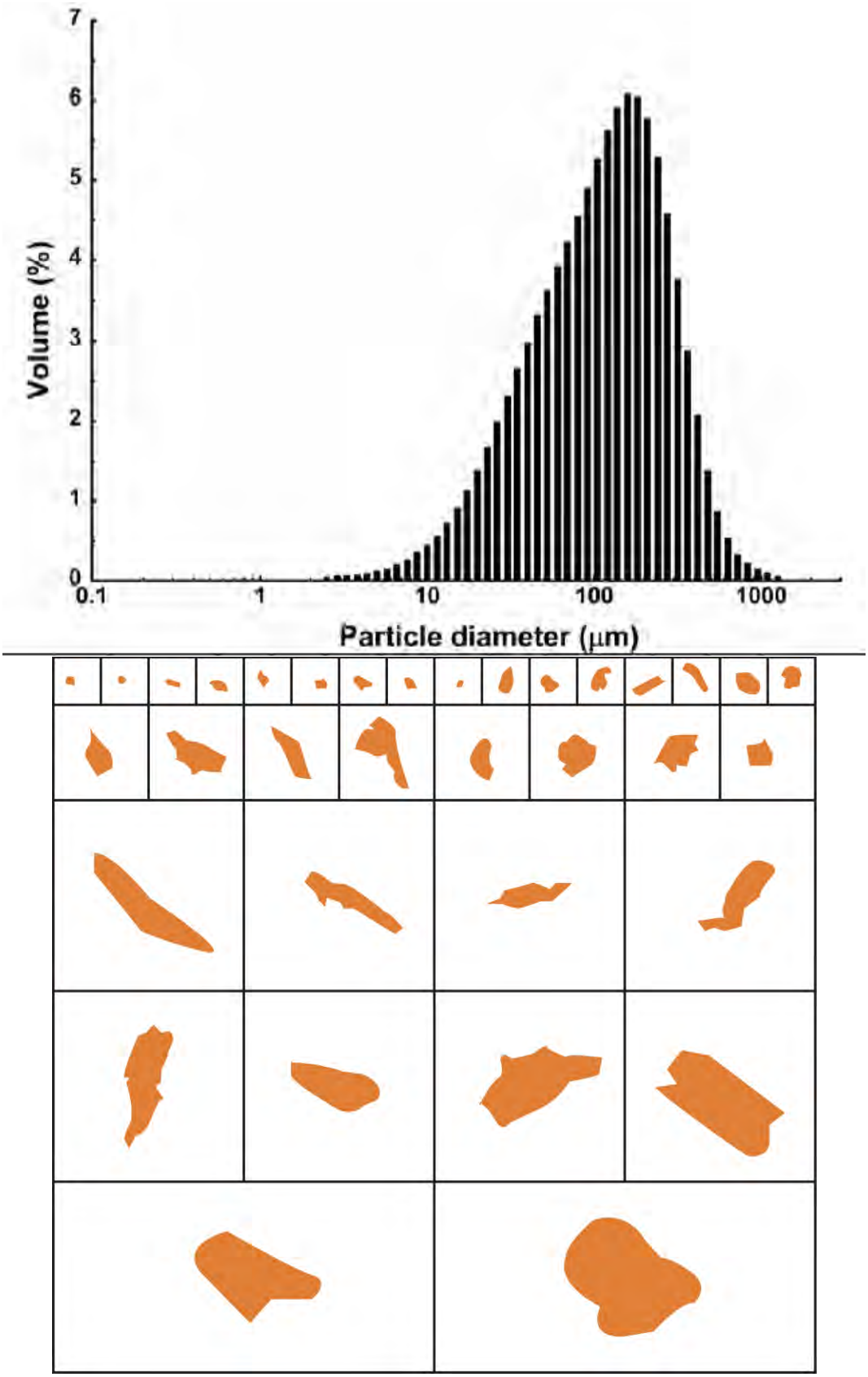


Fig. 3. Particle shapes and particle size of unsieved *Pinus massoniana* dust

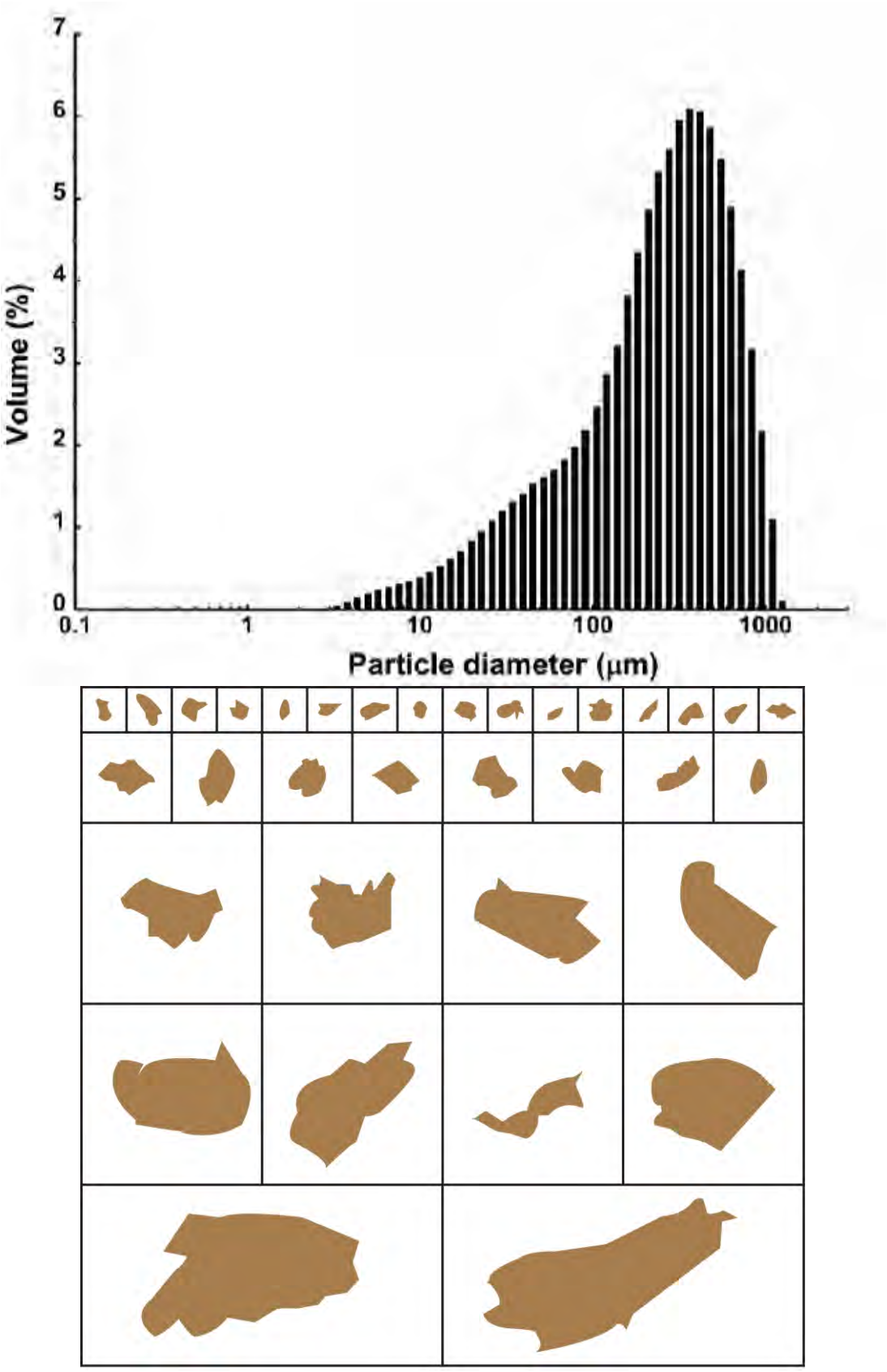


Fig. 4. Particle shapes and particle size of unsieved *Cinnamonum camphora* dust

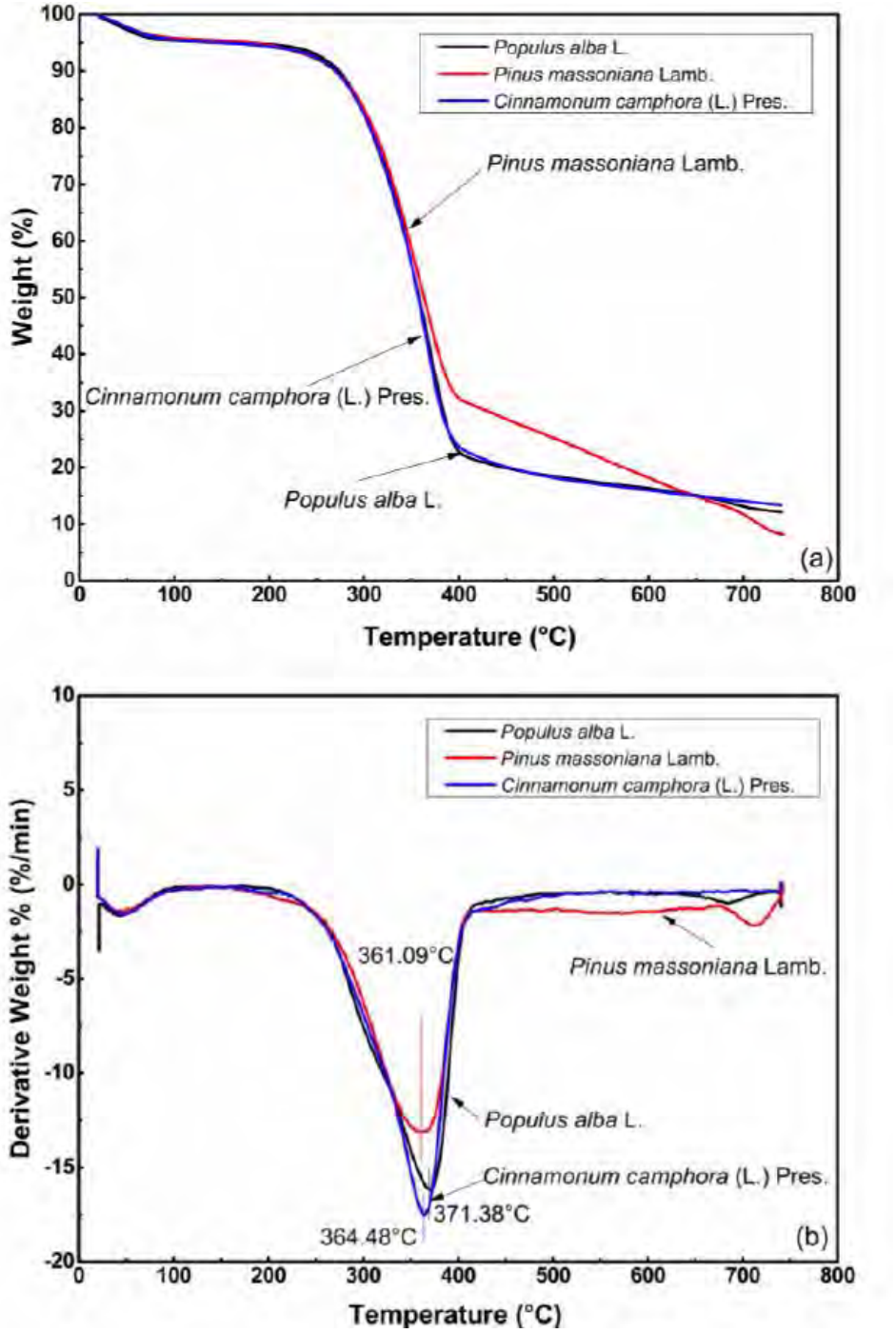


Fig. 5. a) TG and b) DTG curves for the dust samples

When the temperature reached 350 °C, the mass loss of all dust samples was about 50%, and the maximum mass loss occurred at 360 °C. However, the dust samples from *P. alba* and *C. camphora* devolatilize more than that of *P. massoniana* dust, and in the carbonation stage, the *P. massoniana* dust decomposed more than *P. alba* and *C. camphora* dust, leading to a lower content of char residue at 750 °C (Table 5). These results can be attributed to the fact that the *P. massoniana* dust contains turpentine and rosin, which start to decompose and carbonate at 300 °C (Wang *et al.* 2005).

Table 4. Elemental Composition of the Wood Dust

Elemental Composition	C (wt%)	H (wt%)	N (wt%)	S (wt%)
Populus alba	44.84	4.35	0.57	0.81
Pinus massoniana	39.78	3.33	0.32	0.53
Cinnamonum camphora	48.37	4.38	0.67	0.39

Table 5. Thermal Degradation and Char Residue Data by TGA

Sample	$T_{5\%}$ (°C)	$T_{50\%}$ (°C)	R_{peak} (%/min)	T_{peak} (°C)	Char residue at 750 °C (%)
Populus alba	159.9	358.0	15.2	371.4	12.2
Pinus massoniana	181.6	363.1	12.1	361.1	8.2
Cinnamonum camphora	148.2	357.2	16.5	364.5	13.4
$T_{5\%}$: temperature at the mass loss of 5%; $T_{50\%}$: temperature at the mass loss of 50%					
T_{peak}: temperature at the peak; R_{peak}: mass loss rate at the peak					

Explosion Characteristics of Wood Dust Samples

Effect of particle size on explosion pressure and explosion index

Figure 6 shows the pressure evolution during the explosion process for *C. camphora* dust with a particle size of 63 to 125 μm. When the dust concentrations were 500 g/m^3 and 1250 g/m^3, the explosion pressure and the pressure rise rate reach their maximum values, respectively. Similar results were also obtained by Calle *et al.* (2005). According to BS EN 14034-2 (2006), the explosion index (K_{st}) is defined as the explosion pressure rise rate (dp/dt) normalized to a 1 m^3 vessel in the explosion pressure rise rate, making the explosion pressure rise rate measured in different containers comparable. It is calculated using the cubic law in Eq. 1,

$$K_{st} = (dp/dt) \times V^{1/3} \quad (1)$$

where V is the volume of the explosive container, 20 L.

Figure 7 is the relationship between P_{max} or K_{St} of dust samples and particle size. When the particle size increased from 0-63 μm to 250-500 μm, the P_{max} and K_{St} of *Pinus massoniana* Lamb dust decreased from 7.56 bar to 6.80 bar and from 129 bar·m/s to 59.2 bar·m/s, and the decreasing rate was 10.1% and 54.1%, respectively. The dust samples from *C. camphora* and *P. alba* showed similar changing trends to that of *P. massoniana* dust. Therefore, a conclusion can be drawn that particle size affects K_{St} much more than P_{max}. This result is consistent with the literature (Calle *et al.* 2005).

In addition, it is interesting that *P. alba* dust had higher P_{max} and K_{St} values than *P. massoniana* dust and *C. camphora* dust in the selected particle size. The *P. alba* dust exhibited a relatively high length to diameter ratio which makes it tend to float in the air for a long period during the explosion test and enhance its explosive power.

For the *C. camphora* and *P. massoniana* dust, the oval-shaped particles make them relatively difficult to disperse in the air. The explosive characteristics of dust are related to its volatility content, and the more volatile the content, the greater the explosion severity of the dust (Gu and Wang 2008). From the TG curves in Fig. 5, the volatile content of the *P. alba* dust and *C. camphora* dust was significantly higher than the *P. massoniana* dust.

Finally, the sulfur elemental content and H/C ratio of the *P. alba* dust were highest among three types of dust samples. However, compared to *C. camphora*, the dust from *P. massoniana* had a higher content of sulfur, but it did not achieve higher values of

P_{max} and K_{St}. This result suggested that the effect of sulfur on P_{max} and K_{St} had been offset by the high content of rosin acid in *P. massoniana* dust.

The wood dust with similar particle size had different explosion pressure and explosion index values, and the relationship was the same as the H/C ratio of each kind of wood dust, which are ranked as *P. alba* > *C. camphora* > *P. massoniana*.

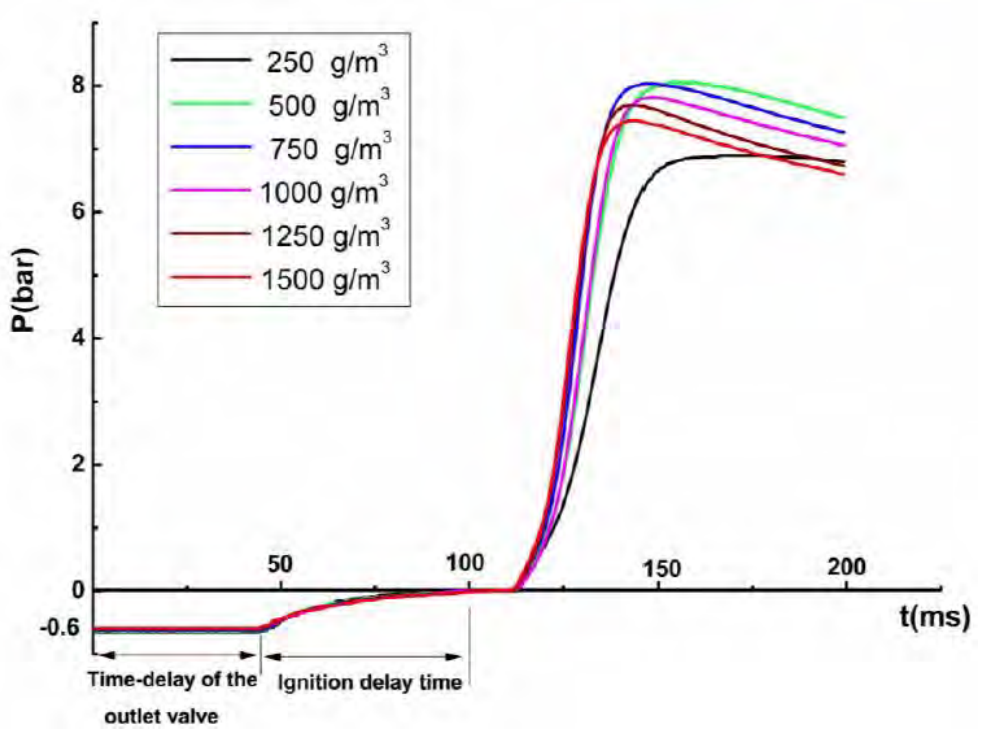


Fig. 6. Pressure / time curve (*Cinnamonum camphora* dust with particle size of 63 to 125 μm)

Effect of dust concentration on explosion pressure and explosion index

Figure 8 shows the explosion pressure and explosion index of dust samples with increasing dust concentration. As the dust concentration increased, the explosion pressure rose initially until the maximum was reached and decreased afterwards, demonstrating that the dust concentration has a threshold value. Lee *et al.* (2016) and Kordylewski and Amrogowicz (1992) obtained similar results. When dust concentration increased within the threshold, the dust involved in the explosion reaction and the heat released increased, leading to a rise in the explosion pressure.

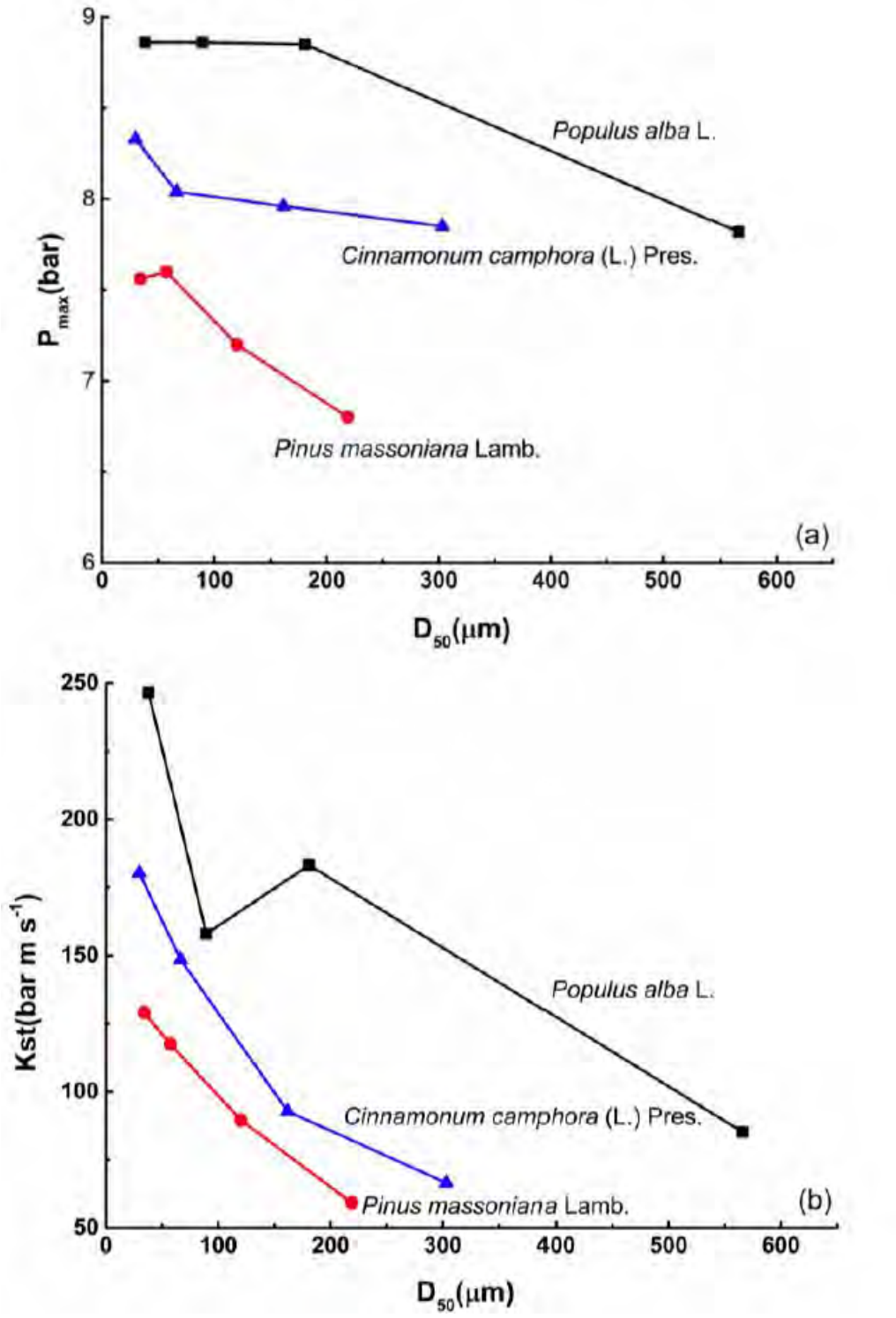


Fig. 7. Effect of wood dust particle size on a) P_{max} and b) K_{st}

Further increase in the dust concentration beyond the threshold resulted in an increase in the number of particles in the explosion sphere and an insufficient amount of oxygen, causing a reduction in the number of particles per unit volume participating in the explosion reaction and thereby decreasing the explosion pressure. On the other hand, the heat and shock waves generated by the explosion were absorbed by the excessive

dust, which caused the heat released by the reaction to be less than the heat lost by the absorption. This hindered the spread of the flame and eventually lead to the downward trend of the dust explosion. Finally, the excessive dust in the explosion sphere can also reduce the explosive level and efficiency of the gunpowder.

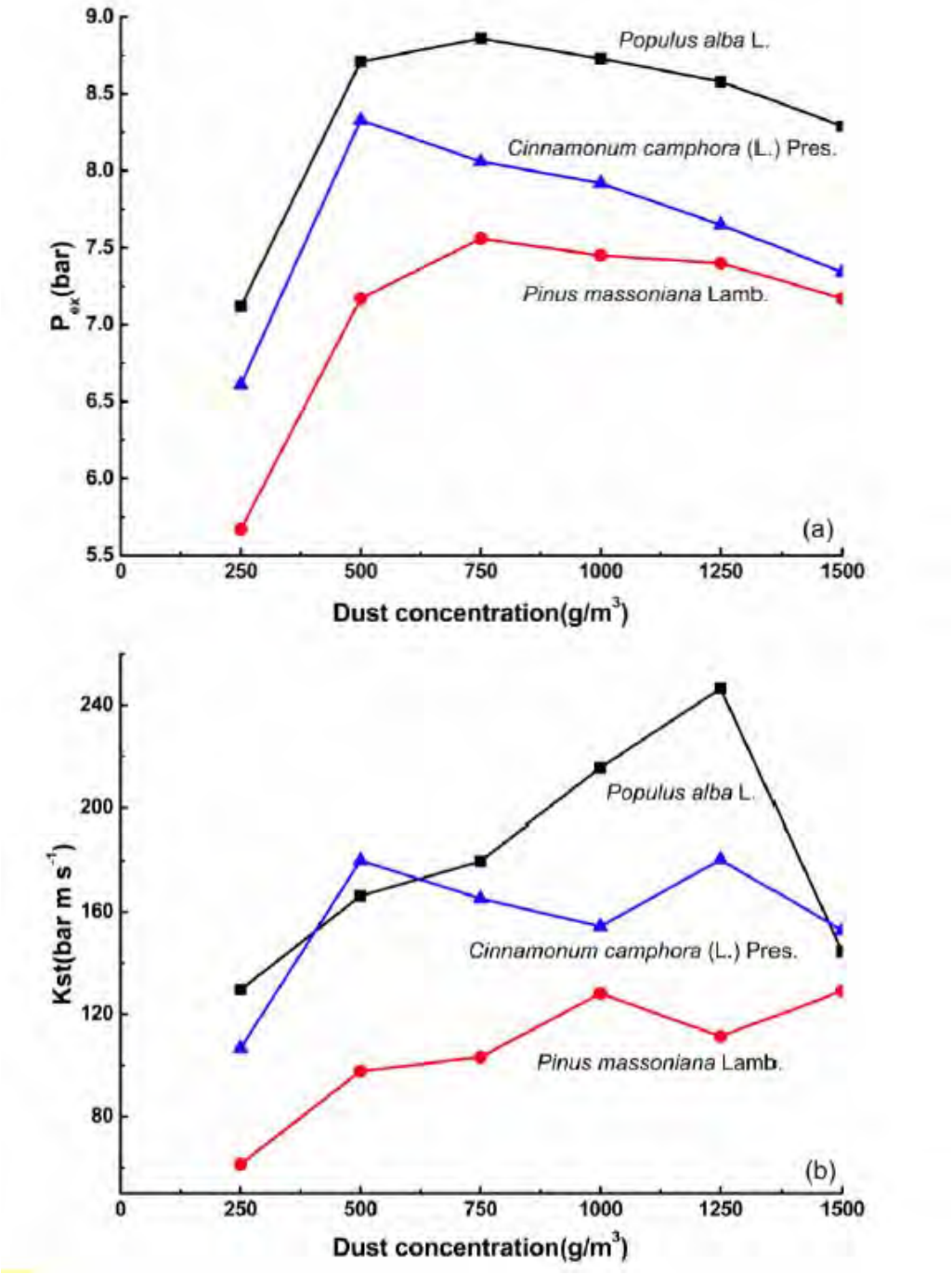


Fig. 8. Effect of dust concentration on a) P_{max} and b) K_{st} (particle size, 0 to 63 μm)

For different species, the threshold of dust concentration was not identical. For example, for the dust of *P. alba* and *P. massoniana*, the threshold, 750 g/m^3, was higher than that of *C. camphora*, 500 g/m^3. The thermal degradation data in Table 5 shows that the mass loss rate of *C. camphora* dust first reached 5% at 148 °C. The higher the concentration of *C. camphora* dust, the smaller the number of particles involved in the subsequent explosion reaction, resulting in a lower dust concentration threshold.

The dust concentration values corresponding to the maximum explosion pressure and the maximum pressure rise rate are different, as shown in Fig. 6. Obviously, the maximum speed and the maximum acceleration of the explosion reaction do not necessarily occur at the same time. Accordingly, in the testing procedure of the explosion, a series of experiments were repeated for a range of dust concentrations. This conclusion is consistent with the literature reports (Amyotte *et al.* 2012; Tascón *et al.* 2016; Cao *et al.* 2017).

Similarly, among the three types of wood dust with a particle size of 0 to 63 μm, *Populus alba* dust exhibited the highest values of P_{max} and K_{St}, and the *Pinus massoniana* Lamb dust had the lowest.

Synergistic effects of particle size and dust concentration on the explosion severity of the wood dust

Figure 8 shows that for the explosion pressure of the three types of wood dust, the threshold of dust concentration is 500 g/m^3 or 750 g/m^3. The dust concentration of 500 g/m^3 or 750 g/m^3 were used as examples to discuss the synergistic effects of particle size and dust concentration on explosion severity.

In Fig. 9, for the dust samples of *P. alba* and *C. camphora* with the same dust concentration, the explosion pressure increased with decreasing particle size. The smaller the particle size, the larger the specific surface area and the larger the contact area between dust particles and the oxygen, resulting in faster heat release during burning. Besides, the convective heat rate of the dust and the gas in the explosion sphere is accelerated with decreasing particle size, thus shorting the ignition time of the dust. However, for the *P. massoniana* dust with a dust concentration of 500 g/m^3, the explosion pressure did not reach above the changing trend, and its P_{max} corresponded to the particle size range of 63 to 125 μm instead of 0 to 63 μm. This result may be caused by the fact that the *P. massoniana* dust contains a large amount of turpentine that makes small dust reunion and thus reduces its explosion severity.

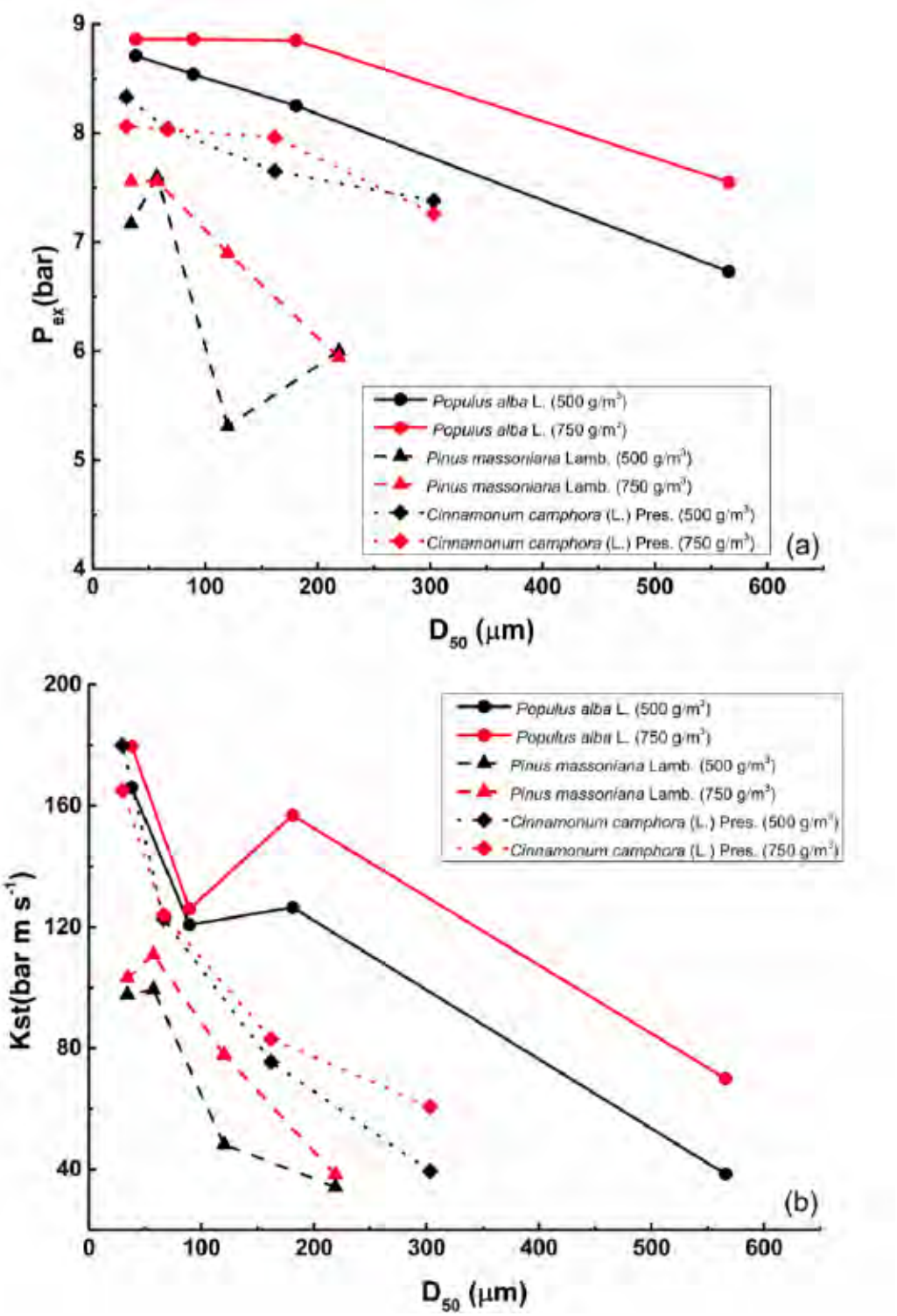


Fig. 9. Synergistic effects of particle size and concentration on a) P_{max} and b) K_{st}

In regard to the K_{st} value of selected dust samples, the maximum value corresponds to the particle size of 0 to 63 μm, except for *P. massoniana* dust. Thus, under the synergistic effect of the threshold dust concentration and the smaller particle size, it is more likely to induce an explosion accident with a high strength.

CONCLUSIONS

1. The particle size affects the explosion index (K_{St}) much more than the maximum explosion pressure (P_{max}). Both K_{St} and P_{max} present a decreasing trend with increasing particle size, and the P_{max} values are in the range of 7 to 9 bar, regardless of species.
2. For different species, wood dust with similar particle size have different explosion pressure and explosion index values, which are ranked as *Populus alba* L. > *Cinnamonum camphora* (L.) Pres. > *Pinus massoniana* Lamb.
3. For the explosion pressure of wood dust samples with same particle size, the dust concentration exhibited a threshold value that produced P_{max} values of 750 g/m^3, 750 g/m^3, and 500 g/m^3 for *Populus alba* dust, *Pinus massoniana* dust, and *Cinnamonum camphora* dust, respectively.
4. Particle size and dust concentration have a synergistic effect on the explosion pressure and explosion index. Wood dust with a smaller particle size is more likely to explode at the threshold of dust concentration.

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Application of soda-AQ pulping to agricultural waste (okra stalks) from Sudan

Safaa Hassan Omer[1], Tarig Osman Khider[2]* , Osman Taha Elzaki[3], Salaheldin Dafalla Mohieldin[3] and Suhair Kamal Shomeina[3].

Abelmoschus esculentus okra as whole stalks was examined for its suitability for pulp and paper production. It's, fiber dimensions, morphological and chemical characteristics were reported. The pulping trials with soda- Anthraquinone (AQ,) at different chemical charges. Application of 21% as NaOH with 0.1% AQ gave good results in degree of delignification, mechanical properties. Utilization of okra pulps and blender is recommended due to good pulp properties. Evaluation of general characteristics of okra stalks in terms of fiber dimensions morphological indices, chemical components, Soda-AQ cooking and to study their suitability for paper production. Okra Fiber dimension evaluation done after maceration with a mixture of 30% hydrogen peroxide and acetic acid (1:1) for core and bark parts separately and was carried out under microscope staining with aqueous safranin. The Soda-AQ cooks at different active alkali levels were calculated as NaOH on oven dry raw material. The fibers from okra stalks studied (core and bark) were in the range of hardwood fibers, with short fiber length, especially the core with more or less moderate walls, narrow lumen and fiber width. The fiber width of bark was medium –narrow with medium wall thickness. The ash content was rather high whereas the silica content was comparatively high The hot water extractives from okra stalks was (4.1%), cold water (0.4) ethanol/ cyclohexane (1.1), ethanol extractives (1.2%) and 1% NaOH (27.6%) were rather high. The cellulose (Kurschner-Hoffer) was (48.5%) The lignin content was (15.3%) which was relatively moderate. The use of 0.1% AQ enhanced the delignification in the three trials applied. The screened yield increase with increase of chemical dose applied while the rejects decrease. When 21% NaOH was applied, the screened yield was 32.2% with negligible amount of rejects, however with lower alkali charge 18% the screened yield was decreased to 28% with very low rejects 1.5%. on the other hand rejects were increased to 7% when 15% NaOH was applied with very low screened yield 19%.The pulps produced from okra soda-AQ are suitable for production of printing and writing papers and it is advisable to use them in blending due to good papermaking properties.

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Application of soda-AQ pulping to agricultural waste (okra stalks) from Sudan

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Abstract

Abelmoschus esculentus okra as whole stalks was examined for its suitability for pulp and paper production. It's, fiber dimensions, morphological and chemical characteristics were reported. The pulping trials with soda- Anthraquinone (AQ,) at different chemical charges. Application of 21% as NaOH with 0.1% AQ gave good results in degree of delignification, mechanical properties. Utilization of okra pulps and blender is recommended due to good pulp properties. Evaluation of general characteristics of okra stalks in terms of fiber dimensions morphological indices, chemical components, Soda-AQ cooking and to study their suitability for paper production. Okra Fiber dimension evaluation done after maceration with a mixture of 30% hydrogen peroxide and acetic acid (1:1) for core and bark parts separately and was carried out under microscope staining with aqueous safranin. The Soda-AQ cooks at different active alkali levels were calculated as NaOH on oven dry raw material. The fibers from okra stalks studied (core and bark) were in the range of hardwood fibers, with short fiber length, especially the core with more or less moderate walls, narrow lumen and fiber width. The fiber width of bark was medium –narrow with medium wall thickness. The ash content was rather high whereas the silica content was comparatively high The hot water extractives from okra stalks was (4.1%), cold water (0.4) ethanol/ cyclohexane (1.1), ethanol extractives (1.2%) and 1% NaOH (27.6%) were rather high. The cellulose (Kurschner-Hoffer) was (48.5%) The lignin content was (15.3%) which was relatively moderate. The use of 0.1% AQ enhanced the delignification in the three trials applied. The screened yield increase with increase of chemical dose applied while the rejects decrease. When 21% NaOH was applied, the screened yield was 32.2% with negligible amount of rejects, however with lower alkali charge 18% the screened yield was decreased to 28% with very low rejects 1.5%. on the other hand rejects were increased to 7% when 15% NaOH was applied with very low screened yield 19%.The pulps produced from okra soda-AQ are suitable for production of printing and writing papers and it is advisable to use them in blending due to good papermaking properties.

Keywords: *Abelmoschus esculentus* stalks, Fiber dimensions, Chemical composition, Soda-AQ cooking, Pulp properties

High lights

- Okra fruits is important vegetable but its stalks is burned in tropical and suptropical areas
- Soda-AQ cooking is suitable methods for pulping the agricultural residues.
- There is seldom literature on pulping of okra stalks and rational utilization is highly needed.
- In large areas in Asia and Africa, these stalks are burned and treated as waste.
- Production of paper pulps in good paper properties with low lignin content (kappa number) and improved viscosity could be expected.

Background

Non woody plants and agricultural residues as flax, cotton, bamboo and cereal straw were used extensively in pulp and paper production. However okra *Abelmoschus esculentus* stalks could be one of promising non woody plants in paper production [1, 2]. The family of okra (*Abelmoschus esculentus*) and cotton (*Gossypium hirsutum*) is Malvaceae, okra is one of the oldest cultivated crops, it was recorded by the Egyptians in 1216 A.D., however there was strong evidence, okra was cultivated

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earlier than that in Ethiopia, some other reports considered India as center of origin [3–6].The estimated annual production in the world was about 4.8 million tons; and the share of India (4.528 million tons), Nigeria (0.826 million tons), Sudan (0.249 million tons), Pakistan (0.116 million tons), Cote d'Iviore (0.115 million tons), Egypt (0.100 million tons) and Iraq (0.153 million tons) [7]. Okra is important food supplement in tropical regions and has nutritional and medicinal values, it is used traditionally in treating diseases as diabetes, pyretic syndrome, and spasmodic [7–11].

Stalk fiber of okra is characterized by high lignin, low α-cellulose, and shorter fiber length, while bast fiber is characterized by low lignin, high α-cellulose, and longer fiber length [12] the pulps obtained from okra stalks is good enough [13] with a high carbohydrates content (65.0%), low lignin contents (20.5%) and similar to chemical components of non-woody plants indicating okra stalks as promising source for papermaking utilization, in addition to that okra fibers can be applied as reinforcement in polymer composites [14–16].

The Anthraquinone (AQ) acts as redox catalyst during alkaline pulping, reduce aldehyde end groups of the carbohydrates, forming carboxylic acid, inhibits the alkaline depolymerization results in an increased yield. The soda-AQ cooking suitable for pulping non-woody plants and agricultural residues from economic and environmental points of views [17, 18].

The present study focused in evaluation the characteristics of Sudanese *Abelmoschus esculentus* okra stalks in terms of fiber morphological properties, chemical composition, Soda-AQ pulping and papermaking characteristics and therefore indicate their suitability for paper pulp production.

Methods

Abelmoschus esculentus okra (Fig. 1) stalks were selected randomly according to TAPPI Standards [19] from Marenjan area in Gezira state, central Sudan is characterized with clay soil with low to moderate annual rainfall. The length of stalks was 2. 5-3 m tall and 2-2.5 cm in diameter. The prepared raw materials were packed in plastic bags and transported by bus to National Centre for Research (NCR) in Khartoum state. Leaves and steams were separated manually, and then stalks were chopped into 2-4 cm length. Chips were left for air drying according to TAPPI standard (T 257-cm- 02) [19]. The air dry samples of core and bark of okra were manually separated and chopped to 3–5 cm length. Fiber dimension evaluation done after maceration with a mixture of 30% hydrogen peroxide and acetic acid (1:1) for core and bark parts separately and was carried out microscopically at 300x and 400x magnifications according to (TAPPI-232 cm-01) after staining with aqueous safranin [20, 21]. The raw materials was characterized chemically in accordance with applicable TAPPI standards for different components, namely: preparation for chemical analysis (TAPPI-264-cm-97) sampling and testing for moisture (TAPPI-210 cm-93) lignin (TAPPI-222), alpha cellulose (TAPPI-203 OS-61), hot water soluble (TAPPI-T- 207), Pentosans (TAPPI-223-cm-01) solvent extraction of wood (TAPPI-204), and ash (TAPPI-212) [22].

Fig. 1 *Abelmoschus esculentus* okra plant

According to the suggestions of other authors, the operation conditions used during soda-anthraquinone cooking of okra were selected, as follows: maximum temperature 165C^0, time to maximum temperature 60 min, time at temperature 120 min, anthraquinone concentration 0.1% and liquid/okra stalks ratio was 5. Representative sample of a portion prepared chips for pulping trails was ground in a star mill and the 40X60 mesh fraction was used for chemical analysis according to TAPPI standards and Obolenskaya [23].

All the conditions were constant except for soda concentration as (NaOH, 15-21% on oven dry weight of okra stalks) for optimization of cooking and the concentration of alkali was the most effective variable. After pulping, the cooked material was washed with water at room temperature to remove the residual cooking liquor and was fiberized in a disintegrator at 1200 rpm for 30 min, at room temperature and l0% consistency. The pulp was then beaten in Valley beater according to TAPPI-200-sp-01 freeness of pulp (Canadian standard method TAPPI 227om-99), Kappa number (TAPPI-236 om-99), viscosity (TAPPI-230om – 99), physical testing of pulp sheets (TAPPI-220-sp-01). Conditioning of testing atmosphere (TAPPI-402-sp-98), Burst strength (TAPPI-403om-97), Tensile (TAPP-404-cm-92), tearing resistance (TAPPI-414 om-98), folding endurance (TAPPI-423 cm-98) and density (TAPPI258-om-02) and ISO standards [24].

The chemical charges for all cooks at different active alkali levels were calculated as NaOH on oven dry raw

material. All cooking conditions were kept constant (the pulping variables time to reach maximum temperature, time at maximum temperature, maximum temperature, the concentration of AQ on oven dry okra stalks and Liquor to okra stalks ratio, as shown in (Table 1) with chemical charges as NaOH were varied between 15 to 21%. Pulping was carried out in 7 l electrically heated digester with forced liquor circulation.

Results

The fibers from the two okra stalks studied (core and bark) were in the range of hardwood fibers, with short fiber length, especially the core (0.66 mm) as shown in (Table 2), with more or less moderate walls, narrow lumen and fiber width. The fiber width of bark was medium –narrow and in the hardwoods range (10-35 μm) the bark fiber has wall thickness (6.2 μm) could be classified as medium thick (Fig. 2).

The ash content of *Abelmoschus esculentus* okra stalks was rather high (6.3%) as indicated in (Table 3), but typical for tropical non-woody plants. The silica content was comparatively high as usual for such non-woody raw material. However the silica content was rather high (1.6%) so there is some problems during cooking. The hot water extractives from okra stalks was (4.1%), cold water (0.4) ethanol/ cyclohexane (1.1), ethanol extractives (1.2%) and 1% NaOH (27.6%) were rather high due to the presence of many soluble polysaccharides and phenolic compounds.

On the other hand they are an indication of easy access and degradation of the cell wall materials by weak alkali. The cellulose (Kurschner-Hoffer) was (48.5%) which meant good pulp yields at suitable alkali utilization. As Obolenskaya, [21] mentioned that the kurschner-Hoffer values are usually 4-7% higher than alfa-cellulose. The lignin content was (15.3%) which was relatively moderate. This should result in moderate cooking chemical charges and a short cooking cycle. Cellulose to lignin ratio was higher than 2 (3.2) and predicted normal pulping with alkaline methods [25]. The presence of water-soluble hemicelluloses in pulp fibers increases their swelling tendency and water absorption during beating as indicated by relatively high pentosans content (19.3%).

Table 1 *Abelmoschus esculentus* okra stalks: Pulping conditions

Cooking conditions	Soda-AQ1	Soda-AQ2	Soda-AQ3
Active alkali charge as NaOH %	15	18	21
Anthraquinone, %	0.1	0.1	0.1
Liquor to okra stalks ratio,	5	5	5
Maximum temperature, ^{0}C	165	165	165
Time to maximum temperature, min	60	60	60
Time at maximum temperature, min	120	120	120

Table 2 *Abelmoschus esculentus* okra stalks: fiber dimensions and morphological indices. Fibers after cooking conditions presented in Table 1

Fiber dimensions	Measured value of core	±SD	Measured value of bark	±SD
Fiber length, mm	0.66	0.09	0.92	0.08
Fiber width, μm	17.6	0.94	21.7	0.89
Lumen width, μm	6.4	0.95	9.3	0.97
Wall thickness, μm	5.6	0.41	6.2	0.22
Morphological indices				
Runkel index	1.8		1.3	
Wall fraction	63.6		57.1	
Flexibility coefficient, %	36.4		42.9	
Rigidity coefficient, %	31.8		28.8	
Felting power (slenderness)	37.5		42.4	

Anthraquinone (AQ) is a powerful redox-catalyst in alkaline pulping especially when non-woody raw material is cooked. The results of soda-AQ cooking of okra with 15-21% NaOH showed in Table 4. Use of 0.1% Anthraquinone (AQ) enhanced the delignification in the three trials. The screened yield and rejects were indicated in (Fig. 3), thus screened yield increase with increase of chemical dose applied with the rejects decrease, during cooking with alkali charge 21% as NaOH it seemed no or negligible amount of reject whereas during 15% NaoH trial about 7% rejects with lower degree of delignification (kappa number 29.6). Good viscosity, kappa number when high chemical charge applied (21%). However at lowest alkali dose 15% NaOH, highest kappa number (29.6), and lowest viscosity 1010 ml g^{-} 1. The brightness for the three cooks were more or less the same. According to Gierer [26, 27] the intermediate formation of quinonemethide is preceded by the cleavage of β-ether aryl-ether bonds.

The strength properties of three trails pulps (Table 4) indicated in general the slight difference in strength

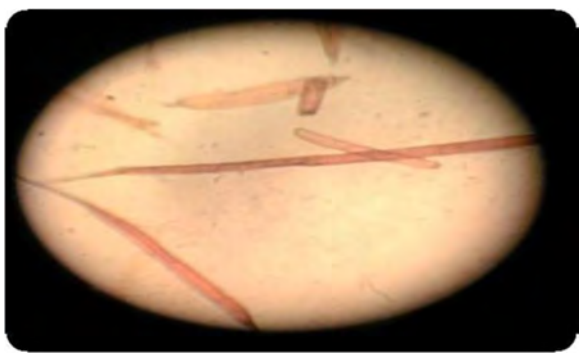

Fig. 2 *Abelmoschus esculentus* okra stalks, fiber structure under microscope

Table 3 The Chemical components of *Abelmoschus esculentus* (okra) whole stalks

Chemical Composition, %	Whole stalks
Ash	6.3
Total Silica	1.6
Solubility in	
Hot water	4.1
Cold water	0.4
Alcohol (Ethanol)	1.2
Ethanol: cyclohexane(1:2)	1.1
1% NaOH	27.6
Kurschner- Hoffer cellulose	48.5
Alfa-cellulose	43.7
Pentosans	19.3
Lignin	15.3
Total Extractives	9.3
Cellulose to lignin ratio	3.2

properties with relatively higher of 21% soda-AQ pulp properties.

The highest viscosity was for 21% soda-AQ which reflected positively for all strength properties especially at high degree of freeness except for tear resistance. Due to adverse effect of the large amount of fines produced, all soda-AQ had low initial brightness since alkali treatment induces darkening of the pulp as shown in (Fig. 4).

Discussion

The lumen width of the bark (9.3 μm) indicated that these fibers should collapse easily upon beating, resulting in improved interfibre bonding in the pulp and producing compact and low porosity sheet. The core had lower fiber dimensions and inferior morphological indices, indicating the bark as better pulpable material. This clearly showed by Runkel index and flexibility coefficient. Both two types of fibers could be classified in third group of Istas Classification [28], characteristic for fibers with fairly thick walls and rather narrow lumen. Although there is still controversy in accepting morphological data in predicting the properties of the pulp, the multi-regression technique seems undoubtedly valuable in showing which morphological characters are important in the pulp properties.

The amount of ash and silica content showed that ash composed of a high proportion of inorganic components other than silica. This should increase the alkali consumption and may cause some problems at waste liquor recovery [29]. The high silica content causes difficulties in the regeneration of chemical pulping, but might be beneficial in total chlorine free (TCF) bleaching where sometimes silicates are added for stabilization of cellulose. A high hot water soluble content also indicated a higher accessibility of the cell wall components to pulping liquor. Therefore, pre-extraction of the raw material before cooking might help to decrease the chemical consumption and obtain useful substances.

Table 4 Pulping results and strength properties of hand-sheets obtained from *Abelmoschus esculentus* okra stalks

Pulping Process		15% Soda-AQ	18% Soda-AQ	21% Soda-AQ
Pulping results				
Kappa number		29.6	27.8	22.2
ISO brightness, %		19.6	20.4	22.3
Viscosity, ml g^{-1}		1010	1045	1065
Strength properties				
Initial pulp freeness,	SR			
Apparent density, g cm^{-3}	25	0.52	0.61	0.61
	50	0.62	0.65	0.67
Breaking length, Km	25	7.5	8.1	8.1
	50	8.1	8.3	8.5
Tensile index, N m g^{-1}	25	40.1	43.2	45.3
	50	60.2	61.4	63.1
Tear index,, m N m^2 g^{-1}	25	7.8	7.4	7.2
	50	5.6	5.6	5.7
Burst index, K Pa m^2 g^{-1}	25	2.2	2.1	2.3
	50	3.6	3.9	3.7
Folding endurance, $\log_{10}$n	25	06	0.9	0.9
	50	1	1	1.1

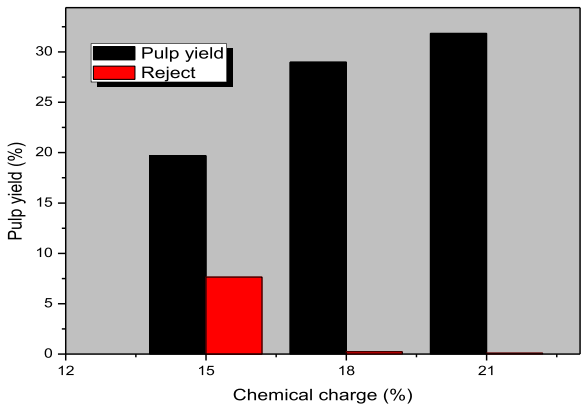

Fig. 3 Screened yield and rejects of *Abelmoschus esculentus* okra stalks versus chemical charge% as NaOH

It is well known that tensile strength, burst and double folds increase with increase in freeness level, this clearly reflected during application of freeness 25 and 50. The high tensile strength, which mainly based on the good bonding ability of the fibers, results from high pentosans content due to the high stability of xylan and cellulose in the outer cell wall layers. The high hemicellulose content also improved the beating [25, 29].

In paper production the primary role of hemicelluloses is to imbibe water and thus to contribute to fiber swelling. This leads to internal lubrication of the fiber and improves its flexibility and ease of beating. The swelling pressure contributes to loosening of the structure and fibrillation. The hemicelluloses being amorphous and adhesive in nature tend to hornify as the fiber shrinks and dries. Thus hemicelluloses serve as a matrix binding substance between fibers in a pulp. Burst and tear strengths are highly correlated to a high proportion of hemicelluloses [30, 31].

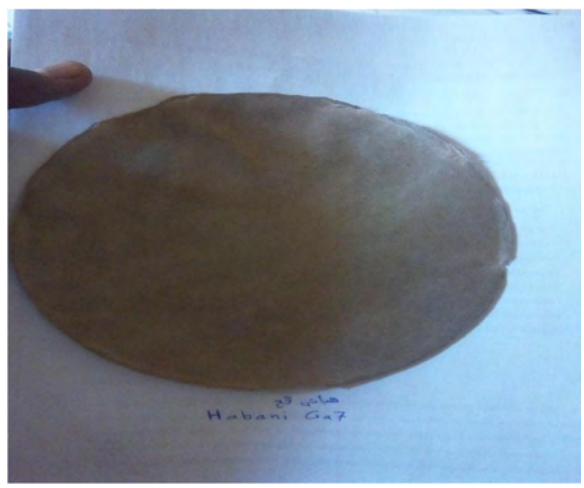

Fig. 4 Prepared hand sheet from pulp of *Abelmoschus esculentus* okra stalks for physical properties evaluation

The dominating source of darkening, however is definitely the condensed and degraded lignin. Nevertheless, too high alkali concentrations must be avoided especially at the end of the cooking procedure. Otherwise, over-proportional degradation and dissolution of hemicelluloses and cellulose might take place, resulting in reduced yield and viscosity. The combination of low yield but good papermaking properties suggested that okra pulps could be used in blends with the short-fibered hardwood pulps.

Conclusion

The okra stalks has multiple purposes and could be promising raw material for pulp and paper production as agricultural waste. The use of soda-AQ pulping accelerated the delignification and beating rate, increased yield and viscosity and gave pulp with superior properties and highest alkali charge. The screened yield of 32.2% was achieved with negligible amount of rejects, at bleachable Kappa number 22.2 and viscosity 1065 ml g^{-1} during application of high alkali charge 21% as NaOH. Decreasing this alkali charge to 18% gave screened yield 28% with very low rejects 1.5% kappa number 27.8 and viscosity 1045 ml $g^{-1.}$ The rejects were increased to 7% during application of 15% NaOH with high Kappa number 29.6 and viscosity 1010 ml g^{-1}. The fiber dimensions and morphological indices represented okra stalks as in range of tropical non woody plants. The chemical composition of okra gave indication of suitability of soda-AQ cooking for these agricultural residues. The pulps produced are suitable for production of printing and writing papers. Due to relatively low screened yield and good papermaking properties, it is advisable to blend these pulps with other high yield pulps.

Additional file

Additional file 1: Physical properties of Abelmoschus esculentus (Okra plant). (DOCX 795 kb)

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Availability of data and materials
We have already included most of data in the manuscript, the lab and data, some data not included in the manuscript attached as Additional file 1.

Authors' contributions
SHO and SKS were carried out, supervised the chemical analysis, soda-AQ pulping and revised the draft manuscript. OTE did the fibers dimensions and

their analysis, review the draft manuscript, SDM supervised and carried out the evaluation of paper properties and revised the draft manuscript. TOK wrote the draft manuscript, designed the study and supervised the work. All authors read and approved the final manuscript.

Ethics approval
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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PAPERmaking!

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5 Tips to Help You Protect & Grow New Ideas

Lion cubs are born tiny, blind, and helpless. Weighing just 3 pounds and with their eyes shut tight for a week or longer after birth, the baby lions only get a chance to become apex predators because their mothers protect and nurture them until they're old enough to hunt and survive on their own.

New ideas may be even more vulnerable than lion cubs, as most organizations don't have fearsome mothers guarding them.

From the humble sticky note — now available in a near-infinite variety of colours and sizes — to the camera in your phone, ideas that are now ubiquitous were once small and vulnerable, their potential unknown.

Even leaders who value creativity often quash new ideas before they've been given a fair hearing.

When we surveyed global executives, 94% said innovation was important or very important to their organizations. But only 14% said their organizations were good at innovation.

Doing a better job of nurturing new ideas is a good place to begin addressing that innovation gap.
How to Protect a New Idea

https://www.ccl.org

In *How to Treat New Ideas*, authors David Magellan Horth and Michael T. Mitchell draw on decades of personal experience, data, and lessons from scores of organizations around the world. They identify 5 tips that can help companies nurture new ideas:

1. Resist the instinct to kill a new idea.

Leaders need to understand that their first reaction to a new idea is typically "fight or flight." When an idea that is new, foreign, or maybe even odd emerges, we're programmed to fight it or resist it, perhaps maybe even ignore it in hopes that it will go away.

Steve Wozniak, cofounder of Apple, worked at blue chip firm Hewlett-Packard before he joined forces with Steve Jobs. He reportedly went to his HP bosses 5 times with the idea of building a personal computer; 5 times they said no.

This instinct comes from a finely tuned and powerful part of our brains—the limbic system. The limbic system is one of the larger and most ancient part of our brains. It's the part of our brains that helped insure that we survived as a species.

Where would we be without our limbic brains and the deeply embedded "fight or flight" response? Likely, our ancestors would have been extinguished as they chose to try to hug some prehistoric beast rather than fight it off with a club or run for their lives. The drive to fear or run away from a particularly novel idea is a natural reaction, and one that's so powerful it overwhelms us.

But leaders who want to encourage innovation should take a deep breath and allow themselves and their teams to think through the idea before rejecting it. They must watch out for signs they are subconsciously sabotaging innovation.

2. Practice innovation thinking.

Innovation, by definition, means doing things differently. That creates risks and uncertainty—often considered enemies of a successful business.

The logical, analytical thought processes we rely on usually are not very helpful in the early stages of innovation. The key is to practice innovation thinking.

That means listening to your intuition and asking "What if?," believing there's always a better way.

There's nothing wrong with traditional business thinking—it's required to manage a modern organization. But when a new idea comes along, it's time to switch into innovation thinking mode. Innovation thinking gives new ideas the oxygen they need to continue developing.

3. Frame and clarify the idea's purpose.

Now that you're starting to dig into the possibilities of a new idea, how do you give that new idea some concrete direction? One important technique is to frame and clarify the idea's purpose. In other words, what might this be good for?

Successful innovators will often ask themselves what problem a new idea can help solve or what opportunity it might address. Sometimes this takes a little patience.

When 3M scientist Spencer Silver created a "low-tack," pressure-sensitive adhesive instead of the super-strong glue he'd been trying for, he couldn't imagine what it would be good for. When a colleague mentioned a problem with the slips of paper he used to mark songs falling out of his Sunday hymnal, Silver had a solution.

The result was 3M's Post-it notes, now a staple item in every office supply closet.

4. Use the POINt technique.

At this point, the promise of at least some new ideas might be starting to clarify. But to sharpen that promise and test it a bit more rigorously, you can use the POINt technique developed by Pfizer executive Bob Moore.

POINt stands for:

Pluses: Praise the idea and consider what's good about it as presented.
Opportunities: Picture the opportunities and benefits that might be realized if you implemented the idea.
Issues: While you don't want to kill new ideas, it's OK to consider some of their challenges and limitations.
New thinking: Use new thinking to develop solutions for the issues you've raised about the new idea.

Nurturing new ideas doesn't mean being naive about them. Rather, it means considering, with clear eyes, both the opportunities and challenges a new idea presents, and thinking through potential solutions to those challenges.

5. Connect ideas to ideas.

Not every new idea will become a fully realized product or business solution on its own. But that doesn't mean those ideas don't have value.

One useful exercise to get more value out of new ideas is to combine previously unconnected ideas. Consider the Sony Walkman, which combined two concepts: pre-recorded cassette tapes and a device small enough to carry around. For the first time, people could take their music wherever they went.

Brainstorming, mind-mapping, and forced connections are techniques that can be used to connect one idea to another.

Learn more about our guidebook, *How to Treat New Ideas*.

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Slowdown in Spring showers

Drivers are being urged to take care on the roads if they get caught in a sudden Spring shower. The motoring experts at LeaseVan.co.uk have put together their top tips for driving in wet conditions during Spring.

Tim Alcock from LeaseVan.co.uk said: “Drivers always need to be cautious of changing weather conditions throughout the year but during Spring, heavy showers can pose a big risk. If drivers get caught out, top priority is to slow down, leave plenty of stopping room and make sure the car windscreen is kept mist free to help with visibility. Visibility can be quickly reduced during a sudden downpour and if there’s somewhere safe to pullover and wait out the shower, then it’s often worth doing. Wipers can struggle to keep up with heavy rain. Drivers also need to be mindful of other road users, the risks caused by flooded routes and excess surface water.”

https://www.leasevan.co.uk/

Here are LeaseVan.co.uk 's tips for driving in Spring showers.

1. Vehicle maintenance
Check your tyres and make sure they're properly inflated and have good tread to grip on slippery road surfaces.

2. Stopping distance
It takes longer to stop when the roads are wet and slippery. Allow at least double the usual separation distance between you and the car in front.

3. Slow down
Keep your speed down when driving in showers. Wipers struggle to keep up in a heavy downpour so your visibility will be reduced. Drive slower and you'll have more time to react to hazards.

4. Put your lights on
Use dipped headlights so other road users can see you.

5. Stop
If the shower is really heavy and visibility is poor, pull over somewhere safe and wait out the rain.

6. Flooded roads
If the Spring showers are heavy, you may find yourself on flooded roads. If it looks too deep stop, turn round in a safe place and find an alternative route.

7. Aquaplaning
This happens when your tyres lose traction from the road. Roads with lots of surface water pose the biggest risk. Reducing your speed will help.

8. Pedestrians and cyclists
Be mindful of other people on the road, particularly cyclists and pedestrians. If you splash a pedestrian, you could face a fine of anything from £100 to £5,000.

9. Steamed up car
Make sure any heat is going straight on to your windscreen to stop it getting misted up and to keep visibility good.

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Why Mentoring & Sponsoring Are Important—Particularly for Women

Women must advocate for themselves if they want to move their careers forward. But to succeed, they can't go it alone. All successful leaders need a network of champions—including mentors and sponsors.

"The people around us have the ability to either support or hinder our growth toward the leaders we can be," says CCL's Jennifer Martineau, co-author of Kick Some Glass: 10 Ways Women Succeed at Work on Their Own Terms.

"If people don't have access to the relationships important to leadership success, they're missing out."

And in fact, women are missing out.

https://www.ccl.org

Women outnumber men at almost every educational level and are about half the workforce in most countries, but:

- Women hold just 24% of senior management roles.
- Women make up a mere 3% of Fortune 500 CEOs.
- Only 1 in 18 women earns a 6-figure salary in the US—versus 1 in 7 men.
- For women of colour, this wage and leadership gap is even wider.
- Progress has been slow or stagnant in the percentages of women reaching senior, top, and director-level positions in all countries in which benchmarking studies have been conducted.

Yet the business case for advancing women leaders is compelling. In addition to doubling a company's talent pool, recruiting women increases financial performance:

- Fortune 500 companies with the highest representation of women on boards financially outperform those with the fewest female board members.
- A recent Gallup study found that gender-diverse business units have higher average revenue than less diverse business units.
- Having larger percentages of women in an organization also predicts greater job satisfaction, higher levels of employee engagement, and decreased rates of burnout—for all workers, regardless of gender, age, ethnicity, or leadership level.

In short, having more women in the workplace is associated with positive outcomes for both women and men.

So, how can women advance their careers, and how can organizations ensure they're making the most of all their talent?

A key strategy is to prioritize the mentoring and sponsorship of women—particularly by influential (often male) leaders.

Both mentors and sponsors are critical to helping aspiring women leaders gain the perspective and connections they need to take on larger roles and advance their careers.

What's the Difference Between a Mentor and a Sponsor?

By the time they reach mid-career, most leaders can name a handful of advisors—bosses, coaches, colleagues, and friends—who've helped them build confidence and develop needed skills. These advisors may be mentors and/or sponsors.

While both guide professional development, there are important differences between mentors and sponsors:

	MENTOR	SPONSOR
Role	Experienced person at any level	Senior leader in the organization
Goal	Provide guidance for career choices and decisions	Use influence to help employee obtain high-visibility assignments
Who drives the relationship?	Both mentee and mentor; requires mentor to be responsive to the needs of the "mentee"	The sponsor, who chooses to advocate for "sponsoree," including behind closed doors with other leaders
Actions	Helps mentee determine paths to meet specific career goals	Advocates for sponsoree's advancement; champions her potential

Mentors vs. Sponsors

Mentors provide guidance and support, whether around a specific need or for ongoing development. They listen to their mentees' experiences and give constructive, direct, and honest feedback.

Our research with the Leaders' Counsel found that people who are mentored:

- Are better prepared for promotions and have higher success rates;
- Stay with their organizations longer;
- Feel more satisfied with their jobs and careers; and
- Rate higher on performance measures.

We also found that "mentees" have greater impact in their organizations, are perceived as being more innovative and creative, show higher resilience to setbacks, and have stronger networks.

A mentor may also be a sponsor—but not necessarily. A sponsor is a specific type of mentor who goes above and beyond giving advice.

Sponsors are advocates who actively work to advance the career of their "sponsoree," touting their accomplishments and potential, connecting them to others in their network, and recommending them for bigger roles. A sponsor pushes their "sponsoree" to take on challenging assignments and actively advances their career progression—including in off-the-record or closed-door meetings with other leaders.

Since the people who can advocate and create opportunities for others have some level of authority in an organization, they are likely upper-level leaders—people in power. And as the statistics above noted, in most organizations, that pool of influencers is still primarily male.

So "while sponsors are important for men, they are critical for women," says Martineau. "Yet men are more likely than women to have sponsors."

Mentoring at all career stages is important, but without sponsors who take that next step to advocate on their behalf, women—especially women of color—are at a disadvantage.

Why Is There an Imbalance in Sponsorship Between Men & Women?

There are several reasons why more men are sponsors and more men are sponsored.

Like attracts like.

Since people naturally tend to gravitate to other people who are like them, male leaders may unconsciously be inclined to mentor and champion other men.

Similarly, women may not feel comfortable asking somebody several levels up—especially someone who doesn't look like them—for advice or sponsorship. So even with no other factors at play, more men than women are sponsored, and leadership power structures remain largely unchanged.

Unconscious bias also plays a role.

"Historically, images and ideals of leadership have been associated with stereotypically 'male' qualities, and so because of that, women are less likely to be perceived as 'leadership material,' as compared to men," notes senior CCL researcher Cathleen Clerkin.

Research shows that women face a double bind of being seen as competent or likable—but not both.

Research has also found that women receive fewer stretch assignments and more vague, personal, and unhelpful feedback than men—preventing them from getting clear information about their performance that would push them to learn, grow, and improve.

Assumptions are problematic.

"Often, women have the right qualifications and the personal readiness but are not considered for a promotion or critical assignment," says Laura Santana, who works closely with female leaders in CCL's Women's Leadership Experience and other leadership development programs.

"People make assumptions about women's capabilities and interests and then make decisions for them:

- She's too nice; she wouldn't want this job…
- She has young children; the travel schedule will be too demanding…
- She won't want this promotion; she'd have to relocate her family…
- She hasn't done this before; she won't feel up for the challenge…

"These assumptions may not be conscious or spoken, but they cause women to be overlooked for roles they would be great at."

"Queen Bee Syndrome" contributes, too.

The few women who have broken through the glass ceiling often still find themselves feeling stuck because of gender bias. While many women do sponsor, promote, or support the career advancement of other women, those who don't are sometimes called "queen bees" and are considered unsupportive of other women.

But our research has found that when women executives do advocate for diversity and promote other women, they receive lower competency and performance ratings. So it's understandable that senior women may hesitate to advance the careers of more junior women—it may feel as if it comes at too great a personal cost. Men who sponsor or promote women are not similarly penalized—and may even be rewarded for supporting diversity.

To mitigate power and bias, both men and women in positions of power should mentor and sponsor talent—regardless of gender. With awareness of the reality of power and bias in everyday actions, leaders should check their thinking, adjust as needed, and call out bias whenever they see it.

Aspiring Women Leaders: Don't Go It Alone

Think you might need a mentor or sponsor? If you don't already have one, the answer is yes.

"You absolutely need mentors and sponsors! You just need them for different things at different times," says Kelly Simmons, who developed CCL's Advancing Technical Women program.

"In new roles, you need to learn new skills, find out what you don't know, and learn. If you're not moving ahead or are feeling stuck or confused about your situation, get help—it's not all on you. Don't put all the responsibility on yourself to advance in your career or succeed in a new role."

You might be thinking:

- "If I do a good job, people will notice. If I do just a little more, work a little harder, it will happen. I don't need a mentor or sponsor."
- Or, "I want to earn that promotion myself; it feels like cheating or pulling rank if I have a senior decision-maker on my side."
- Or, "The timing isn't right, right now; I'll go for the next opportunity."

Many women wrestle with these same concerns.

But without access to the people who can set you up for the experiences you need—and support you through the inevitable challenges—your career progress is likely to stall, leading to short-term frustration and long-term consequences.

Wherever you are in your career, you need a network of champions—colleagues but also mentors and sponsors—to help you shift the way you think and act.

Can Men Really Be Good Mentors to Women?

Yes! Men in leadership roles are ideally positioned to strengthen the leadership pipeline in their organizations by helping to retain and advance talented women.

Plus, mentoring and sponsoring others offers benefits to both parties. Research from our work with the Leaders' Counsel found that leaders who mentor and advocate for others have:

- A stronger commitment to their organization;
- An enhanced perception of their leadership by others; and
- A greater sense of well-being, including increased job and personal satisfaction.

Through mentoring and sponsoring, our research also found you can and build and enhance your own networks, more quickly access job-related and organizational news, and become a better leader yourself. You also gain a chance to reflect upon and articulate your own expertise and experience—something you may not take time to do otherwise.

Some men think they wouldn't be good at mentoring someone who is different from them. Others have said they're wary of perceptions or misinterpretation of their work relationships with women.

But if you're a man who is hesitant to seriously mentor or sponsor a woman, don't say no yet. Check out Athena Rising: How and Why Men Should Mentor Women, a book by two men and take advantage of our free resources to help you get started mentoring or sponsoring.

Take some time to learn how you can make a difference to the talented women around you—and help your organization thrive.

What Are You Waiting For?

Ideally, women would have the mentors they need to help them navigate their careers, and senior leaders would see their skills and potential and enthusiastically sponsor them. But, since this isn't happening by default in most organizations, there's a leaky pipeline of talent.

What can be done?

Establishing a mentoring or sponsoring relationship may not be easy to do. It can feel a bit awkward and confusing to get started, but it doesn't have to be.

We offer our free mentoring resources for aspiring women leaders, potential mentors and sponsors, and HR executives, including:

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8 Networking Skills that Every Professional Needs to Have

Gregory Ciotti

When it comes to most advice on networking, many business publications place too much emphasis on "what's easy" rather than "what works".

This has only been amplified by the recent dominant presence of social media.

With useless "tips" like:

'Set up a LinkedIn profile!'
'Get active on Twitter!'
'And… um, email people I guess!'

…it's no wonder people get frustrated when they look for information on how to properly network with others.

Networking also has a somewhat 'sleazy' association to it: people picture the grease-ball haircut on the really loud guy with 800 business cards who's all talk and no action.

The thing is, good networking does not have to be this way, not at all.

So set aside your bias against networking, and step into 'natural networking' for building real relationships with people who can help you get where you want to be.

https://www.bidsketch.com

Networking Skills that Work
If you've struggled with sincere networking in the past (as I have), definitely give this list a run-through and take notes when you notice an area where you can improve your own networking habits.

As a last bit of advice before we get into the list, be sure to network outside of your industry from time to time!

We often get so focused with business related networking that we never reach out to people who may be doing cool stuff in other fields of work… and you never know what may come of it.

1.) Make Networking a Regular Activity

This is my solution to one of the most common questions about networking: how do I get started?

If you're worried about jumping in to networking or how you can keep it as a habit, just follow this one simple strategy — every other day (or every day, or twice a week, etc.), reach out to one person who's work you find interesting.

That's it!

Don't ask for anything (more on that in a minute), just reach out with an email that shows your mutual respect/interest in what they do, and that you just wanted to say "Hey" to a person doing cool things.

That way, you have no fear of coming off as sleazy/begging, will consistently reach out to new people (not just for a week before you quit), and you'll likely come across a lot of interesting folks in your industry, which is always a plus.

No more excuses!

2.) Stop Being an Internet Panhandler

As a guy who loves studying behavioral psychology, one of the most interesting topics to me is what exactly changes in people's personalities when they interact with others online. Not much has been published on the subject, but the online disinhibition effect is one that we all probably recognize in one way or another.

The point is this: People on the internet tend to lack diplomacy & tact, and one of the ways that this rears its ugly head is that people will ask for things on the internet that they'd never expect someone to give them in "real life."

While most people on the street would be hesitant to ask a stranger for $10, on the internet people will ask for THE WORLD and then get upset when you don't deliver!

As an example… when I recently wrote a huge article on productivity, I got a lot of good emails after it was published from people who enjoyed it (more on that in a bit).

On the other hand, I got a lot of TERRIBLE intro emails from people essentially demanding that I help them with their productivity problems. One guy even told me that he wanted a "quick" analysis of his productivity problems over an hour long Skype call!

"Sure thing, my time is apparently worth nothing to you so let me drop everything I'm doing and call you up!"

As freelancers, many of us know this feeling all too well, yet a lot of us still suffer from "internet pandhandler syndrome" when trying to network with people. I wrote in my previous post on freelance marketing about how I was able to land features on big publications through email, and I included a single tip that can help you avoid this annoying habit…

Don't ask for anything in the first email!

Genuine networking doesn't start with your hands out during the first contact.

3.) Know Who You're Reaching Out To

This should be a no-brainer, but if you've ever gotten an unsolicited email that felt like a spam message but actually wasn't, you know what I mean here.

The most important thing to remember here is that if you are trying to connect with an **influential** person, this becomes even more important — not because they are inherently more important, but because they probably have people trying to reach out all the time.

You can stand out by doing your homework and actually getting to know some facts about the person you're about to reach out to, beyond the "surface level" stuff that everybody already knows.

People reach out to me a lot of discuss content strategy, and I'm flattered when they bring up some work of mine that they saw on Help Scout, Bidsketch, or any other place I regularly appear.

As basic as that may seem, remember point #2… on the internet, everyone comes across as*: "Blah blah blah enough about you, let's get back to me!"*

Separate yourself from the pack and actually come prepared knowing about the person's passion projects, and I guarantee you'll get remembered.

4.) Use Positive Language

I actually talked about this in my list of customer service skills, and this is true for building proposals (as described in this example eBook about software development proposals), but it goes far beyond dealing with customers — it's great for networking too.

This is especially true when you consider that so much communication today is done via text, and it's hard to display emotions and other subtle cues without the other person's face being in sight.

For instance, compare these two similar requests…

"Hey. I want to do an interview with you on your new project by this Friday, we have very similar audiences."

vs.

"Hey, I'd love it if we could do a quick interview sometime soon on your new project, my audience loves your work."

While "saying" the same thing, you likely immediately realized that #2 was far more inviting and using positive language to get the same message across, but without the bluntness (which can be misinterpreted for rudeness via text) of the first example.

When in doubt about the tone of your message, it is best to keep this rule in mind and evaluate whether or not you are using positive language, there is essentially no downside (just don't be overly chipper or "Whoo hoo!" for every single message) and it is a great way to avoid communication problems that stem from using harsher language.

5.) Cultivate Your "Power" Contacts

As much as many people may not like to hear it, "All contacts are equal, but some are more equal than others."

You're going to come across people who become power contacts as you become more connected with those in your industry. These people will be the ones who are constantly introducing you to new/interesting contacts, referring you to others for more work, and just generally pushing your business forward.

I can name one supernetworker of mine in Leo Widrich, co-founder of the BufferApp.

Although we're both busy, I try to stay in regular contact with Leo, make contributing to the Buffer blog a monthly priority, and constantly make mentions of Leo wherever I post (hint hint).

These are simply the contacts you'll form where the "give and take" has reached a fairly high level, and you're both willing to support the other where possible.

Be sure to keep an eye on these people, networking isn't always Pareto principle in practice, but in many instances your most frequent contacts will be the ones that really matter.

You don't need to know the most people, just the right people.

6.) Learn How to Email

Real business gets done over email.

A tweet may get someone's attention, but when it comes to establishing real relationships, the conversation truly begins when you start the reciprocity via email.

That said, you should know how to write a good email, both during the "outreach" stages of networking and when you've already established a connection.

Let's break some advice down for each stage…

#1 — Outreach

When you're looking to initially get someone's attention, you need to tread carefully.

Here are 3 good pieces of advice for outreach emails:

- **KISS**: Keep it short, stupid. I wrote about this in my guide on How to Email Busy People, but the #1 killer in outreach emails is sending people a book when all they want is a paragraph. You're the one reaching out, so don't waste their time with a wall-o-text, 3 short paragraphs ought to do it.
- **Make it about them**: You can give a quick spiel as to why you're an interesting guy/gal to connect with, but since you're hitting their inbox first, make the first email mostly about them.
- **Find a mutual connection**: This could either be a mutual friend or a mutual interest, but one of the best ways to personalize an outreach email is to find a legitimate thing in common that you and receiving party have.

#2 — Established connections

Once you've established contact, the conversation begins to shift quite a bit (obviously). It's similar to when you make a new friend vs. talking to a friend you've had for 2 years, you're familiarity changes what you talk about.

That said, don't let your good connections go to waste over a bad email.

Here's how you can improve the next stage…

1. **NO CONSTANT PANHANDLING!**: That's right, this is making another appearance. If the only time you contact this person is to get something out of them, you're doing it wrong.
2. **Send them interesting emails**: What should you be emailing them then? Interesting content that they may enjoy, mentions that you've given them, insightful questions or thoughts that appeal to both of your businesses/interests, etc.

Pretty simple right?

Use email to stay in touch with those important people in your networks, staying connected is often much more important than getting connected.

7.) Don't Expect Anything

This "skill" is actually one of the most important of all, because with the right mindset you can usually avoid many of the big networking mistakes out there.

When you are always out to get something, you are not truly networking with people, you're just running a long-term manipulation game.

The RIGHT mindset is to know that creating a big network is the smart thing to do, but also understanding that whatever comes should just come, you don't need to actively be pestering your connections for everything.

It's great when a new connection works out from a professional standpoint, but it's hard to measure some other things that having a large network can bring, like…

1. More information & great conversation with smart people
2. Introductions to others
3. Creating a presence of being "that guy that everybody knows and likes"

Just because a connection doesn't result in more direct dollars in your bank account doesn't mean it was fruitless, and you shouldn't be pursuing connections with people just to wring something out of them.

Speaking of which…

8.) Burn Useless Bridges

Yikes, somewhat of a controversial point to place on a post about networking, no?

The thing is, **this skill is an absolute must to learn.**

Eventually, you're going to come across "leeches," people who you've connected with but don't see the relationship as give-and-take, more like, "*How much can I get out of you?*"

Networking is supposed to help you grow your business by meeting genuinely awesome people, not create a network of vultures who only reach out to you when they need something.

Cut these people off, and fast, you don't need anyone holding you back.

Note that this isn't the same as people who want to help you, but can't and don't ask much from you. This advice is for the greedy, those hitting your inbox with favour after favour that never gets returned.

PAPERmaking!

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101 Time Management Tips to Boost Productivity Every Day

John Rampton

For most of us, time management and staying productive is a daily struggle. Sometimes that's not the end of the world. But, if you don't address this sooner then later, the things you were supposed to do today get pushed to tomorrow, then the next day. Eventually, you could end-up several weeks behind.

That's not good for business or your stress-level. Thankfully, you can prevent that from happening by using these 101 time management and productivity tips. Let's start to gain yourself more time.

https://www.entrepreneur.com

1. Just breathe.
Here's an interesting fact from Tom Evans, host of the Zone Show podcast. A tortoise's life expectancy is around 120 to 140 years, while an elephant lives for around 80 to 90 years. Even though our own life expectancy is increasing, it used to be just between 50 and 60 years.

While there are a number of factors that influence the life expectancy of these animals, Evans notes that, "a tortoise breathes around four times every minute. An elephant breathes around eight times every minute and we breathe around 12 to 15 times every minute."

As such, Evans, suggests that if you want to change your relationship with time then you should start breathing more slowly. "To begin we need to use our diaphragm and to do belly breaths. This of course is how a baby breathes. We've just got out of the habit."

"Now you don't have to do it all the time but just doing seven to nine deep and slow breaths at the start of the day is enough to slow things down. You can also do it before any creative task or if you have been stressed. It works especially well if you are running late for a meeting. By breathing more slowly, we 'expand' time."

2. Measure twice, cut once.
My dad used to tell me, "Measure twice, cut once." This is actually a famous proverb for anyone involved in carpentry or building since it advices to do things right the first time around.

Double-check your work so that you don't spend the time going back and correcting your mistakes.

3. Turn off the TV.
It's been found that we spend eight years and ten months of our lives watching TV - plus an additional eight months discussing plot holes and characters. Instead of watching so much television, spend that time on higher-leverage tasks.

4. Eat the frog first.
"Mark Twain once said that if the first thing you do each morning is to eat a live frog, you can go through the day with the satisfaction of knowing that that is probably the worse things that is going to happen to you all day long," writes Brian Tracy.

"Your 'frog' is your biggest, most important task, the one you are most likely to procrastinate on if you don't do something about it."

5. Schedule according to energy.
Speaking of eating that frog, do that when you have the most amount of energy and focus - aka your "magic hours." This is typically 2.5 hours after you wake-up. By creating a schedule based around your energy you can create a routine that ensures your as productive as possible. Make sure to schedule out time on your Calendar.

6. Wake-up earlier.
Want more time? Then start waking-up earlier. This way you have the time to read, exercise, respond to emails, and plan out your day properly.

7. Keep a time diary.
A time diary a simple way to find out how you spend your time. By recording how you spend your time for a month or two, you'll see where you're wasting time and what influences productivity.

8. Make use of waiting time.
Let's say you have a doctor's appointment. Have something with you to do. This could be reading a book, catching up on correspondence, or writing your upcoming eBook.

9. Make a list and get it out of your head.
Don't let everything you have to do swirl around in your head. Jot them done so that it clears your brain and prevents you from getting overwhelmed.

10. Think "half-time."
For example, if you're cooking dinner, make the twice the amount and freeze half of it. This way you're not spending that time again preparing and cleaning your meal on another night.

11. Ditch commitments that waste your time, energy and attention.
One of the most effective ways to gain more time is to eliminate those commitments that are, well, a waste of your time. Identify these commitments that are unproductive and don't schedule them into your calendar growing forward.

12. Be decisive.
That time you spend flip-flopping on a decision could be spent on something that's actually productive. Make a decision, live with it, and move on.

13. Cross something off.
We're familiar with crossing items off to-do-lists. But, you should also start crossing off items that you're not going to do. This keeps your to-do lists from getting out of control. It also prevents you from overcommitting.

14. Lighten your cleaning standards.
Obviously you want your home and office to be clean and organized. But, settling on "dirt removal" instead of "spotless" will definitely save you a ton of time and energy in the end. For example, as opposed to scrubbing your shower stall every week, wipe it down everytime you use it.

15. Establish "maintenance days."
Group your cleaning, laundry, and errands on specific days. This way they're not lingering over your head when working on more pressing matters.

16. Schedule your work in batches.
Speaking of grouping, start batching similar tasks together. For example, spend one day solely dedicated to writing, another to meetings.

17. Combine efforts.
If you're volunteering or meeting a client for lunch, then run errands that are nearby This way you're cutting down on the time spend going back and forth all day.

18. Learn keyboard shortcuts.
Online users between the ages of 18 to 24 years old spend an average of 1,979 minutes online per month. With that in mind, it makes sense to learn keyboard shortcuts and touch type so that you can save some time when browsing online. Here are some Office 365 Calendar hacks, Yahoo Calendar tips and Google Calendar hacks to help along the way.

19. Shorten your emails.
Keep your emails short and to the point. I try to keep all of my emails under five sentences.

20. Delegate or outsource.
Instead of doing tasks yourself, delegate or outsource them to someone else so that you can focus on more important tasks.

21. Automate repetitive tasks.
There's also certain tasks, like scheduling meetings and recurring billing, that you can automate via software.

22. Schedule less.
I know what you're thinking. This is pretty obvious. But, you're probably spreading yourself too thin without even knowing it.

Review all of your activities and see which ones aren't helping your reach your goals. You should also look at the activities that no longer fit into your schedule.

23. Work four hours a day.
Science has found that you should only work four hours a day. This doesn't mean you can goof off the rest of the day. It's all about focusing on your most important tasks when you're most productive. Spend the rest of your days resting, practicing your skills, and completing less challenging tasks.

24. Stop multitasking.
Multitasking doesn't work. In fact, it takes longer to complete a task when we multitasks because our minds are shifting back-and-forth. Instead, focus on one task at a time. Train your brain to slow down a little. It's like running, the more train your body, the faster you'll become.

25. Don't beat yourself up.
What happens if you spend a Saturday morning binge-watching Stranger Things? Stop wasting your time feeling guilty about it. Sometimes that happens. Do your best not to make that a habit and move-on instead of living in the past.

To make the most of your time, here are tips for implementing a productivity system.

26. The "Pomodoro Technique."
The "Pomodoro Technique" is where you use a timer and schedule short breaks, usually five minutes, after 25 minutes of focused work.

27. Seinfeld's "Don't break the chain" method.
Jerry Seinfeld would use a wall calendar and red marker to stay focused. He would cross out the days on the calendar when he wrote.

"After a few days you'll have a chain. Just keep at it and the chain will grow longer every day. You'll like seeing that chain, especially when you get a few weeks under your belt. Your only job next is to not break the chain."

28. David Allen's "two-minute rule."
According to David Allen, author of the best-selling Getting Things Done, if a task takes under two-minutes to complete -- do it now -- so that it's out of the way.

29. Break your day into five-minute slots like Elon Musk.
How does Elon Musk run both Tesla and SpaceX? He breaks his entire day into five-minute slots - even his lunch. Doing so keeps him productive since it ensues that he stays on-track and doesn't waste his time.

30. Jay Shirley's "Must, Should Want Method."
Here's a simple exercise from Jay Shirley. Every morning start your day by answering three questions: What must your do to create the most impact today? What should your do to build a better future? What do you want to do so that you can enjoy today and life more completely?

This gets your day started on the right foot, while increasing your productivity and happiness.

31. The Eisenhower Matrix.
This strategy was developed by Dwight Eisenhower. As explained by James Clear, "Eisenhower's strategy for taking action and organizing your tasks is simple. Using the decision matrix below, you will separate your actions based on four possibilities.

1. Urgent and important (tasks you will do immediately).
2. Important, but not urgent (tasks you will schedule to do later).
3. Urgent, but not important (tasks you will delegate to someone else).
4. Neither urgent nor important (tasks that you will eliminate)."

This matrix "can be used for broad productivity plans ('How should I spend my time each week?') and for smaller, daily plans ('What should I do today?)."

32. Airplane days.
"Some years ago, Hughes AirWest, a regional airline that once served the western U.S., hired a consulting firm to compare the efficiency of flying first-class with flying economy-class, and with working in a normal office," writes Brian Tracy.

"What they found was that one hour of uninterrupted work time in an airplane yielded the equivalent of three hours of work in a normal work environment. The keyword was ''uninterrupted.'' If you plan ahead and organize your work before you leave for the airport, you can increase productivity by accomplishing an enormous amount while you are in the air."

Of course, you can apply this to your daily life as well since it highlights the importance of planning and organization.

33. Follow your ultradian rhythms.
Coined by psycho-physiologist Peretz Lavie, ultradian rhythms are simply the natural rhythms that the body cycles through every 90-120 minutes. It can get pretty complex, but the idea is that you should concentrate when your energy levels are highest, but to rest when you feel drained.

34. The "big rocks system."
Based on the principles outlined by Stephen R. Covey, author The Seven Habits of Highly Effective People, this is where you schedule time for your most important priorities first by imagining them as "big rocks" filling a bucket or jar. If you start with "big rocks," and then put in sand or smaller rocks, all the gaps and cracks will get filled.

35. "No Meetings Wednesdays."
Companies like Facebook and Asana have a rule where there are no meetings on Wednesdays. Other companies have this rule for other days of the week, but the idea is the same. As opposed to wasting your time in a meeting, you can focus on important individual tasks. I've implemented this two days a week at my company Calendar. It works like a charm. We've seen an increase in code deployed and bugs by 14% since implementing this eight months ago.

36. The "anti to-do-list."
Instead of composing just a to-do list, create a to-done list where you write down everything you've already accomplished. It's a powerful way to keep you motivated when you need a boost.

37. Sunday check-ins.
There are some entrepreneurs and CEO's who briefly check-in with their teams on Sunday's. This way everything is ready to go on Monday morning. If you're a flying solo, you can schedule a Sunday check-in with yourself to make sure you have everything in-order for Monday and the rest of the week. We got this via Slack to make it easier for everyone and not be too formal.

What brings this altogether is focus and attention. The following tips can be a big help.

38. Get you environment right.
Work in an environment that has your auditory sweet spot (some prefer silence, others like background), organized, comfortable, free of distractions, and comfortable. Also make sure you have all the tools and resources readily available. And, paint your workplace a color that improves your productivity.

39. Turn off notifications.
Turn off all notifications for email, Facebook, Twitter, and other social media channels when eating that frog.

40. Plan for interruptions.
Try all you might, there will occasionally be interruptions. Plan for these in advance by having some flexibility in your schedule so that you don't get log jammed.

41. Shrink your mental deadlines.

If you believe it's going to take you an hour to do something, give yourself 40 minutes instead. By shrinking your mental deadline you'll work faster, as well as improve your focus.

42. Make a procrastination list.
This is a list of high-leverage activities that you can chip away at whenever you're procrastinating or have down time. Examples include reading industry magazines, organizing folders, or reviewing your contact lists.

43. Create a stop doing list.
This is a list of those bad habits that waste your time or hinder your productivity. Write these habits down so that you can develop a realistic plan to replace these bad habits with good habits.

44. Use Brainwave Entrainment.
Brainwave entrainment isn't a new development. In fact, it's a 100+ year old science that uses special tones and sounds to influence an individual's brainwave patterns. This has scientifically been proven to help change a person's state of mind.

45. Focus@Will.
Focus@Will is an app that not only removes distractions, it also increases productivity. How? It discovers the type of music to put your brain into a "flow state."

46. Use a password manager.
The average person has 27 discrete online logins. That takes-up a lot of real estate in our brains. And, trying to recover lost logins is time-consuming. Invest in a password manager, like LastPass or 1Password to rectify this problem.

47. Hack your vision.
Blue wavelengths from fluorescent lights and electronic devices can fatigue your eyes and accelerate eye aging. To combat this start by taking a couple of small steps like blinking more and reducing your exposure before bed. You may also want to consider getting protective lenses.

48. Actively listen.
Active listening is when you all of your attention and focus is at the conversation at-hand. As a result, you'll free-up and boost productivity since you're avoiding misunderstandings and not having the other party stop and repeat themselves.

49. Have a cut-off time.
Set a specific time to completely check-out from work so that you can avoid further exposure to blue light and recharge your batteries. Doing so ensures you'll be fully energized the following day.

The foundation of our productivity is our health, so here are physical productivity tips to simplify getting and staying in shape.

50. Exercise.
"I definitely can achieve twice as much by keeping fit," Richard Branson tells FourHourBodyPress. "It keeps the brain functioning well."

When does someone like Richard Branson find the time to exercise? By waking up at 5:00 am everyday.

51. Fuel-up wisely.
"Keep your energy high by eating the right foods that fuel your body instead of dragging it down," recommends Rieva Lesonsky on the OPEN Forum. "Avoid sugar, simple carbohydrates like pasta and bread, and junk food -- they can give you a temporary energy high, but then you may crash."

52. Drink caffeine intelligently and stay hydrated.
"Use caffeine strategically: It can take about 20 minutes for a cup of coffee to kick in, so drink it 20 minutes before you need to power up, and you should be good to go," adds Lesonsky.

"Above all, try to stay hydrated. Often, when you feel tired or hungry, all you really need may be a big glass of water to get back in the game."

53. Get 7-to-9 hours of sleep.
You might be able to get by with a couple of hours of sleep when you're younger, but that won't fly as you get older. Remember, getting seven-to-nine hours of quality sleep every night improves your attention, concentration, creativity, decision-making, and health. It also reduces stress and impulsiveness.

54. Skip the nightcap.
Drinking alcohol before bed prevents your from getting a quality night's rest. If you do have an alcoholic beverage, have one several hours before your hit the hay.

55. Stop and smell...the lemons.
Via Rodale's Organic Life;

"Research from Ohio State University found that sniffing lemon improved people's moods and raised levels of norepinephrine, a brain chemical linked to executive decision-making and motivation. Another study found that students exposed to a citrus-scented cleaner were more likely to clean up after themselves, while in a Japanese study the scent of lemon improved typing accuracy, with workers making 54 percent fewer errors."

56. Meditate
As mentioned in a previous Calendar post, "Meditation at its simplest form is the ability to focus on a single point typically your breath. In order to truly meditate you need to remove everything else from thought."

57. Strike a power pose.
"Strike Power Pose for More Productive Day: A 'Power Pose' is a method of telling your body to start moving," states Murray Newlands.

"Productivity is all about telling the brain: 'I am in charge, I feel good to go.' A 'power pose' actually can cause a burst of testosterone, that's responsible for feelings of dominance. Having a power pose in place for around 2 minutes may assist with confidence, decrease stress, and encourage a greater tolerance for risk."

If you want to learn some awesome power poses, then check out Murray's 7 body positions and gestures that can improve productivity.

58. Take a nap.
When you feel like you're dragging, go ahead a take a short nap - preferably in the afternoon. This doesn't just recharge your batteries, napping can improve your memory, alertness, and creativity.

59. Set the right temperature.
Productivity decreases when you're either too hot or too cold. That makes sense since you're focused on how much you're sweating or shivering. While there are several factors to consider, keeping the temperature between 70º–72ºF (21–22ºC) is usually ideal.

60. Soak up the sun.
Natural light increases your energy levels, helps you focus, reduces stress, and assists in better sleep.

61. Smile!
According to A Life of Productivity, smiling makes you more productive because it boosts your immunity, makes your happier, handle stress better, and helps you focus on the big picture.

62. Bring your dog to work.
Studies have found that we "become more trusting, relaxed and nicer towards each after interacting with a canine." Furthermore, playing with your best friend reduces stress. This isn't a problem if you work from home, but what if you can't bring your dog to work? Looking at pictures of animals can have similar effects.

63. Standing and walking meetings.
Some meetings are essential. But instead of sitting - like you've been doing all day - start having standing or walking meetings. It's not just better for your health, these types of meetings reduce distractions, promote collaboration, and saves time.

Success requires being equally fit physically and mentally. Try these mental productivity tips:

64. Have a plan.
Let's say you're building your dream home. Obviously you would have an architect design your home. This ensures that it's built correctly and that you have all the materials needed to get the job done on time.

Start by identifying a daily mantra, your short-term goal, and your long-term goal.

65. Take five.
This isn't taking a five-minute break. It's actually taking five minutes before any call or task to determine what you want to attain. As noted in Entrepreneur, "This will help you know what success looks like before you start. And it will also slow time down."

After the call or task, decide on whether or not the desired result was achieved. If not, figure out what's missing for the next time around.

66. Develop a growth mindset.
Discovered by Stanford psychologist Carol Dweck, those with a growth mindset "believe that their most basic abilities can be developed through dedication and hard work—brains and talent are just the starting point. This view creates a love of learning and a resilience that is essential for great accomplishment."

67. Regularly review the past week.
This is a time management habit championed by David Allen by taking the following steps;

1. Get clear by emptying your inbox, wrapping up any loose end, and tidying up.
2. Now you want to get current by reviewing your upcoming calendar, projects, actions lists, and checklists and ditching the inessentials.
3. Finally, get creative. Find unique ways to slip projects you've been putting off into your schedule.

68. Write in your happiness journal.
Every night write down the three things you're grateful for that occurred within the last 24 hours. As explained in Daring to Live Fully, "This brings your brain into better balance. It also retrains your brain so that it will start seeing more possibilities."

You can also write about one positive experience you had in the last 24 hours and jot down at least four details about this experience. "This is helpful because when you take a moment to remember a positive experience, your brain labels it as meaningful, which deepens the imprint."

69. Get an easy win.
While you should usually focus on tackling the hardest tasks first, sometimes you need an instant victory, like making your bed when you wake-up. It's a simple way to feel accomplished and build momentum for the rest of the day.

70. Learn to say 'no' effectively.
When starting out in your career, it's not uncommon to say "yes" to new responsibilities. There comes a point, however, that you can't keep this pace-up. The Power of No: Because One Little Word Can Bring Health, Abundance, and Happiness by James Altucher and Claudia Azula Altucher is an excellent book to help you learn how to say "no" more effectively.

71. Find your groove.
A flow state is where you're completely absorbed in what you're doing at the moment. To get into this flow state, you should work on activities that are challenging, but also equal to the skills you possess.

72. Schedule breaks throughout the day.
"There's a lot to be said about the power of rest throughout the workday," writes Renzo Costarella. "If you power through the day without taking the time to decompress you'll do yourself more harm than good."

"The best way to take breaks is to schedule them throughout your day. That way you can truly control the flow of work."

73. Disconnect
Sometimes you need to completely unplug and disconnect in order to recharge and avoid burnout. For instance, on Saturday afternoons shut off you phone for a couple of hours so that you aren't answering phone calls, texts, or emails.

74. Rehearse situations.
Rehearse your commute home, for example. What can you grab for dinner? Is there a Salad Works along the way? If so you can stop there than McDonald's. This way you can resist temptations.

75. Bargain with yourself.
"If you don't want to do something, make a deal with yourself to do at least five minutes of it," says Instagram founder Kevin Systrom. "After five minutes, you'll end up doing the whole thing."

76. Identify your keystone habits.
Charles Duhigg, author of "The Power of Habit," defines "keystone habits" as those that can transform your life. Examples include planning out your days, exercising, and having strong willpower.

77. Establish S.M.A.R.T. goals.
Make sure your goals are specific, measurable, attainable, realistic, and time based. This makes it easier to define and achieve them.

78. Stop tracking your progress on goals.
According to psychologist Kelly McGonigal, “although it runs counter to everything we believe about achieving our goals, focusing on progress can hold us back from success.” Instead, McGonigal suggests that you, “View your actions as evidence that you are committed to your goal” and remind yourself why you want to reach your goal.

79. Set “process goals.”
A process goal is what you actually need to achieve in order to achieve a larger goal. For example, if you want to increase sales by 25%, then your process goal would be to call 5 potential clients daily.

80. Anticipate obstacles.
While you can’t expect for every unexpected occurrence, you should anticipate certain obstacles. This way you can have a contingency plan so that you can keep going forward no matter what.

81. Own your mistakes, then move on.
We all mistakes. Learn from them so that you won’t repeat these same mistakes in the future.

82. End your day on a high-note.
Did you get that blog post written ahead of schedule? Did you then call your best friend since you now have the spare time? That feels awesome, right? Ending your day on a high note encourages you to do the same the next day.

Success always is a team sport, so here are organization and prioritization tips:

83. Schedule your entire day.
Benjamin Franklin said, "If you fail to plan, you are planning to fail!" With that in mind, kick-off every morning by planning your entire day. This includes everything from your most important tasks to meetings to commute times.

84. Keep your desk clear.
When you have a cluttered desk that sends a visual cue to your brain that causes stress. Spend the last couple minutes of your day cleaning and organizing your desk so it’s clear for the next day.

85. Use an online calendar and calendar tool.
With an online calendar you can access it from multiple devices, schedule meetings/appointments, set up reminders, block time, and set up recurring events.

On top of an online calendar, a calendar tool creates a daily routine, puts time limits on tasks, keeps your time in-check, and helps you plan for breaks.

86. Declutter your calendar.
Calendars are paramount to time management and productivity. But, they’re not effective when they’re so full that they’re bursting at the seams.

Clear the clutter from your calendar by only adding priorities that are date-specific. Don’t fill it with minute activities or events that no longer fit into your lifestyle.

87. Consolidate your tools and apps.
Even though there thousands of tools and apps that can assist you with time management and productivity, don’t go hog wild. Having too many of these tools and apps are counter-productive. Limit yourself to the essentials.

88. Share your calendar.
Share your calendar with clients and colleagues so that you can schedule productive meetings and be aware of deadlines without the back-and-forth emails. You can also share your calendar with your family so that they know where you are and that you can delegate household chores.

89. Set a maximum of three priority tasks per day.
Lengthy to-do lists aren't effective. That's because you simply don't have the time or energy to cross everything off your list. Instead, keep your to-do lists lean and mean by choosing your three most important tasks for the day.

90. Define three daily outcomes every morning.
This isn't your to-do list. These are three outcomes that you want to accomplish by the end of the day.

91. Jot down "forgettables."
What happens when something pops in your mind while you're working on an important task? Have a pen and paper nearby so that you can jot it down. This gets the thought out of your head, without doing much damage to your flow.

92. Schedule buffer and travel time.
Don't jump directly from task-to-task or meeting-to-meeting. You need time to recharge, refocus, and/or commute. It also prevents you from running late, which eats into the time you've set aside for another task or appointment.

93. Break larger projects into bite-sized pieces.
It's almost impossible to set the light at the end of the tunnel when working on a large project. That's why breaking these projects into smaller, more manageable tasks. The University of Georgia has published a handy article to get your started.

94. Set deadlines.
Setting deadlines on everything is a useful trick to keep you on track and avoid procrastination. Personally, if I need to have a blog post submitted by Friday, I set the deadline for Thursday. It alleviates stress while giving me time to review it.

95. Tap into the power of visualization.
"Mental practice can get you closer to where you want to be in life, and it can prepare you for success!," writes AJ Adams, MAPP in Psychology Today.

For example, in a study of weight trainers, those "who carried out virtual workouts in their heads" increased muscle strength by almost half as much when compared to those who didn't.

96. Set-out visual reminders.
These could be inspiring quotes that you print and display around your home or office to keep you motivated.

97. Find a mentor.
A mentor will share with you the tips and tricks that have worked for them, as well as the mistakes to avoid.

98. Enhance or develop skills.
Learning or strengthening skills can help you complete tasks faster. This is because you not only have the knowledge, you also have new approaches to solve problems. It also boosts your confidence.

99. Take one step at a time.
Baby steps. It's probably one of the easiest and most powerful time management and productivity tips. Instead of focusing on the task, focus on what you're doing now.

For example, when I was writing this massive article, I focused on one point at a time and then moved-on, as opposed to worrying about all 101 tips at once.

100. Don't worry about perfection.
Stop worrying about something being "perfect." It doesn't exist. It's only a figment of your imagination that can never become a reality. Do your best and keep on moving forward.

101. Reward yourself.
It's no secret that rewarding yourself when you've reached a goal or milestone is an effective way to keep you motivated and productive. The trick is being smart with your rewards. Skip the sugary treats for something like a massage. This avoids sugar crashes, but reduces anxiety and stress.

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 5, Number 1, 2019

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Report Writing: An introductory guide

Reports are documents used to convey information in a relevant format. This guide will provide some hints and tips about what reports are, how they differ from essays and how best to structure them to create professional looking documents.

https://my.cumbria.ac.uk

Report Writing

An introductory guide

The Skills Team, University of Cumbria

August 2018

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UNIVERSITY OF CUMBRIA

Summary

Reports are documents used to convey information in a relevant format. This guide will provide some hints and tips about what reports are, how they differ from essays and how best to structure them to create professional looking documents.

Disclaimer

Please Note: This guide has been written in the style of a report. However, there are many ways to layout a report. Check your module guide for individual tutor requirements.

Contents

Figures and Tables

Introduction

Reports are used in many professions including health, medical, science, government, business, and the police. As they are used to provide key information, they are considered to be a highly effective communication tool. But they need careful planning to create maximum impact. This guide will outline some of the formatting and style issues to consider.

1. Differences and Purpose

1.1 The main difference from essays is that reports can make use of the following to enhance their look and feel:

- labelled sections
- headings and subheadings
- bullet points or short paragraphs
- images, tables and diagrams

1.2 Good report writing is a key employability skill. Reports are used to provide information, make recommendations, feedback on surveys or outline strategy. Therefore, a good report should be accessible, readable and attractive.

2. Importance of the Brief

2.1 Reports are usually the result of a specific brief or assignment. The format of the report therefore needs to reflect what your tutor is asking for.

2.2 Read the brief carefully and if need be ask your tutor which layout they wish to see. They may leave that decision up to you as it can depend on your findings.

Here are some basics to get you started:

3. Format or Layout

3.1 Below are some suggested sections for a scientific or laboratory report and a business or policing report. The key is to be flexible so only include those sections relevant to the brief. Therefore, use these suggestions as guidelines and add to, change or omit sections as needed.

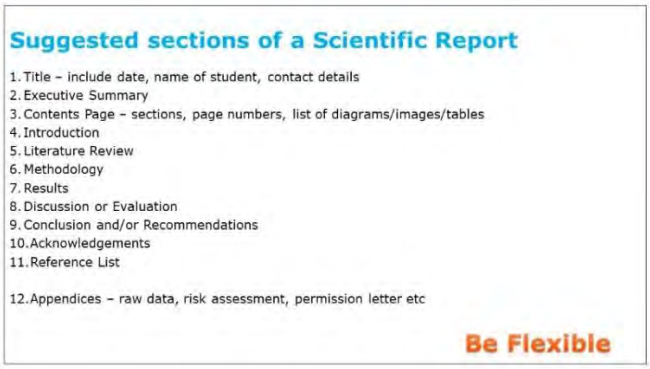

Figure 1: Suggested sections for a scientific report

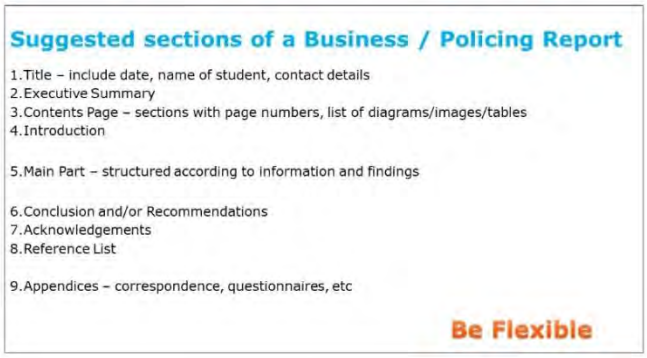

Figure 2: Suggested sections for a business or policing report

3.2 Readers of reports will often 'dip' into a report initially to get the overall messges. Which sections might they read first? Most likely: Executive Summary, Conclusion, and Recommendations

3.3 Microsoft applications provide formatting tools such as cover pages, page numbering, headers and footers etc. to enhance the look and feel of the report.

4. Writing skills

4.1 You still need to use formal well-written text. However, unlike essays, the text can be divided up effectively into short sub-sections or bullet or numbered points to ensure your key messages are accessible.

4.2 You still need to make use of well-structured sentences and paragraphs and use signposting to aid the flow of your text. Check out our general writing tips.

5. Visual media to illustrate your reports

5.1 Enhance the impact of your report by including images, figures or illustrations, diagrams, tables, infographics etc. A few golden rules though:

1. They must all be relevant and have a purpose
2. This purpose must be explained
3. They must be referenced if not your own - Check *Cite them Right* for styles
4. They must be labelled
5. They can be listed in the contents page so they are easy to find

5.2 If appropriate add an image or colour to the title page or front cover of your report. You can also use colour within the main body of your report.

6. Example of Reports

6.1 Scientific

- Invertebrate Survey (Telfer, 2013)
- The Clean Growth Strategy (HM Government, 2017)

6.2 Business / Policing

- Smart Cities (McKinsey & Co, 2018)
- Report of the Stephen Lawrence Enquiry (Macpherson, 1999)

7. References

HM Government (2017) *The clean growth strategy: leading the way to a low barbon future*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf (Accessed: 9 August 2018).

Macpherson, W. (1999) *Report of the Stephen Lawrence Enquiry.* Available at: https://www.gov.uk/government/publications/the-stephen-lawrence-inquiry (Accessed: 9 August 2018).

McKinsey (2018) *Smart cities: digital solutions for a more livable future.* Available at: https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Smart%20cities%20Digital%20solutions%20for%20a%20more%20livable%20future/MGI-Smart-Cities-Full-Report.ashx (Accessed: 9 August 2018).

Telfer, M.G. (2013) *Invertebrate survey of Northstowe, Cambridgeshire*. Available at: https://www.scambs.gov.uk/sites/default/files/documents/ES%20Appendix%20F_Part_8_0.pdf (Accessed: 9 August 2018).

8. Further reading

Check Onesearch for the full range of titles available. Some will be aimed at general audiences, others at specific subject areas.

Bogg, D. (2016) *Report writing for social workers*. 2nd edn. London: Open University Press.

Bowden, J. (2011) *Writing a report: how to prepare, write and present really effective reports*. 9th edn. Oxford: How to Books.

Forsyth, P. (2016) *How to write reports and proposals*. 4th edn. London: Kogan Page.

Price, M. (2013) *Lab reports and projects in sport and exercise science: a guide for students*. Harlow: Pearson.

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PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 5, Number 1, 2019

Paper Industry Technical Association
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The Paper Industry Technical Association (PITA) is an independent organisation which operates for the general benefit of its members – both individual and corporate – dedicated to promoting and improving the technical and scientific knowledge of those working in the UK pulp and paper industry. Formed in 1960, it serves the Industry, both manufacturers and suppliers, by providing a forum for members to meet and network; it organises visits, conferences and training seminars that cover all aspects of papermaking science. It also publishes the prestigious journal *Paper Technology International* and the *PITA Annual Review*, both sent free to members, and a range of other technical publications which include conference proceedings and the acclaimed *Essential Guide to Aqueous Coating*.

ABB OFFERS A NEW APPLICATION TO HELP CUSTOMERS WORK SMARTER NOT HARDER

Pioneering digital technology company ABB has a new application that will help customers achieve higher levels of productivity and improve economic return to meet their performance and quality objectives.

The Asset Management Application is a digital solution that enables process industries to manage and protect their assets through predictive and preventative maintenance to avoid costly failures. Cost effective management becomes a reality through the optimisation of workflows and in-depth analysis of results, offering efficient asset management strategies that enable smarter, more informed decisions.

The application offers industrial plants real-time condition monitoring of equipment, connected devices and field devices to reduce unscheduled downtime, prevents equipment failures and optimises operation and maintenance of the installed base. ABB enables predictive and preventative maintenance by diagnosing asset conditions and predicting looming equipment problems on premise and, for the first time, at an enterprise's global level. Moreover, the application enables the usage of advanced analytical methods such as machine learning and artificial intelligence to analyse equipment problems and optimise the performance.

As geographically dispersed production sites constantly grow, global connectivity, helped by advanced cloud technologies, is an important feature. It brings added benefits of wider collaboration across teams, management and operations.

ABB Ability™ Edge ensures a secure connection between assets and the cloud, efficiently separating IT and OT. Edge technology can also act as a platform for applications to give customers the option to operate solely on premise rather than in the cloud.

In the case of a problem, users can make informed and quick decisions, based on clear recommendations. Actions range from immediate attention to scheduling maintenance in the near future and the identification of issues that can be resolved during its routine maintenance of equipment. The application is available for basic instrumentation equipment across all processing and manufacturing industries, for detailed assets such as motor transformers or circuit breakers and complex electrical or rotating equipment, and mechanical handling equipment such as conveyor belts. By providing a precise cause of any equipment problems, the application also enables speedy identification and recovery, further reducing costs.

"One of our priorities when developing the Asset Management App was to provide customers with complete control over knowledge of the process. In doing so we will, for the first time, give them the flexibility to quickly create their own asset models from the intelligence they gather." says Neil Shah, Global Product Manager for Device Management & Asset Optimization at ABB. "Asset analysis, including root-cause analysis, is another key factor in helping customers to remain competitive in today's industrial markets."

The Asset Management Application will be launched in the second half of 2019. It sits within ABB Ability™, ABB's digital offering, which includes more than 210 Industrial Internet solutions and an Industrial Internet technology platform and cloud infrastructure. Drawing on insights across 20 plus industries and more than 40 years of experience in digital technology, ABB Ability™ helps customers to develop new processes and advance existing processes by providing insights and by optimising planning and controlling for real-time operations. The results can flow into control systems such as ABB Ability™ System 800xA and ABB Ability™ Symphony Plus to improve key performance metrics of plants and assets.

With over 70 million connected devices, more than 70,000 digital control systems and 6,000 enterprise software solutions, ABB is a trusted leader in creating digital solutions for customers in the industrial space.

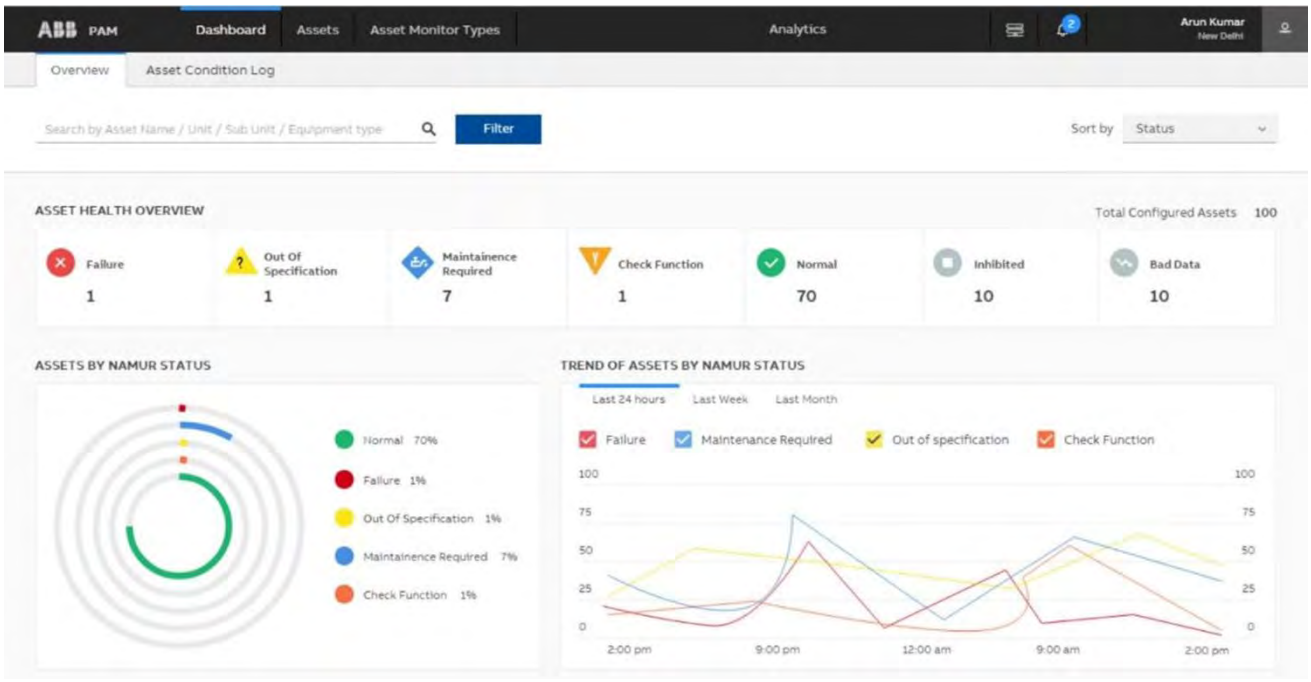

ABB UNVEILS LATEST UPGRADE TO DCS FREELANCE

Security is a top priority in the age of Industry 4.0 and enhanced security is one of a range of new features and benefits included in Freelance 2019.

Originally launched in 1994, Freelance is ABB's cost-effective distributed control system (DCS) solution for process industries. It combines the advantages of a DCS with Programmable Logic Controllers (PLC) and is characterised by ease of use, scalability, flexibility and reliability. Freelance 2019 is the latest version of the DCS.

The Freelance suite of solutions comprises Freelance Operations for use at operator level, a scalable process level option, and Freelance Engineering which is used to configure and commission the system including the operator interface. The new version provides significant improvements throughout the complete system.

New features and benefits of Freelance 2019

Improved usability: Freelance 2019 provides a significant increase in efficiency and usability for its Operations and Engineering solution by adding advanced navigation, filter and sort functionality. The user experience has been improved with a new, very modern UI.

Scalable: A new controller, PM 904F, expands the Freelance AC 900F controller family in the upper range, supporting four communication interfaces. It also provides more application memory and enables the reservation of specific memory. As for all Freelance controllers user applications are 100% runtime-compatible which also enables smooth upgrade opportunities.

More connectivity: Up to four monitors can now be connected to a single operator workplace. The available display types per monitor, as well as the arrangements of the monitors, are easily configured and fulfil the typical requirements for occupational safety and operator effectiveness.

Enhanced security: Freelance provides an additional alternative to its user management capabilities known as "Security Lock" by a solution called "Extended User Management". This new option makes use of Windows user accounts, supporting both local and domain accounts. As a result typical requests for options such as central password management, rules for password complexity, or password aging can be fulfilled.

Compatibility: Freelance 2019 can run on Windows 10 and Windows 7 in the same system architecture. This allows customers to do a step-wise upgrade to modern IT infrastructure which helps in reducing maintenance costs.

“Being user-friendly, cost-effective and robust has already made Freelance a popular choice for businesses of process industries in more than 100 countries worldwide. Its flexibility and extensive reach are demonstrated by the 1000s of installations of the solution in industries,” said Ingo Mauritz, Global Product Line Manager for Freelance at ABB.

“Wacker Chemie in Germany uses Freelance with Freelance Operations as the tool to efficiently operate and monitor their ketene plant. In China, Freelance provided uniform configuration of field devices online at YunNan HongTa DianXI Cement obtaining the maximum automation with minimum engineering. Freelance was also integral to the modernisation of Glinojeck, a leading European sugar producer and was at the centre of one of the most sophisticated reverse osmosis desalination projects in the Middle East,” added Mauritz.

As in earlier versions of Freelance customers have the option of staying automatically up-to-date by subscribing to the Automation Sentinel life cycle program by, for example, providing automatic cyber security patches.

Available in a wide range of languages, Freelance takes five minutes to install on any standard computer and can easily be self-learned. The intuitive operator interface enables easy operation and diagnosis of the entire system and being just one file it is easy to back up as the entire application fits on a small memory stick.

ABB ACS6080 DRIVE FOR HIGH PERFORMANCE MOTOR CONTROL

ABB has expanded its all-compatible drives offering to include the ACS6080 medium voltage (MV) drive for critical applications. The new drive introduces a breakthrough control technology, developed by ABB, that brings high performance motor control to demanding processes used in industries such as mining, metals and marine. The drive also enables plants to operate more efficiently and produce higher quality output.

Traditionally, achieving high dynamic performance and excellent power quality required hardware with multiple devices. However, this increase in components could decrease reliability of the operation. The ACS6080 drive maintains the same highly reliable hardware as its predecessor, the ACS6000, and includes the new advanced control capability, known as Model Predictive Pulse Pattern Control (MP3C).

ABB's MP3C technology combines model predictive control with optimised pulse pattern to modulate the semiconductors. This means that at every point in time this control can anticipate the best motor operation point by finding the perfect compromise between dynamics, efficiency and harmonic distortion.

The new control enables system integrators and plant operators to maintain stability, while reducing investment and operational costs by using a smaller drive or a smaller motor. The increased power capability of the ACS6080's single power module reduces the footprint of the drive by up to 20 percent. The new control helps to reduce operational cost in two ways: it is more energy efficient than other control solutions, and maintenance costs are reduced as there is less mechanical and thermal stress on the equipment leading to longer lifetime of the components.

The ACS6080 provides extensive input/output connectivity and supports all major fieldbus protocols, making it easy to integrate into existing systems and processes. It is compatible with ABB Ability™ condition monitoring services, allowing customers to obtain real-time data about the status and performance of the monitored equipment from any location.

"The ACS6080 MV drive provides benefits which help deliver exceptional value to industrial processes in terms of product quality, uptime, safety and energy efficiency," says Mark Land, Manager – MV Drives, ABB Limited.

The new drive delivers a high level of safety for people and equipment via an arc-resistant design and certified functional safety features. The ACS6080 is built on ABB's common drive architecture, enabling a faster and harmonised start-up, commissioning and monitoring. Once a user has learned how to use one all-compatible drive, they can then operate any other drive in ABB's all-compatible offering.

The modular design of the ACS6080 enables it to be configured for single or multi-motor applications. It controls all types of AC motors including induction, synchronous and permanent magnet, without the need for different software. The ACS6080 can be tailored to any heavy industrial application, and has a power range from five megawatt (MW) to 36 MW.

ABB Ltd., Daresbury Park, Daresbury, Warrington, WA4 4BT

ABB LAUNCHES UK-WIDE VARIABLE SPEED DRIVES HIRE FLEET

Users of low voltage variable speed drives (VSD) can now keep processes running, test new applications or prove predicted energy savings before purchase, through a leasing program provided by the ABB authorised value provider network.

ABB has invested significantly in the rollout of a variable speed drive hire fleet across the United Kingdom and Ireland, with units extending from 3 kW up to several megawatts. Hire drives can be delivered the same day, and installed and commissioned within a matter of hours by engineers from one of twelve ABB authorised value providers. With a fast response, 24 hours a day, all year round, no other drive hire scheme offers such wide geographical coverage across the UK and Ireland.

Customers can choose from a wide range of drives, including the ABB general purpose drive, ABB machinery drive and ABB industrial drive. All are fully maintained and pre-loaded with the latest firmware.

There are four scenarios where hiring a drive can deliver customer benefits:

Emergency or unexpected failure: Hiring a drive can be a quick, low cost way of keeping critical processes running in the event of a breakdown. It reduces the cost of downtime whilst providing time to repair the failed equipment or to source and allocate capital for a permanent replacement.

Temporary capacity: Hire drives can be used for short-term, semi-permanent or seasonal applications, allowing companies to ramp process capacity up or down with ease, while eliminating storage and maintenance costs.

Prove predicted energy savings: If a variable speed application has not previously used a drive, or if an existing drive is due for upgrade, hiring can be a low cost way to prove predicted energy savings before purchase and in a real environment. This can help customers to make more informed buying decisions.

Equipment testing: Testing houses may be called upon to test variable speed applications, but may not have a suitable drive with which to pair it in-house. Hiring a drive can allow testing to get underway at short notice and low cost.

Drives are hired at a fixed daily rate (minimum hire period may apply), which includes all installation and maintenance for the duration of the hire. The ABB authorised value provider network can be contacted by telephone on 0333 005 7001, or via www.new.abb.com/uk/drives-for-hire.

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MAJOR UPGRADE OF ABB ABILITY™ SYSTEM 800XA

The new release of ABB's Distributed Control System (DCS) 800xA 6.1 brings significant value to capital projects with more flexible and efficient engineering.

ABB Ability™ System 800xA 6.1 provides significant innovations to the entire DCS architecture and introduces technologies that shorten timescales for project execution, reduce the impact of late changes and enhance the scalability of the system, bringing substantial value to capital projects. This is achieved by the introduction of new Ethernet I/O solutions, additional High Integrity controllers and a series of new engineering tools such as a new Ethernet I/O Field Kit, an Ethernet I/O Wizard for field commissioning and the possibility to engineer with signals in the Control Builder.

"Our new flexible I/O solutions and engineering workflow will significatly change the way projects are delivered in future," said Luis Duran, ABB's System 800xA Product Manager. "The new system can deliver major cost savings on large captial projects. Through greater standardisation, tasks can be done in parallel allowing users to make late changes more easily".

The Select I/O is an Ethernet based single channel I/O that uses xStream engineering to reduce project delivery schedules. Independent teams can work in parallel and then bind together with precision and efficiency later. This reduces the impact of changes during the project, particularly late changes and effectively reduces the commissioning time. Testing efforts and the hardware footprint are considerably reduced as well. Pre-tested, standardised cabinets can be wired directly to field devices and eliminate the needs for physical marshalling cabinets, reducing drawings, equipment and labour. Testing efforts and the hardware footprint are considerably reduced as well.

The new version supports IEC 61850 Ed 2 which means that it is ready for new digital solutions, e.g. digital substations. The electrical integration capabilities in System 800xA offer detailed, real-time information on power consumption down to the individual loads and secure a reliable and steady electrical power supply. The system prevents blackouts and disturbances of operations – while controlling energy costs, enhancing safety and mitigating both environmental and health impacts. Moreover, it's easier to configure and integrate IEC 61850 networks within System 800xA's engineering environment providing additional project execution flexibility and the further decoupling of project tasks which in turn reduce design and commissioning time.

Select I/O: Modular, single point, late binding, Ethernet I/O solution that can be digitally marshalled into the ABB Ability™ System 800xA architecture

System 800xA's hardware is equally effective for small hybrid systems as it is for large, high availability, integrated automation applications. The modularity of the subsystem results in higher return on assets by providing the flexibility to choose the specific functions necessary to meet actual requirements.

The new system also includes support for two new safety controllers; PM857 and PM863. providing even more flexibility for the most mission critical applications. These characteristics in combination with new Select I/O Safety Single Channel Modules expand the existing capabilities and increase the flexibility. The High Integrity controllers offer flexibility of network design as they can be used for integrated but separate safety operations or for fully integrated applications where safety and business critical process control are combined in one controller without sacrificing safety integrity.

xStream Engineering: Innovative tools for digital marshalling and late binding remove dependencies and enable multiple workstreams.

ABB Ability™System 800xAand its extended automation concept has over 11,000 installations world-wide, in practically every industry, automating processes, controlling and monitoring electrical equipment, and reducing risk through high integrity safety systems. It is part of the ABB Ability™platform that enables customers to securely integrate and aggregate their data, combine with wider industry data, apply big data and predictive analytics, and generate insights that can help them drive performance and productivity improvements. www.abb.com/800xA

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ARCHROMA LAUNCHES LEUCOPHOR® AFCN FOR FOOD CONTACT

Archroma announced the introduction of a new optical brightening agent (OBA) specially designed for food packaging and paper, Leucophor® AFCN liq. The newly launched OBA has been approved for food contact by the US Food and Drug Administration.

Urbanisation and digitalisation are rapidly changing our lifestyle. People around the globe are increasingly purchasing and consuming on the go. A growing part of food containers are made from renewable sources, such as paper and board. It is necessary to ensure that these paper containers are free from substances that would be harmful for the consumer.

Archroma is committed to continuously challenge the status quo in the deep belief that we can make our industry sustainable. We strive to introduce innovations that allow safe, efficient and enhanced manufacturing processes - and end products.

Leucophor® AFCN liq was designed with these guiding principles in mind:

- Leucophor® AFCN liquid has approval for use in food-contact paper and paperboard under FDA Food Contact Notification 1921, which became effective on 9 November 2018.

- Leucophor® AFCN liq is ideally suited for stock application and for use in coating formulations that contain polyvinyl alcohol (PVOH), carboxymethyl cellulose (CMC) or casein as a secondary binder.

- Leucophor® AFCN liq is a disulphonated OBA, with a characteristically high substantivity in the wet-end delivering the papermaker cost savings through the ability to make more rapid grade changes.

"There is a fast-growing demand for food packaging made with paper and board, and our Leucophor® AFCN liquid OBA has been developed to help manufacturers to respond to that demand", comments Andrew Jackson, Global Product Manager Optical Brightening Agents, Paper Solutions Business, Archroma.

"Complementing our FDA-compliant tetrasulphonated OBAs and shading colorants, Leucophor® AFCN liquid provides our customers with greater flexibility to produce attractive, white, paper-based packaging and containers for food applications. Because it's our nature!"

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JARSHIRE EXPLAINS HOW DOTEC EMBRACES INDUSTRY 4.00

When looking for a reel or roll handling solution, it is unlikely that Connectivity, the Internet of Things, Big Data, AI or App-control are at the forefront of a customer's mind. However, experience has shown that it is not long before forward-looking prospective customers begin to understand its importance and investigate.

Today, systems are becoming more and more complex due to the need for additional functions and better safety features. This need has resulted in many more pneumatic components and, as a result, building has become very labour intensive – especially since "in industry 4.0", everything is required to be connected.

Until now, Dotec has incorporated its own electronic platform in the range of LiftAssist handlers. However, whilst researching suitable control components, Dotec's R&D manager came across the Festo Motion Terminal. The resultant close cooperation between Festo and Dotec resulted in a system that has encapsulated the control of complex movement combinations, safety, modern communication and digitalised pneumatics. A fully integrated Digitized Pneumatics control, based on the Festo Motion Terminal VTEM, has come to fruition.

Dotec's main reasons for an upgrade:

- Key features of Dotec LiftAssist equipment are ergonomics and user convenience – i.e. responsiveness, smoothness in operation, easy to use and to be fail-safe.

- Dotec was looking for more flexibility; only one type of control and software to configure when customising to order; enabling monitoring and modifications on site, be it a change in parameters or a firmware upgrade; interconnectivity was essential to monitor the system wherever it is in the world, to collect big and small data for predictive maintenance, and to better remote assist.

- And, importantly, to be ready for the future. In an era of robotics, computer vision and artificial intelligence, at some point it is a logical step to upgrade to a robot or autonomous system. This is part of Dotec's R&D agenda. Taking account of industry 4.0 is the company's challenge for a successful future.

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JARSHIRE ON HIGH PRESSURE WATER JET TAIL CUTTING

The Italian equipment specialist Weingrill has announced a new development within its range of tail cutters claiming that its HP-Waterjet is the best alternative to dry-end tail cutters with rotating blades, and that this new device offers major advantages over traditional cutting systems.

Dry-end tail cutting

Modern paper machines demand high reliability and performance. Today most have dry-ends equipped with fixed or rotating blade tail cutters, any of which provide an acceptable cut quality under ideal operating conditions – i.e. limited base weight range, high paper dryness and assuming a well sharpened blade.

High-pressure water-jet cutting

With the purpose of meeting evolving market demands, Weingrill has developed the HP-Waterjet Tail Cutter, whose working principle is based on the use of high-pressure water. In simple terms, the equipment is composed of one pumping station providing the water and one nozzle turning the applied pressure into a high velocity water jet. Paper can then be “cold cut” without any alteration of its chemical and physical properties.

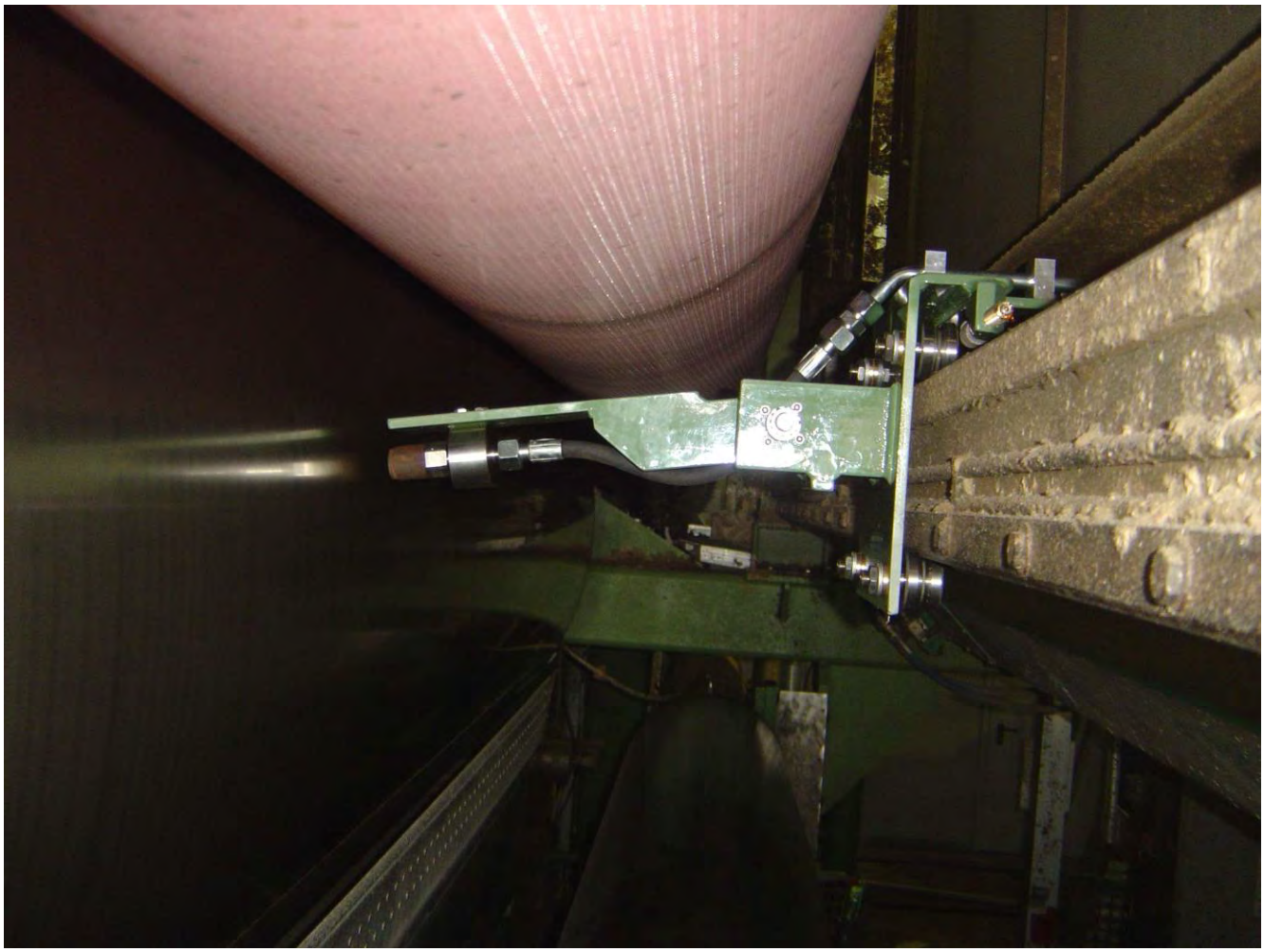
Fully automatic, the tail cutter has been specifically designed to provide an alternative tail cutting system to traditional blade tail cutters. The high-pressure water medium ensures no mechanical contact with the paper leading to a dust- and drag-free cut, and reduced threading downtimes. In addition, non-contact cutting eliminates the inconvenience of inevitable wear and tear and replacement relating to rotating (or fixed) blades, and the associated time losses.

It should also be noted that high-pressure water cutting exerts lower cutting forces on the paper compared with traditional blade devices, which results in stronger sheet edges and reduced web breaks.

With applications in all kinds of paper and board production, including coated grades, the HP-Waterjet provides for very reliable and successful tail threading that quickly reacts to paper breaks, so minimising associated production losses. In comparison with blade tail cutters the HP-Waterjet ensures the following benefits:

- It is not subject to wear therefore not requiring continuous service (blade sharpening).
- Airborne dust is eliminated significantly reducing paper breaks in addition to improving air quality and the overall working environment.
- Due to its compact construction the water jet guarantees efficient paper cutting at high speed without disturbing or breaking the sheet.
- The water jet exerts a lower cutting force on the paper. Consequently, the cutting operation is faster and smoother with reduced cross-machine cutting time, improving the efficiency of tail transfer from section to section.
- The water jet does not require physical adjustments and it is not influenced by profile variations or sheet fluttering.

- The cutting head has more flexible mounting options. It can be applied against dryer fabrics, in proximity of dryer cylinders or in open draws. When applied to open draws, a supporting plate is provided along with the cutting head.
- It is a compact cutting device, which can be installed in relatively old and narrow dry-end fabric runs.
- The water jet produces sharper and stronger sheet edges than a knife or rotary blade.
- It is provided with a pre-programmed control unit, which is automatic and user-friendly.



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VALMET INTRODUCES NEW FIBER FURNISH ANALYZER

Valmet introduces the completely redesigned Valmet Fiber Furnish Analyzer, which takes advantage of Valmet's extensive field experience and new technology. Valmet Fiber Furnish Analyzer provides fast and precise online measurement of key fibre and furnish properties for paper, board and tissue makers.

New image analysis techniques enable the Valmet Fiber Furnish Analyzer to automatically measure a wider range of furnish properties. Additional modules can also be added to the Valmet Fiber Furnish Analyzer platform, with standardised measurements of Canadian Standard Freeness or direct Shopper-Riegler as well as a chemistry module to monitor pH and conductivity. The Analyzer is ideal for process control and, with the addition of a remote manual sampling station, it is also a valuable laboratory tool providing fast and accurate analyses.

Rather than relying on infrequent and time-consuming laboratory tests, machine operators now have the information to act quickly and decisively. Better control of refining levels, monitoring of incoming pulp quality or fibre blend optimisation are further improved with the built in Valmet Data Modeler and Valmet Soft Sensor, which continuously predict pulp strength properties from a combination of measured properties.

"Operators can now see fibre development and impact of process changes on pulp strength in real-time. Without waiting for physical tests, shift to shift quality variations can be greatly reduced to provide significant energy and raw material savings," says Ismo Joensuu, Product Manager, Analyzers & Measurements, Automation Business Line, Valmet.

Technical information about Valmet Fiber Furnish Analyzer

With comprehensive self-diagnostics and Industrial Internet capabilities, including remote product and application support, measurement reliability is assured. Valmet Fiber Furnish Analyzer also enables operators to remotely activate the automatic collection of follow-up samples for later laboratory verification and automatic validation of pulp strength modelling.

Connections to existing and future mill systems are securely supported by versatile communication interfaces. The application areas of Valmet Fiber Furnish Analyzer have also been widened. A new sampler for coarse pulps is now available as well as an optional de-foamer addition to improve measurement capabilities with certain grades of pulp.

For further information, please contact:
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Read more: www.valmet.com/valmetmap

MATERIALS HANDLING

MIDLAND PALLET TRUCKS ANNOUNCES EXPANSION TO EXISTING RANGE OF MOVING SKATES

Midland Pallet Trucks, nationwide leaders in the provision of high quality hand pallet trucks and other materials handling equipment, has announced the introduction of a new range of moving skates, also known as machinery skates, shifting skates, and load moving skates. The five new models in the Midland Pallet Trucks collection are designed to work alongside the firm's selection of hydraulic lifting jacks to offer a simple, all-in-one solution for safe, secure, and efficient moving of heavy machinery.

The new moving skate models include the X4-Y4 8000kg set, the X8-Y8 16000kg set, the X12-Y12 24000kg set, the X16-Y16 32000kg set, and the X18-Y18 36000kg set. These products have been added to Midland Pallet Trucks' existing range of moving skates to enhance and expand the collection and provide customers with greater choice. All models are available now directly through the Midland Pallet Trucks website.

The five new introductions to the Midland Pallet Trucks moving skate collection can be used within a variety of industrial environments, and are both steerable and adjustable for complete ease of use and added safety within the workplace. Featuring flexible swivel action due to the inclusion of a thrust bearing, and a powder-coated, durable finish, all of the latest models are designed and manufactured to the highest quality, ensuring top performance in warehouses.

"We've specialised in moving skates for many years now, but have previously focused primarily on 6-18 ton weight capacities as these were what our customers were coming to us for," says Midland Pallet Trucks Managing Director Phil Chesworth. "At a time when the needs of our customers are changing rapidly, we've taken measures to meet these new demands by introducing a wider capacity range, all the way from an 8 ton machinery skate set to a much more heavy duty 36 ton capability.

"Our ultimate aim is to continue expanding our range to give our customers greater choice."

All skates within the new Midland Pallet Trucks range feature quality polyurethane skate wheels; an alternative to the standard nylon wheels included on many forms of machinery skate. The greater resistance of polyurethane compared to nylon ensures that this new skate collection performs optimally and to a continually high standard even on rough, uneven warehouse floor surfaces. Polyurethane is considered to be an effective material for skate wheels, offering a high level of crack resistance, unrivalled durability for longevity, and a minimal need for ongoing maintenance.

DRIVER ENVIRONMENT FOCUS FOR HYSTER® LIFT TRUCKS

As the driving experience is an essential element of success in high intensity applications, Hyster Europe is focussing on enhancing the operator environment according to the application, including in the wood, metal, construction, ports and paper industries.

“When handling expensive, awkward and heavy loads, the driver environment matters more than ever,” says Chris van de Werdt from Hyster Europe. “Every lift truck brand claims its products are ergonomic, but you have to ask, ‘under what conditions?’ Intelligent Hyster® lift truck design focuses on the driver environment in all applications, but this proves particularly important for efficiency and driver comfort in extreme and demanding operating conditions.”

Wood handling

Throughout the wood supply chain, lift truck drivers may have to drive in reverse due to tall loads obscuring forward visibility. These operations can be very uncomfortable if the design of the driver environment doesn’t account for it.

The shape of the rear of the truck, including the position of the exhaust stack, can affect visibility, while the seat needs to minimise body rotation to accommodate reversing. The Hyster® H13XM-6 is a typical lift truck used in the wood industry and addresses these challenges. With a clever rear design and the option of a swivel seat that turns 15/30 degrees, it aims to provide maximum comfort for the driver when driving in reverse. Depending on the application needs, Hyster Europe can also fit lift trucks with full rotating seats and drivers can be further assisted by camera systems.

In addition, TouchPoint™ mini-lever controls help reduce awkward shoulder and arm postures by locating the hydraulic functions directly at the driver’s finger tips. This maintains driver comfort and helps the driver to focus on reversing.

Paper Industry

In the paper supply chain, it is common to handle large, expensive and fragile paper reels using giant clamps.

“It’s important for drivers in paper applications to use trucks and attachments that not only minimise the risk of damage, but also optimise speed and performance,” says Chris. “However, this should not be at the expense of driver comfort.”

A popular truck is the Hyster® S9.0FT which gives a 9-tonne lift on a 7-tonne chassis footprint, providing the instant advantages of added space and manoeuvrability during handling. The truck also offers a spacious driver environment, thanks to the design of the overhead guard and optimised floorspace in the operator cabin.

The truck’s isolated drivetrain minimises the effects of powertrain vibration on the driver, while features such as ergonomically designed hydraulic controls, a contoured arm rest and a multi-function joystick also help to ensure comfort as well as lifting and handling accuracy.

“Lift truck driver comfort is about far more than having some general ‘ergonomic’ features within the cab,” says Chris. “The best way to optimise the driver environment, even in the toughest operating conditions, is to select an intelligently designed heavy-duty lift truck with standard and additional features that meet both the demands of the application, and the needs of the driver.”

SAFETY

WHAT IS ISO/TS 19837:2018 - TRAPPED KEY INTERLOCKING DEVICES?

ISO/TS 19837:2018 - Safety of Machinery – Trapped Key Interlocking Devices – Principles for design, selection and configuration is the first international ISO document devoted specifically to trapped key interlocking and answers many of the questions that have arisen relating to performance levels, key coding, and power interlocking. It is a significant step forward which will provide more choice for users of interlock devices and systems.

Trapped Key Interlocking has its roots in the rail and power distribution industries where sequential control was, and still is, critical to safe, continuous operation. In the 1960's trapped key interlocking was gradually utilised by the manufacturing sector, where isolating machinery before gaining access, was the requirement.

Machinery with multiple energy sources and access points can be easily safeguarded using trapped key interlocks. Fortress Interlocks has developed specialised products over the years which can isolate air and hydraulic supplies as well as electrical power in sequence before allowing access points to be opened.

When ISO14119:2013 Safety of Machinery – Interlocking device associated with guards, Principles for design and selection, was published trapped key interlocking had become no more than an annex, even the scope was clear that it did not provide all the specific requirements for trapped key systems. In many respects ISO14119:2013 served to confuse users and potential users familiar with decades of trapped key interlocks installations.

ISO/TS 19837:2018, three years in the making, is a welcome addition to the existing suite of machinery safety standards. Perhaps the most critical question addressed is where mechanical or hybrid mechanical/electrical systems sit in relation to performance levels introduced in ISO 13849.

Power Interlocking is now more properly referred to as "Isolation control through direct mechanical action" and falls within the Safety Related Part of The Control System. This coupled with the section "Validating performance level" makes evaluating performance levels for trapped key systems much clearer.

The difference between actuators and keys is cleared up, following the confusion created in ISO14119:2013, and both are addressed in the "Terms and definitions" and "Symbols and abbreviated terms" sections.

The need for a schematic detailing the trapped key system operation and establishing key coding appears under "Key Transfer Plan" and will provide users with an excellent tool in the system design phase as well as a documented system layout after installation. Key coding and management is also addressed extensively.

A much-needed standardisation of symbols to represent trapped key interlocks will make it easier for customers to understand schematics, and the excellent pictorial examples throughout the document are useful for those building a trapped key interlock system.

www.fortressinterlocks.com

TESTING / ANALYSIS

EMTEC ELECTRONIC WITH ITS SUCCESSFUL INNOVATIONS AT THE ZELLCHEMING EXPO

The pulp, paper and supplier industry will meet also this year at the Zellcheming Expo 2019 in Frankfurt/Main, Germany. From June 25th to 27th the company emtec Electronic will present their innovative measuring devices in hall 4.1 at the booth no. G18, by which the complete production process can be controlled and guided in the right direction.

At the beginning of this year, emtec Electronic celebrated a great success: the 300th TSA Tissue Softness Analyzer has been sold. The device is now used in 48 countries, in each part of the world. Especially for tissue products, the TSA gives reliable and objective information about the three basic parameters, which determine the human feeling, the softness, roughness and stiffness. From these three, an overall hand feel value can be calculated. New for hand sheet measurements: an updated version of the TSA and an improved measuring method for hand sheets (made in the lab) enables a reliable prediction of the final product quality in the lab without expensive machine trials.

Two of the most-modern measuring systems for the wet-end are the CAS touch! to measure the particle charge, and the FPA touch! to measure the surface charge of fibres. The small and light devices help to optimise the utilization of chemicals with the target to stabilise the process, to improve the product quality and to reduce costs.

The ACA Ash Content Analyzer enables the determination of the mineral filler content without combustion, that means without destruction of the samples, within seconds. Both, the total mineral filler content, as well as the individual filler components (e.g. calcium carbonate, kaolin/talcum, titanium dioxide, iron oxide) and their percentage distribution are measured.

Besides this, the EST12 emtec Surface & Sizing Tester is shown. A device to determine important and for the converting relevant paper surface properties such as surface hydrophobia / sizing as well as the surface porosity, which influence printability, coatability and gluability of paper and board. The PDA.C02 Penetration Dynamics Analyzer as modular system is the equivalent, that delivers additional information by the use of different modules.

EXNER COMPACT SENSOR FOR RELIABLE TURBIDITY MEASUREMENT

The compact NIR backscattering sensor EXspect 271 has an innovative optical measurement system and offers economical and reliable turbidity measurement.

In its EXspect 271 backscattering sensor, the company EXNER is launching a compact measuring device for reliable and economical turbidity measurement. One major benefit of the new sensor is in the spherical design of its optical measurement system. This minimises the attachment of air bubbles and the build-up of deposits. The focussing of the beam due to the sapphire lens allows for a measurement right on the barrier layer of the medium, meaning only the reflection is measured, and not the proportion of the light beam absorbed. Both the attachment of all kinds of things to the measurement system and the measurement of absorbed proportions are drawbacks on the current market.

The measurement takes place in the near-infrared region (NIR) at a wavelength of 880nm, which allows for colour-neutral measurement. The LED light source being used guarantees a long-lasting and stable signal. The stainless-steel case of the EXspect 271 has a hygienic design and is suitable for CIP/SIP. As another special feature, NIST-traceable reference standards can be obtained for calibrating or checking the sensors in the field.

Due to its hygienic and robust design, the EXspect 271 sensor is suitable not only for many applications in the food and drinks industries, but also for diverse applications in the processing industry. This includes, for example, yeast recovery, phase separation, purification processes in dairy plants, and the measurement of cellulose concentrations.

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SICK OL1 DELIVERS PRECISE DETECTION IN THE MICROMETER RANGE

The SICK OL1 Optical Micrometer is a highly-accurate, miniature and rugged addition to SICK's portfolio of displacement technologies for thread, material thickness and edge measurements in continuous, sheet feeding and winding machines.

The SICK OL1 Optical Micrometer is a rugged instrument for integration into small spaces. With a miniature sender and receiver placed up to 300mm apart, it uses light curtain measurement technology, based on a multipixel, linear CMOS sensor, for high-precision, high-repeatability measurement and process control in the micrometer range. The OL1 is teamed with the SICK AOD1 Mini displacement evaluation unit for improved stability and consistency of output.

With a 10mm light band and detection resolution down to 0.2mm, the OL1 Optical Micrometer is a versatile and stable performer at short ranges, small tolerances and for handling thin materials, so it can support precision applications in paper, printing and packaging machines.
"SICK was able to apply its world-leading expertise in light curtain technology to develop a technology with micrometer accuracy that delivers high accuracy and efficiency in 1D and 2D profiling and displacement measurement within very limited space," says Neil Sandhu, SICK's UK Product Manager for Imaging, Measurement and Ranging.

"Whether designing new machines, or upgrading existing applications, the OL1 Optical Micrometer provides a highly-reliable and accurate option for web or thread width measurement, double layers, hole diameters or edge positioning and guidance. It is therefore particularly useful in industries such as paper making, printing and packaging industries. Whether it's tiny objects, tubes, threads, wires, transparent or reflective web materials, the OL1 delivers the reliability and fine tolerances required for high tech performance."

The SICK OL1 Optical Micrometer is a sender and receiver in twin miniature (61 x 21 x 10mm) rugged metal housings. The SICK OL1 sender emits a Class 1 laser 10mm-wide parallel light curtain, which is captured by the receiver on a high-resolution CMOS chip, with any object in between registering as a precisely-measured shadow. The SICK OL1 is an analogue measurement device and is combined with SICK's AOD1 evaluation unit for integration with the machine controller.

Alignment is simple with the integrated LED alignment aid at the sensor head. Commissioning and integration with machine controls is quick and easy, via the display configuration with individualised configuration and calculation through the AOD1 evaluation unit. The AOD1 displacement evaluation unit functionality enables simple interfacing with machine and SCADA factory control systems.

For more information on the SICK OL1 Optical Micrometer, please contact Andrea Hornby on 01727 831121 or email andrea.hornby@sick.co.uk.

SICK (UK) LTD, Waldkirch House, 39 Hedley Road, St Albans, Hertfordshire, AL1 5BN.

MISCELLANEOUS

HI-LINE HLI62 VERTICAL AIR RECEIVERS

As a company that listens carefully to changes in market demands and industry trends, Hi-line Industries now holds a range of class-leading Vertical Air Receivers in stock. The top-quality vessels are available immediately at highly competitive prices.

Currently, four sizes of Vertical Air Receivers are being stocked at Hi-line: 300, 500, 1000 and 2000 litre variants. The vessels are manufactured at Hi-line's new factory, centrally located in Burton-upon-Trent where the company has a storage facility populated with the vessels ready for immediate shipping or collection.

Receivers provide valuable temporary storage for compressed air, particularly at facilities with high air consumption. The vessels also serve to stabilise pressure peaks and provide steady air flow. Not having one as part of a compressed air system can increase the load/unload cycles on the compressor, making it work harder.

All of the Vertical Air Receivers stocked by Hi-line are powder-coat finished in compressed air blue (RAL 5015) and are PED compliant to 2014/68/EU. Indeed, quality is the primary attribute of the vessels, which are built by robots to ensure perfect and consistent welding quality. In addition, high-quality 5mm plate and fittings are used throughout. As a result of this build quality, the Vertical Air Receivers are twice the weight (pro rata) of standard catalogue vessels.

All four models of Vertical Air Receiver being stocked by Hi-line Industries offer 11 bar working pressure and come with a 10-year warranty. The vessels can be supplied with or without fitting kits to suit individual preferences. Safety valves, gauges and drains are also available as options.

As a member of the British Compressed Air Society, Hi-line is proud to be part of the 'Made in Britain' campaign that promotes the best of British manufacturing.

Further information is available from:
Hi-line Industries Ltd,
Green Street, Burton on Trent, Staffordshire DE14 3RT
Telephone: 01283 533377 www.hilineindustries.com

SELECTRONIC'S SUNLIGHT SPECTRUM LEDS CLOSE TO SUNLIGHT

IMAGINE artificial lighting in a business or home setting with LEDs producing close to actual sunlight all day long.

Well now you can get just that with the Sunlight Spectrum 2835 SMD packages from UK LED specialists Selectronic and their Chinese partners HongliTronic.

The Witney, Oxfordshire, based Selectronic, celebrating their 40th anniversary this year, are experts in opto-electronic technologies.

"We are pleased to introduce Hongli's Sunlight Spectrum 2835, which is the perfect solution to those wanting very close to natural light from an artificial source," said Selectronic MD Kevin Dry.

"The option to create lighting products that replicate daylight opens a new era of what can be achieved in previously closed-off rooms or underground environments, not to forget the health benefits in dark winter periods from creating artificial daylight particularly when linked with a time clock to accurately reflect the various times of a bright sunny day."

"The Sunlight Spectrum 2835, which produces perfect colour, measuring more than 95 in the range R1 to R15 and continuous saturation, is very close to the actual sunlight spectrum. There is much less blue light and it is a first choice for protecting our eyes."

The technology produces a spectrum of light that best matches sunlight's natural spectrum, giving the ideal solution whether it is for various industrial/retail applications as well as in business, office or home lighting products.

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 5, Number 1, 2019

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Installations

The following pages contain a summary of the various installations and orders from around the world of papermaking, wood panel and saw mills, and bio-power generation, received between November 2018 and the end of April 2019. Also included are new announcements about plans to build new mills or install new machinery (in which case the supplier will be noted as 'TBA').

COMPANY, SITE	SUPPLIER	ORDER DESCRIPTION	START-UP
Anon East Java Indonesia	ABB	Added ABB Ability™ Collaborative Operations to its service deliverables at a major paper mill in East Java - with an annual capacity of 320,000 metric tons, the mill is one of the world's largest single-site producers of writing stationery. ABB - East Java	
Anon Latin America	Toscotec	TAD tissue production line. Toscotec - Anon Latin America	H1 2019
ARCTIC PAPER Kostrzyn Mill Poland	Cellwood Machinery	To supply rebuild of PM1 Couch- and Press Pulper. Cellwood - Arctic Paper	Summer 2019
AUSTROCEL Hallein's Mill Hallein Austria	Valmet	To deliver pressure diffuser for the bleach plant washer. Valmet - Hallein	Fall 2019
BERLI JUCKER CELLOX Prachinburi plant Thailand	A.Celli	E-WIND T100 rewinder. A.Celli - Berli Jucker	
BLUE PAPER SAS Strasbourg France	Valmet	Valmet IQ Web Monitoring System (WMS) and a Valmet IQ Web Inspection System (WIS) (PM1). Valmet - Blue Paper SAS	
CARTIERA CAMA S.R.L Lallio mill Bergamo Italy	Toscotec	Rebuild of the dryer section of its PM1 which produces core board and carton board from 650 to 1,200 gsm, using 100% waste fibres. Toscotec - Cartiera Cama	H2 2019
CENTURY PULP AND PAPER Lalkua India	Valmet	Tissue production line (TM7) to include an Advantage ViscoNip press (the first in India). Valmet - Century Pulp & Paper	
DA ALIZAY SAS France	Valmet	To convert a recovery boiler into a biomass boiler utilizing bubbling fluidized bed combustion technology. Valmet - Da Alizay	Early 2020
DONGGUAN JINTIAN PAPER Sichuan Jintian Paper plant China	A.Celli	E-WIND® P100 rewinder. A,Celli - Dongguan Jintian	Q1 2019
ELDORADO BRASIL Onça Pintada plant Três Lagoas Mato Grosso do Sul Brazil	Andritz	To supply a biomass handling system for their new (50MWe) biomass energy plant Andritz - Eldorado	Mid-2021
ENCE Pontevedra Spain	CleanFlow	To supply a new green liquor filtration system. CleanFlow - ENCE	Spring 2019

COMPANY, SITE	SUPPLIER	ORDER DESCRIPTION	START-UP
GLOBAL HYGIÈNE Charavines France	A.Celli	Tissue production line. A.Celli - Global Hygiene	Q4 2019
GS EPS CO., LTD. Dangjin 4 Biomass Power Plant South Korea	Valmet	To supply automation technology to Phase 2 of this project. Valmet - Dangiin	Q1 2020
GS PAPERBOARD & PACKAGING SDN., BHD. Selangor Malaysia	Valmet	To supply a containerboard line with automation solutions (PM3). Valmet - GS Paperboard Packaging	2021
HAMBURGER RIEGER Spremberg Germany	Voith	Three separate stock preparation lines with a total capacity of 2,450 metric tons per day (PM2). Voith - Hamburger	Q2 2020
IGGESUND PAPERBOARD Iggesund Mill Sweden	Andritz	Modernise fibreline including: brown stock washing; oxygen delignification stage; relocation of screening; and bleach plant modernisation. Andritz - Iggesund	Q4 2019
ILIM GROUP Koryazhma mill Arkhangelsk region Russia	Andritz	To supply wood processing plant with two debarking and chipping lines, chip and bark handling equipment, and a Smart Woodyard advanced control system. Andritz - Ilim Group	Mid-2021
ILIM GROUP Koryazhma mill Arkhangelsk region Russia	Econet Group	Wastewater treatment machinery - clarifiers and sludge thickeners with sluice systems. Econet - Ilim Group	Summer periods of 2019-2021.
JSC VOLGA Balakhna Russia	Andritz	To rebuild the existing groundwood reject line into a TMP (thermo-mechanical pulping) line. Andritz - JSC Volga	Q3 2019
KABEL PREMIUM PULP & PAPER Hagen Germany	Andritz	A new ATMP (Advanced Thermo Mechanical Pulp) line. Andritz - Kabel	Q1 2019
LAAKIRCHEN PAPIER Laakirchen Austria	Voith	Stabiliser boxes / Reel changing system. Voith - Laakirchen Papier	
LONDONENERGY LTD. North London UK	Valmet	Modernise the automation systems as well as the electrical and instrumentation infrastructure of a waste water treatment plant. Valmet - London Energy	2019
LUZHOU YONGFENG PULP AND PAPER China	Valmet	A Valmet IQ Steam Profiler. Valmet - Luzhou Yongfeng	Q4 2018
MAYR-MELNHOF KARTON Frohnleiten Austria	Valmet	A Valmet IQ Web Monitoring System (WMS) with 51 cameras throughout the whole production process (KM3). Valmet - Mayr-Melnhof	

COMPANY, SITE	SUPPLIER	ORDER DESCRIPTION	START-UP
MERCER GROUP Stendal Pulp Mill Germany	Valmet	On-line performance monitoring for nine Valmet TwinRoll wash presses. Valmet - Mercer Group	
METSÄ GROUP Joutseno pulp mill Finland	Valmet	To supply a new wood handling line (capacity 470 m3/hour). Valmet - Metsa Group	Spring 2020
METSÄ TISSUE Mänttä Mill Finland	Valmet	An automation system update and expansion for Gasum's project, in which the mill will replace liquefied petroleum gas (LPG) with Gasum's low-emission liquefied natural gas (LNG) in the burners of the drying processes on the tissue machines. Valmet - Metsa Tissue	Q2 2019
MONDI SCP Ružomberok Slovakia	Valmet	Old Corrugated Container (OCC) and OptiConcept M containerboard making lines with a winder (PM19). Valmet - Mondi SCP	End 2020
PAPEL ARALAR Amézqueta Spain	Valmet	Rewinder (nonwovens) for PM4. Valmet - Papel Aralar	Q2 2019
PAPELERA DEL PRINCIPADO Paprinsa Spain	Valmet	A Valmet IQ Quality Control System, a related reporting system and a recently launched Valmet DNA IQ Dashboard. Valmet - Papelere del Principado	
PAPIERFABRIK PALM Aalen-Neukochen Mill Germany	Valmet	To supply a containerboard making line (PM 5) with extensive packages of mill-wide automation and services. (At 11.7m it will be the largest containerboard machine in the world.) Valmet - Palm	2021
PORI ENERGIA OY Aittaluoto biomass power plant Finland	Valmet	Automation technology. Valmet - Pro Energia	Summer 2020
MOHAWK various sites USA	Greycon	To roll out opt-Studio to the envelope and substrate converting business. Greycon - Mohawk	
NAINI PAPERS India	Valmet	To supply cooking, fibreline and recausticising technology, as well as a new lime kiln. Valmet - Naini Papers	Q1 2020
NORSKE SKOG Skogn Mil Norway	Statkraft	Long term power supply contract. Statkraft - Norsk Skog	
NORSKE SKOG Saugbrugs Mill Norway	Statkraft	Long term power supply contract. Statkraft - Norsk Skog	

COMPANY, SITE	SUPPLIER	ORDER DESCRIPTION	START-UP
PARTEX STAR GROUP Bangladesh	A.Celli	New tissue machine with 15ft steel Yankee A.Celli - Partex	Q1 2019
POLÍMEROS Y DERIVADOS Guanajuato Mexico	Greycon	Software (nonwovens) - opt-Studio advanced functionality of block schedule optimisation, to complete the third and last phase of full project implementation. Greycon - Polimeros-y-Derivados	
PT DAYASA ARIA PRIMA Surabaya Indonesia	PMT	Machine rebuild (PM1) to convert from printing grades to corrugated. PMT - PT Dayasa	
RAKTA Egypt	Papcel	To modernise PM3 (Containerboard) by delivering a new stock preparation line, renovating the press and upgrading the drying section. Also adding a new size press, starch preparation unit, steam and condensation system. Papcel - RAKTA	Q2 2020
SAPPI Saiccor Pulp Mill South Africa	Valmet	A baling line and a cutter layboy rebuild as part of the Vulindlela project. Also a new magnesium oxide (MgO) No.3 brown stock washing and screening line. Valmet - Sappi - baling and cuting Valmet - Sappi - wash & screen	Q3 2019
SHANGHAI BAILONGGANG Wastewater treatment plant China	Valmet	To supply 21 Valmet Total Solids Measurements (Valmet TS) with high-pressure (PN100) option.	H1 2019
SHANGRAO CITY LULIN PAPER Shangrao China	Valmet	To supply grade conversion rebuild to containerboard, with automation solutions, for PM5. Valmet - Shangrao	Early 2020
SHANYING HUAZHONG PAPER Industry China	A.Celli	To supply two 8-metre E-WIND® P100 paper rewinders. A.Celli - Shanying	Q3 2019
SKJERN PAPIRFABRIK A/S Denmark	Toscotec	To rebuild the dryer section of PM1 (Coreboard). Toscotec - Skjern	Q3 2019
SMURFIT KAPPA Cellulose du Pin Mill Facture France	Toscotec	Rebuild of the entire dryer section of the 6m wire (PM5). Toscotec - Smurfit Kappa	Q1 2020
SOUTH INDIA PAPER MILLS Nanjangud India	PMP SA	Two core technological items - Intelli-Jet V® Hydraulic Headbox and two Intelli-Nip® Shoe Presses in Tandem configuration (PM6). PMP - South India Paper Mills	Early 2020
SUZANO PAPEL E CELULOSE Limeira unit Brazil	BTG	Instrumentation / Process Control. (Fibreline C)	

COMPANY, SITE	SUPPLIER	ORDER DESCRIPTION	START-UP
SVEZA GROUP Vologda region Russia	Pesmel	MoU regarding an automated pulp storage of the planned greenfield pulp mill project. Pesmel - Sveza Group	
TEXHONG TEXTILE GROUP Vietnam	A.Celli	Automated warehouses. A.Celli - Texhong Textile	
TURUN SEUDUN ENERGIANTUOTANTO Naantali Finland	Valmet	Flue gas condensing and asphaltene combustion systems. Valmet - Turun Seudun	End 2019
URUMCHI JINGHUAN ENVIRONMENTAL & ENERGY Urumchi China	Valmet	Two boiler plants fired with refuse-derived fuel (RDF) for a greenfield waste-to-energy plant. Valmet - Urumchi	End 2019
VATTENFALL AB Uppsala Sweden	Andritz	Biomass receiving, handling and storage silos, a biomass-fired boiler with flue gas cleaning, and a flue gas condenser. Andritz - Vattenfall	End 2021
VOITH (on behalf of) Gondi Group Monterrey Mexico	Pöyry	To provide detailed engineering services agreement for a new containerboard machine. Poyry - Gondi Group	Mid-2019
ZHEJIANG KINGSAFE NONWOVENS FABRIC Huzhou China	A.Celli	Nonwovens complete line comprising a STREAM® winder, a RAPID® rewinder, a Slittomatic, an extractor, and an automated roll handling and packaging system. A.Celli - Zhejiang	H1 2019

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 5, Number 1, 2019

Paper Industry Technical Association

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Research Articles

Most journals and magazines devoted to the paper industry contain a mixture of news, features and some technical articles. However, very few contain research items, and even fewer of these are peer-reviewed.

This listing contains the most recent articles from the five main journals that publish original research:

- *APPITA JOURNAL*
- *IPPTA JOURNAL*
- *J-FOR*
- *NORDIC PULP & PAPER RESEARCH JOURNAL*
- *TAPPI JOURNAL*

APPITA JOURNAL, Vol.71, No.4, October-December 2018

1. Comparison of polyvinyl alcohol and oxidised starch as surface sizing agents
2. Development and evaluation of suspension-polymerised latex additive for surface sizing of paper
3. Improvement in pulp quality and effluent properties using methanol as carbohydrate protector during ozone bleaching of wheat straw pulp
4. Analysis of sulfolane in biochar

APPITA JOURNAL, Vol.72, No.1, January-March 2019

1. Editorial - New directions for Appita Journal
2. Impact of dissolved organic matter in hydrogen peroxide reinforced alkaline extraction stages
3. Colloidal stability of Pinus radiata wood extractives Part 1: Effect of extractives composition and process variables
4. Grammage dependence of paper thickness
5. Neutral/alkaline sizing of paper with fortified, saponified wood rosin premixed with alum and retained using cationic polymer
6. Transferring science to industrial application: Challenges in running commercial trials

IPPTA JOURNAL, Vol.30, No.3, July-September 2018

1. Advanced Analytics for Optimization of Stage-Wise ISO Brightness Gain in Kraft Pulp Bleaching
2. Advanced Analytics Improve Mill Performance and Reliability
3. Automation in Papermill Finishing House
4. Automation Solutions in Process, Productivity, and Quality in Pulp & Paper Industry for Sustainable Paper Making
5. Business Process Automation for Process, Productivity, Quality & Marketing Optimization at TNPL Board Machine Finishing House
6. Collection and Incineration of Non Condensable Gases (NCG) Through Automation
7. Continuous Improvements in Paper Manufacturing Automation at TNPL
8. Improving Papermaking with Integrated Web Monitoring and Web Inspection Camera Systems
9. Inception of In-House Automation: A March Towards Industry 4.0
10. Increasing Productivity Through Automation
11. Nalco Water, an Ecolab Company Uses Automation and Online Real Time Monitoring to Help on Productivity, Water and Energy Conservation
12. Optimized Automation and Centralized Mill Data Acquisition Techniques for Paper Making
13. Optivision Centerline – Solution Note
14. Paper Mill Automation for Customer Satisfaction and Profit Maximization – Case Studies of Paper Mills in India
15. Papermaking 4.0 by Voith
16. Reduction in Cost of Poor Quality (COPQ) due to Blotches in Paper Machine using Advanced Analytics
17. The Conception of Industry 4.0 in the Environment of Pulp and Paper Companies in India
18. Yokogawa's Synaptic Business Automation – An Approach to the Oprex Profit Driven Operation Including IIOT and Digital transformation

J-FOR, Vol.7, No.4, 2018

1. Non-covalent Surface Modification of Cellulose Nanocrystals by Polyethyleneimine
2. Apparent Structural Hydrophobicity of Cellulose Nanocrystals
3. Partnering for Lignin Biorefinery: Partner Evaluation and Selection Criteria
4. Production of Hydrocarbons from Fast Pyrolysis of Kraft Black Liquor: Integration with a Kraft Mill
5. Biomimetic Adhesion of Phages on Cellulosic Fibres: A Feasibility Study
6. Exploring New Forms of Intermediation in the Forest Value Chain

NORDIC PULP & PAPER RESEARCH JOURNAL, Vol.33 No.4, December 2018

1. Paper technology: Through air drying assisted by infrared radiation: the influence of radiator power on drying rates and temperature
2. Paper technology: New strength metrics for containerboards: influences of basic papermaking factors
3. Paper technology: Selection of filler particle size for maximizing the critical properties of cellulosic paper by filler pre-flocculation
4. Nanotechnology: Detection of iron and iron-cobalt labeled cellulose nanofibrils using ICP-OES and XµCT
5. Paper physics: Variations of fiber structure and performance of ONP delinked pulp after modified-laccase/glutamate treatment
6. Paper chemistry: On-line monitoring of cationic starch gelatinization and retrogradation by 1H NMR-relaxometry
7. Paper chemistry: Wet-peel: a tool for comparing wet-strength resins
8. Paper chemistry: Improved dispersibility of once-dried cellulose nanofibers in the presence of glycerol
9. Recycling: Recycled fiber treated with NaOH/urea aqueous solution: effects on physical properties of paper sheets and on hornification

NORDIC PULP & PAPER RESEARCH JOURNAL, Vol.34 No.1, March 2019

1. Lignin: Method for predicting lignocellulose components in jute by transformed FT-NIR spectroscopic data and chemometrics
2. Biorefinery: Short-term steam treatment of MFC gel with and without water-soluble cellulose derivative
3. Chemical pulping: Method for analysis of ClO2 and Cl2 air emissions from pulp mill
4. Chemical pulping: Consequences in a softwood kraft pulp mill of initial high alkali concentration in the impregnation stage
5. Mechanical pulping: Power–gap relationships in low consistency refining
6. Mechanical pulping: Theoretical analysis of LC-refining – pressure screening systems in TMP
7. Paper technology: Calcination-carbonization two-step process to improve the brightness of fly ash and its application in paper filling
8. Paper technology: Energy efficiency in low consistency refining: a study using a Valley beater
9. Paper physics: Principles of developing physical test methods for disposable consumer products
10. Paper chemistry: Switching off PAE wet strength
11. Coating: Improving fire retardancy of cellulosic thermal insulating materials by coating with bio-based fire retardants
12. Printing: Time-dependent mechanical response of paper during web-fed high-speed inkjet printing

13. Packaging: Model to predict the top-to-bottom compressive strength of folding cartons
14. Environmental impact: A solution for a treatment of bottom sludge from a log-soaking pond for separation of sand
15. Environmental impact: Effects of temperature on white water treatment by the dominant bacteria
16. Environmental impact: Performance of microaerobic granular sludge system for pentachlorophenol (PCP) degradation responding to PCP loading shock
17. Miscellaneous: Potential of kraft lignin as an additive in briquette production
18. Miscellaneous: Effect of wood flour and naphthenic oil on morphology, rheological and mechanical properties of EPDM/PP/AL composite

TAPPI JOURNAL, November 2018

1. Editorial: 2018 TAPPI Journal features diverse content
2. Understanding the risks and rewards of using 50% vs. 10% strength peroxide in pulp bleach plants,
3. Does the kappa number method accurately reflect lignin content in nonwood pulps?
4. Using multistage models to evaluate how pulp washing after the first extraction stage impacts elemental chlorine-free bleach demand
5. Understanding the pulping and bleaching performances of eucalyptus woods affected by physiological disturbance

TAPPI JOURNAL, January 2019

1. Editorial: Lignin: Nature's versatile polymer as a potent chemical platform for 21st century challenges
2. Adsorption performance of magnetic aminated lignin for the removal of Cu(II) and Cd(II)
3. Magnetization of aminated lignin and characterization
4. Structural analysis of poplar and Masson pine lignocresols and comparison of their bovine serum albumin adsorption characteristics
5. Synthesis and characterization of novel foams by pyrolysis of lignin
6. Characterization and evaluation of antioxidation of lignin from bamboo powder using a formic acid-catalyzed ethanol organosolv process
7. Nano-magnesium oxide as hard template synthesis of lignin carbon-based solid acids and its application for cellulose hyrdrolysis
8. Graft copolymerization of acrylic acid of kraft lignin to enhance aniline adsoprtion from aqueous solution

TAPPI JOURNAL, February 2019

1. Editorial: Historical and evolving challenges in the coated paper industry
2. Discrete element method to model cracking for two layer systems
3. Optimazation of coating with water-based barriers
4. Operational limits of blade coating associated with high aspect ratio pigments: Part I – bench top blade coater
5. Operational limits of blade coating assocciated with high aspect ratio pigments: PartII – cylindrical laboratory coater
6. Improving the inkjet codability of folding boxboard
7. Cracking at the fold in double layer coated paper: the influence of latex and starch composition

TAPPI JOURNAL, March 2019

1. Editorial: TAPPI Journal 2018 Best Research Paper delves deeper into press section rewet to address drying efficiency
2. Evaluating hardness and the S-test
3. Controllable anisotropic properties of wet-laid hydroentangled nonwovens
4. Size distribution analysis of microstickies treated by enzyme mixtures in papermaking whitewater
5. A study of the softness of household tissues using a tissue softness analyzer and hand-felt panels

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Technical Abstracts

The general peer-reviewed scientific and engineering press consists of several thousand journals, conference proceedings and books published annually. In among the multitude of articles, presentations and chapters is a small but select number of items that relate to papermaking, environmental and waste processing, packaging, moulded pulp and wood panel manufacture. The edited abstracts contained in this report show the most recently published items likely to prove of interest to our readership, arranged as follows:

The Paper Industry Technical Association (PITA) is an independent organisation which operates for the general benefit of its members – both individual and corporate – dedicated to promoting and improving the technical and scientific knowledge of those working in the UK pulp and paper industry. Formed in 1960, it serves the Industry, both manufacturers and suppliers, by providing a forum for members to meet and network; it organises visits, conferences and training seminars that cover all aspects of papermaking science. It also publishes the prestigious journal *Paper Technology International* and the *PITA Annual Review*, both sent free to members, and a range of other technical publications which include conference proceedings and the acclaimed *Essential Guide to Aqueous Coating*.

3-D PRINTING

Composites of waterborne polyurethane and cellulose nanofibers for 3D printing and bioapplications, Ren-De Chen et al, *Carbohydrate Polymers*, Vol.212. Waterborne polyurethane (PU) is a green, high performance elastomer but the viscosity of the dispersion is generally too low for direct three-dimensional (3D) printing. Composite brings additional properties while reinforcing the substrate. In the study, printable PU composites were successfully prepared by introducing cellulose nanofibrils (CNFs) and the viscosity was effectively regulated by the amount of neutralising agent during *in-situ* synthesis.

COATING

Study of chitosan with different degrees of acetylation as cardboard paper coating, Mariane Gatto et al, *Carbohydrate Polymers*, Vol.210. The biodegradability of chitosan is significant for packaging systems. Another relevant property of chitosan is its degree of acetylation (DA), which affects other properties, such as crystallinity and hydrophobicity. The DA can be modulated by chitin deacetylation or even chitosan reacetylation. The novelty of this paper is the application of reacetylated chitosan as a coating for cardboard paper surfaces to improve the barrier and mechanical properties of the paper. Chitosan with 2% DA was reacetylated to yield chitosan with 48% DA. Both samples were applied as cardboard paper coating, and the coated materials were characterised. The paper-film system of chitosan with 2% DA had better water barrier and mechanical resistance.

ENERGY / ENVIRONMENT

Life cycle energy consumption analysis and green manufacture evolution for the papermaking industry in China, Yi Man et al, *Green Chemistry*, Issue 5. Papermaking is a highly energy-consuming industry. The growth in paper demand will further intensify the need for energy and the stress of GHG emissions. Papermaking involves complex processing routes, and energy is required for collecting raw materials, producing chemicals, and pulp and papermaking. Previous investigations of energy consumption in the papermaking industry have focused primarily on the analysis of one single product or one single pathway, lacking a comprehensive and systematic comparison of various products and pathways. Herein, the results of a life cycle energy consumption analysis of major paper products in China using an extensive system boundary are presented. When 1 tonne of paper was produced in China in 2015, the maximum energy consumption was 38.17 GJ for tissue paper, with a minimum energy consumption of 15.90 GJ for corrugated medium. This study also predicts energy-related GHG emissions and a mitigation target in the papermaking industry in China by 2050.

Short term electric load forecasting model and its verification for process industrial enterprises based on hybrid GA-PSO-BPNN algorithm—A case study of papermaking process, Y Hu et al, *Energy*, Vol.170. Process industry consumes tremendous amounts of electricity for production. Electric load forecasting could be conducive to managing the electricity consumption, determining the optimal production scheduling, and planning the maintenance schedule, which could improve the energy efficiency and reduce the production cost. This paper proposed a short term electric load forecasting model based on the hybrid GA-PSO-BPNN algorithm. Besides the proposed GA-PSO-BPNN model, the GA-BPNN and PSO-BPNN based electric load forecasting models are also studied as the contrasting cases. The verification results reveal that the GA-PSO-BPNN model is superior to the other two hybrid forecasting models for future application in the papermaking process since its MAPE is only 0.77%.

Resource value flow analysis of paper-making enterprises: A Chinese case study, Z Li et al, *Journal of Cleaner Production*, Vol.213. Papermaking enterprises are currently under both environmental pressure and economic pressure for sustainable development in China. Thus, the efficiency, effectiveness, and benefits of resource utilisation need to be improved. High-consumption and high-pollution companies should manufacture paper using sustainable methods. This study highlights a resource value flow analysis from the circular economy perspective, developing an extension of material flow cost accounting and modifying it by accounting for environmental damage as well as economic benefits. In general, applying a resource value flow analysis can both reduce resource consumption and minimise environmental damage, enhancing the sustainable development of a process industry with limited resources.

LOGISTICS

A Description of Supply Chain Planning Problems in the Paper Industry with Literature Review, Florian Jaehn & Raisa Juopperi, *Asia-Pacific Journal of Operational Research*, Vol.36 (1). The paper industry supply chain is highly complex and consists of many processes and planning tasks. It starts with the collection of raw wood and ends up in different paper products from paperboard to high class art papers. Managing the supply chain is difficult and the permanently changing business environment constantly brings new challenges. This paper starts with outlining the challenges in the supply chain management of today's paper industry. After that we evaluate the state of research to determine planning problems covered by the literature. The purpose is to catch up time-wise on the previous overview from 2009 and also to update the planning problems. This overview paper summarises comprehensively the paper industry as of today. It provides a reference work for researchers and other interested parties, and uncovers areas for future research.

Warehouse Design and Operation using Augmented Reality technology: A Papermaking Industry Case Study, D Mourtzis et al, *Procedia CIRP*, Vol.79. In modern, high competitive markets, efficient warehousing is critical as it accounts for a great part of logistics costs. Companies try to adopt highly adaptive and flexible warehouse design that may support the integration of novel technologies such as Augmented Reality (AR). This paper proposes a framework for warehouse design which minimises inventory cost while keeping a high degree of service by supporting the integration of an AR warehousing system. The AR system will support the effective management of operations, by providing meaningful information. The proposed methodology is tested and validated in a real-life case study of a papermaking industry.

MOULDED PULP

Research on the Preparation and Properties of Water Resistant and Oil Resistant Paper Tableware Made by Bagasse Brown Pulp, Li Liu et al, *Applied Sciences in Graphic Communication and Packaging*, pp.609-615. Part of the Lecture Notes in Electrical Engineering book series (LNEE, Vol.477). Water-resistant and oil-resistant paper tableware has broad application prospects. The mechanism of water resistance and oil resistance properties of paper and the determination of oil resistance properties were introduced. The water/oil resisted paper was made of bagasse brown pulp by beating and adding oil-resistant agent, water-resistant agent and retention aid. The effects of water repellent, oil repellent and other factors on the oil and water repellency of paper tableware were studied.

***Molded Pulp Products Manufacturing: Process Development, Characterization and Modeling*, Mattia Didone, PhD Thesis, Manufacturing Engineering, Department of Mechanical Engineering, Technical University of Denmark, Produktionstorvet, 2800, Kgs. Lyngby, Denmark.** The matter of this thesis is the development, characterisation and ultimately modelling of the manufacturing process of moulded pulp products. In particular, focus was placed on studying and optimising the drying step, as the cost of energy required may be from eight to twenty times that needed for pre-forming.

NANO-SCIENCE

A bio-mechanical process for cellulose nanofiber production – Towards a greener and energy conservation solution, Xiuyu Liu et al, *Carbohydrate Polymers*, Vol.208. Enzyme pretreatment prior to mechanical grinding in cellulose nanofiberes production was fully explored in order to save mechanical energy and to find an alternative to chemical treatment, thus reducing the environmental impact of the process. Grinding energy was determined in terms of total energy, effective energy, and was related to nanofibre yield. Fibre morphology, crystalline and chemical structures were analysed to reveal the mechanisms behind enzyme actions. The results showed that with enzyme pretreatment, the effective energy was reduced by 60%, and yield of nanofibres was increased by 76%.

Comparative study of aramid nanofiber (ANF) and cellulose nanofiber (CNF), Bin Yang et al, *Carbohydrate Polymers*, Vol.208. Cellulose nanofibre (CNF) has faced challenges toward advanced applications due to the poor water resistance, wet strength, and poor thermal stability. The fabrication methods, morphologies and dispersibility between CNF and aramid nanofibre (ANF) were compared. Then the mechanical strength, especially the retention of wet strength (RWS), optical property, UV shielding, wettability and thermal stability of CNF and ANF nanopapers were further investigated. The results show that ANF and ANF nanopaper have significant advantages in dispersibility, water resistance, wet strength, thermal stability and UV-blocking ability over the CNF and CNF nanopaper. This work demonstrates that the ANF could be an ideal alternative to CNF for advanced nanocomposites.

A novel method for preparing microcrystalline cellulose from bleached chemical pulp using transition metal ions enhanced high temperature liquid water process, Xiaopeng Yue et al, *Carbohydrate Polymers*, Vol.208. A novel method for preparing microcrystalline cellulose (MCC) from bleached chemical pulp based on the transition metal ion-enhanced high temperature liquid water (HTLW) process was established in this study. Transition metal ions (Fe3+, Cu2+ or Cr3+) were used to enhance the depolymerization effect of HTLW treatment on fibres. The transition metal ion-enhanced HTLW treatment provides an acid free method for preparing MCC.

Preparation and characterization of cellulose nanofibrils from coconut coir fibers and their reinforcements in biodegradable composite films, Jun Wu et al, *Carbohydrate Polymers*, Vol.211. Coconut waste husks were effectively utilised in this study as a promising cellulose source for production of purified coir cellulose (PCC) after multiple treatments, e.g., ultrasonic-assisted solvent immersion, alkaline treatment, bleaching, etc. The cellulose nanofibrils were comprehensively characterised in terms of their functional groups, crystallinity, morphology, and thermal stability. The potential reinforcement of CCNFs as a filler for biodegradable PVA based films was investigated.

Mango Kernel Starch Films as Affected by Starch Nanocrystals and Cellulose Nanocrystals, Ana Priscila M. Silva et al, *Carbohydrate Polymers*, Vol.211. Mango seeds have been used to obtain components for nanocomposite films, namely, starch and starch nanocrystals (SNC) from seed kernels, and cellulose nanocrystals (CNC) from seed shells. Starch-based films were prepared with different contents and combinations of SNC and CNC. The optimised conditions (1.5 wt% CNC and 8.5 wt% SNC on a starch basis) resulted in a film with enhanced strength, modulus, and barrier to water vapour when compared to the unfilled film, although the elongation has been impaired.

Preparation of cellulose nanomaterials via cellulose oxalates, Jonatan Henschen et al, *Carbohydrate Polymers*, Vol.213. The current work describes the use of a bulk reaction between pulp and oxalic acid dihydrate to prepare cellulose oxalate followed by homogenisation to produce nanocellulose. The presented results illustrate that cellulose oxalates may be a low-cost method to prepare nanocellulose with properties reminiscent of those of both cellulose nanofibrils and cellulose nanocrystals, which may open up new application areas for cellulose nanomaterials.

Nanocellulose production from recycled paper mill sludge using ozonation pretreatment followed by recyclable maleic acid hydrolysis, Roi Peretz et al, *Carbohydrate Polymers*, online. Nanocellulose (NC) has garnered much interest worldwide due to its physical and chemical properties. Nanocellulose is produced from biomass materials by bleaching pretreatment, followed by acid hydrolysis. This work demonstrated the production of NC from recycled paper sludge (RPS), a crystalline cellulose rich waste, by ozonation pretreatment, followed by maleic acid hydrolysis. These results demonstrate that ozonation can be used as an effective pretreatment for NC production.

NOVEL PRODUCTS

Development of microporous cellulose-based smart xerogel reversible sensor via freeze drying for naked-eye detection of ammonia gas, Tawfik A. Khattab et al, *Carbohydrate Polymers*, Vol.210. Microporous cellulose xerogel can be defined as low density biomaterial that can be employed for a variety of promising applications of different fields. The characteristics of xerogel are a consequence of their microstructure. An easy-to-use and reversible solid-state colorimetric sensor for ammonia gas was developed by embedding a bromocresol purple (BCP) pH-sensory chromophore into the environmental friendly carboxymethyl cellulose as bio-based polymer (CMC) matrix. The vapochromic xerogel provided an instant colour alteration signal from yellow to purple when exposed to ammonia gas or an ammonium hydroxide aqueous environment as monitored by the absorption maxima, colour coordinates and colour strength.

Stimuli-responsive cellulose paper materials, Zhijian Li et al, *Carbohydrate Polymers*, Vol.210. Cellulose paper can be functionalised, such as modified with stimuli-responsive polymers, small molecules or inorganic particles, papers may be sensitive to external stimuli from environments and consequently find applications in wide ranges including protein separation, controlled drug release, switchable surfaces, sensoring devices and smart substrates with various colours, etc. However, there are no reviews summarising the progress of such exciting research field. Here in this mini review, we discuss the advantages of cellulose paper as stimuli-responsive substrate and summarise the fabrication techniques, properties and applications of various stimuli-responsive papers reported to date which are triggered by temperature, pH, humidity, ions, light, magnetic field, solvent gas and biomolecules.

Using cellulose fibers to fabricate transparent paper by microfibrillation, Zhenzhen Li et al, *Carbohydrate Polymers*, Vol.214. Fabricating transparent paper from cellulose nanofibres (CNFs) normally involves high energy or the use of expensive chemicals for the extraction of CNFs from cellulose fibres and time-consuming paper formation processes because of the slow filtration rate of CNFs. In this study, we reported a strategy for the fabrication of transparent paper using microfibrillated cellulose fibres (MFCFs), which were prepared by extracting nanosized fibrils from the cellulose fibre surfaces by a two-step refining process. The transparent paper made from MFCFs shows higher thermal stability, higher tensile strength, higher resistance to deformation, and more flexibility than the nanopaper made from commercial CNFs. This work provides a promising method for the manufacture of transparent paper from cellulose fibres.

Poly (lactic acid) composites reinforced with kraft pulp fibres: Production by a papermaking process and characterisation, S Sousa et al, *Composites Part A: Applied Science and Manufacturing*, Vol.121. Four different pulp fibres, representing short and long cellulose fibres and chemically modified fibres, were tested as reinforcements for poly(lactic acid) composites. A simple papermaking method was used to form the composite sheets, which were further compression moulded. The effects of morphological, chemical, and mechanical characteristics of kraft pulp fibres and their contents on the PLA composite characteristics were investigated.

PACKAGING TECHNOLOGY

Fabrication and characterization of starch-based nanocomposites reinforced with montmorillonite and cellulose nanofibers, Jiali Li et al, *Carbohydrate Polymers*, Vol.210. In this study, one-dimensional (1D) cellulose nanofibres (CNFs) were used to stabilise the dispersion of two-dimensional (2D) montmorillonite (MMT) plates in aqueous system. Then the prepared MMT/CNF solution was simultaneously merged into water soluble corn starch (CS) to obtain CS/MMT/CNF composite freestanding films through a casting method. The reinforcing effect from building blocks of MMT and CNF, interfacial interactions of hydrogen and covalent bonding together led to enhanced tensile strength and Young's modulus, reduced moisture susceptibility and increased transparency of the ternary CS nanocomposites. These extraordinary properties of the ternary nanocomposites clearly point towards a new strategy for designing and fabricating high-performance starch-based nanocomposites by using binary fillers with different geometric shapes and aspect ratio. This kind of ternary nanocomposite can be widely used in food packing and preservation as a biodegradable and green film.

Effect of electrolyte on regenerated cellulose film as gold nanoparticle carrier, Lijuan Liu et al, *Carbohydrate Polymers*, Vol.210. The catalytic performances of gold nanoparticles immobilised on regenerated cellulose films were influenced by cellulose structure. Cellulose was regenerated in aqueous coagulants containing different electrolytes, to fabricate regenerated films with different coagulated network structure and property. Hofmeister sequence can be used to describe regeneration, namely more kosmotropic ions in the coagulants led to cellulose films with more homogeneous coagulated network structure, possibly due to the dehydration of cellulose caused by the ions. Gold nanoparticles were then immobilised on the films to prepare portable catalysts. This work provided not only the fundamental information about the intermolecular interactions between ions and macromolecules, but also an effective approach to construct powerful catalysts.

Fabrication of food-safe superhydrophobic cellulose paper with improved moisture and air barrier properties, Hui Li et al, *Carbohydrate Polymers*, Vol.211. We presented a facile method for preparing a food-safe superhydrophobic packaging paper with improved moisture and air barrier properties in this study, which is combining construction of polymer-nanoclay hybrid multilayers with subsequent carnauba wax treatment. The obtained paper was used for strawberry packaging at ambient temperature, and it was very effective at reducing the weight loss and maintaining titratable acidity compared with the unpackaged strawberries, which might has a great potential as food packaging materials.

Highly transparent and thermally stable cellulose nanofibril films functionalized with colored metal ions for ultraviolet blocking activities, Weisheng Yang et al, *Carbohydrate Polymers*, Vol.213. Although many preparation methods have been reported so far, it is still a great challenge for Ultraviolet (UV) protection films that simultaneously have extremely high transparency and excellent UV shielding properties. Herein, we reported a simple, eco-friendly process for preparing high transparency TOCN-COOM (M: metal ions) films with diverse UV-shielding performances via adsorption of coloured metal ions (Fe3+, Co2+, Ni2+, Cu2+). The introduction of Fe3+ led to an excellent UV blocking, especially almost 89% absorption of Ultraviolet A (UVA) and full absorption of Ultraviolet B (UVB). The formation of metal-carboxylate complexes is also advantageous for improving thermal stability. Hence, the obtained TOCN-COOM films have wide application prospect in the field of UV shielding.

Role of the Relaxation State of Polymer Components in Wood When Making Composite Packaging Materials (Corrugated Cardboard), E. L. Akim et al, *Fibre Chemistry*, Vol.50 (4). We consider targeted variation of the relaxation state for polymer components of wood in stages of the life cycle of corrugated cardboard. From the standpoint of the structural physicochemistry of wood, we present a mechanism for the processes occurring in traditional corrugated cardboard production technology. Our thesis is that cellulose and hemicellulose can go from the glassy state to the rubbery (highly elastic) state at 220°C, but under real conditions this transition occurs at room temperature and even at negative temperatures in the case of plasticization by a sufficient amount of water. Transition of lignin from the glassy state to the rubbery state occurs at a temperature above 130°C, and at 70°C-120°C under conditions of sufficient hydration. Formation of strong interfibre bonds is possible only when the polymers forming the contact are in the rubbery or viscous-flow state.

PAPERMAKING

Study on the wet-web strength and pressability of paper sheet during the press process with the addition of nano-fibrillated cellulose (NFC), Zonghong Lu et al, *Carbohydrate Polymers*, Vol.210. The properties of wet-web strength and pressability of base paper affect the frequency of sheet breaks and machine runnability during the paper-making process. In this paper, the effect of nano-fibrillated cellulose (NFC) on the wet-web strength and pressability of paper sheet during the press process of paper-making was explored. It was found that the tensile energy absorption (TEA) of the sample was increased from 6.32 to 10.93 J/m^2 at 50% wet web solid content when 5% NFC was added. The web solid content was decreased from 50.51% to 42.85% when 0%-5% NFC was added under the same drainage and press conditions, indicating that the addition of NFC during the paper-making process can retard the pressability of paper sheet. The study put forwards a new view to discuss/study the effect of added NFC on the wet-web strength and pressability of paper sheet.

Carboxymethylated cellulose nanofibrils in papermaking: influence on filler retention and paper properties, AF Lourenço et al, *Cellulose*, Vol.26 (5). The present paper deals with the production of cellulose nanofibrils (CNF) from bleached Eucalyptus kraft pulp by carboxymethylation and TEMPO-mediated oxidation, followed by high pressure homogenisation. The main purpose of the work was to increase the filler retention and mechanical strength of printing and writing paper grades. Mineral fillers are of utmost importance in papermaking and therefore a thorough study of the CNF influence in filler-containing handsheets is mandatory. In this sense, flocculation studies revealed the extraordinary ability of CNF to flocculate calcium carbonate, which was translated into high filler retentions in the paper matrix. Moreover, the interactions between bleached pulp, CNF, mineral fillers and common paper additives, such as cationic starch, alkenyl succinic anhydride and cationic polyacrylamide, were investigated. The results show that, depending on the materials applied, CNF are able to promote an adequate bonding between fibres and filler aggregates, reducing the requirements for the additives. The addition of carboxymethylated or TEMPO-oxidised CNF to the fibrous matrix led to handsheets with better structural, mechanical and optical properties than those of reference handsheets (without CNF and with additives).

Mechanisms of strength and stiffness improvement of paper after PFI refining with a focus on the effect of fines, Hamid Reza Motamedian et al, *Cellulose*, Vol.26 (6). Refining (i.e., mechanical beating of pulp) is a common procedure that is used in paper-making to improve the mechanical properties of the final product. The improvements caused by refining are mainly attributed to increased density and to a better bonding between fibres. In this work, we study how various mechanisms that can be triggered by refining affect the tensile behaviour of the sheets.

A paper sizing agent based on leather collagen hydrolysates modified by glycol diglycidyl ether and its compound performance, X Wang et al, *International Journal of Biological Macromolecules*, Vol.124. In this research, collagen hydrolysates with different average molecular weights from leather collagen were chosen as raw materials. Five environmental-friendly sizing agents (SA) were prepared by cross-linking collagen hydrolysates with glycol diglycidyl ether (GDE) and further grafting them with butyl acrylate (BA) and styrene (St). Then the compound sizing agents (SGDESA-x, x = 1, 2, 3 and 4) were obtained by simple physical mixing of GDESA and starch. The surface sizing performance of GDESA and compound sizing agents were studied. The coated corrugated paper exhibited strong water resistance, good physical and mechanical properties even after refolded for 20 times.

PULP / PULPING

Determining the repair and maintenance cost of wood chippers, Raffaele Spinelli et al, *Biomass and Bioenergy*, Vol. 122. Chipping weighs heavily on the total delivered cost of wood fuel, which calls for accurate chipping cost estimates. Chipper repair and maintenance cost is perhaps the most obscure among the figures required for a reliable estimate of chipping cost. To clarify this issue, the authors examined the long-term repair and maintenance records for 51 wood chippers operated by 48 chipping service contractors. The study also provides reference figures for the contribution of labour cost to total maintenance cost. Farm tractors incur more repairs than preventive maintenance, contrary to the other dedicated components of the chipping operation, where preventive maintenance represents most of maintenance cost. Forestry users should make allowance for the lower structural strength of tractors and select large models.

Deep eutectic solvents (DESs) for cellulose dissolution: a mini-review, Yang-Lei Chen et al, *Cellulose*, Vol.26 (1). Deep eutectic solvents (DESs), which are a novel class of sustainable designer solvents, have attracted considerable attention in the field of cellulose chemistry. Due to their low cost and analogous physico-chemical properties to ionic liquids, DESs are expected to be alternative solvents for dissolving cellulose. However, at present, the solubility of cellulose in DESs is much lower than in most ionic liquids. In this mini-review, we briefly summarise the current state of knowledge about cellulose dissolution in DESs.

Non-Wood Plant Fibers: Applications in Pulp and Papermaking, JE Atchison - *Encyclopedia of Plant and Crop Science* (Print), 2019. Originally paper was being made from non-wood materials such as papyrus, hemp and textile rags. With the development of technologies for isolating pulp from wood, it resulted in abandoning paper making from many non-wood materials. In this paper we have reviewed the trend in pulp and paper production from different non-wood materials since the perception of the paper making technology up to date through literature review and consultations with experts in the area of pulp and paper production.

Cleaner approach for improving the papermaking from agro and hardwood blended pulps using biopolymers, S Bhardwaj et al, *Journal of Cleaner Production*, Vol.213. Due to rapid deforestation, the paper industry is facing problems like shortage of forest based raw materials, cost increment and negative effects on the environment including increasing air, water and soil pollution. In India, agro residues utilised in stubble burning could be used as a sustainable fibre resource for papermaking, but the paper made from these possesses poor strength properties. Considering the multiple advantages of using agro residues and weak strength properties of the paper made from these, this study was conducted. The effect of blending hardwood pulp and agro pulp with cationic starch or chitosan at wet-end of papermaking with and without subsequent surface sizing using oxidized starch was explored.

Approaches for converting sugarcane trash, a promising agro residue, into pulp and paper using soda pulping and elemental chlorine-free bleaching, NK Bhardwaj et al, *Journal of Cleaner Production*, Vol.217. Industrialisation and urbanisation are the key drivers to threaten the environmental quality and natural resources. Traditionally, pulp and paper industry has been highly reliant on forest based resources for its escalation. Shortage of forest based raw materials, strict environmental regulations and policies have compelled the industry to seek for alternate raw materials for its production. Mills are now focusing on exploring the potential of different agro wastes such as cereal straws and bagasse etc. In present research, sugarcane trash, one of the most abundant agro residues in India, was investigated for its capability in pulping and bleaching.

RECYCLING

Optimal scheduling ratio of recycling waste paper with NSGAII based on deinked-pulp properties prediction, Wenhao Shen et al, *Computers & Industrial Engineering*, Vol.132. The recycling of waste paper has been an effective way to achieve the environmental-friendly growth of papermaking industry. Focusing on the mixed-pulping process which has been generally employed, to ensure the required properties of the deinking pulp (DIP) and minimise the purchase cost of waste paper, an intelligent model scheduling the mixing ratio of waste paper was developed in the study.

STARCH

Modification of retrogradation property of rice starch by improved extrusion cooking technology, Yunfei Liu et al, *Carbohydrate Polymers*, Vol.213. Modifications of molecular structure, and of short- and long-term retrogradation properties, in rice starch by an "improved extrusion cooking technology" (IECT) were studied. These results show that, under appropriate conditions, IECT is a type of extrusion which can be used to change retrogradation properties of rice starch that have not been previously available.

Effect of Octenylsuccinylation of Oxidized Cassava Starch on Grease Resistance and Waterproofing of Food Wrapping Paper, Li Zhong et al, *Starch - Stärke*, No.1-2, 2019. The surface of food wrapping paper is coated with octenylsuccinic anhydride (OSA)-modified cassava starch to develop food packaging with high waterproofing and low grease permeability. Oxidised cassava starch is modified using various concentrations of OSA. The effects of OSA concentration, starch content, incubation time, and coating rate on oil resistance and hydrophobicity, grease and water barrier properties are quantified. The influence of octenylsuccinylation of oxidised cassava starch on the optical and physical properties of paper is also investigated.

TESTING

Maximum Vibration Transmissibility of Paper Honeycomb Sandwich Structures, Rui Yang et al, *International Journal of Structural Stability and Dynamics*, Online. The maximum vibration transmissibility of paper honeycomb sandwich structures with different sizes of honeycomb core under various static stresses was investigated using the sine frequency sweep test. The effects of the cell length of the honeycomb, the thickness of the sandwich structure, and the static stress on the maximum vibration transmissibility were evaluated.

Test method for enhanced mechanical shock fragility statistics accuracy, Shogo Horiguchi & Katsuhiko Saito, *Packaging Technology and Science*, Vol.30 (4). An optimum cushioning package, which is neither excessive nor inadequate, must be designed to ensure cushioning performance that maintains an acceptable failure rate during transportation while also minimising packaging costs. For this purpose, statistics pertaining to transport hazards and product shock strength must be engaged. The proposed study presents a test method to enhance the statistical accuracy of mechanical shock fragility of products. An example of the application of experimental results to stress-strength models has also been described.

WASTE TREATMENT

Preparation of geopolymer inorganic membrane and purification of pulp-papermaking green liquor, M Xu et al, *Applied Clay Science*, Vol.168. This paper describes a low-cost and highly efficient metakaolin-based geopolymer composite membrane (support + dense layer) at normal pressure and <70 °C. The support was fabricated using geopolymer foam materials and shows a large water flux and good mechanical properties. The dense layer was prepared using a dip-coating process with geopolymer paste on the porous geopolymer support surface. The preliminary ultra-filtration test (0.2 MPa operation pressure) demonstrates that the geopolymer-based composite membrane can effectively treat suspended particles in wastewater and is expected to be applied in the field of wastewater treatment. We then used the composite membrane in the pulp-papermaking green liquor at different temperatures, and it was found that the SS (suspended solids) of the filtrate can be decreased to far below the industrial requirements of green liquor recycling (SS < 20 mg·L−1).

Statistical analysis of sustainable production of algal biomass from wastewater treatment process, Indu Ambat et al, *Biomass and Bioenergy*, Vol.120. Algal biodiesel is one of the most promising renewable and eco-friendly source of energy for transportation, when algae is produced from wastewater. During the process, both goals of biodiesel production and wastewater treatment could be achieved simultaneously. However, the optimal condition for algae production remained unanswered. Algal biodiesel could be produced from various wastewater treatments. In this study the relationship between biomass production versus lipid productivity in various wastewater sources is statistically analysed.

A green composite hydrogel based on cellulose and clay as efficient absorbent of colored organic effluent, Qiyang Wang et al, *Carbohydrate Polymers*, Vol.210. This work has developed a convenient way of constructing wood cellulose and clay green composite hydrogel as efficient adsorbent of coloured organic effluent. The simple procedure and cost effective wood cellulose as raw material for the composite absorbent construction presented in this research are favourable for industrial applications.

Phosphonium-Enhanced Chitosan for Cr(VI) Adsorption in Wastewater Treatment, Sebastian Sessarego et al, *Carbohydrate Polymers*, Vol.211. Adsorption is a commonly used method for industrial wastewater treatment because of its low-cost, easy operation and high efficiency. In this work, chitosan was crosslinked and functionalised with a low-cost phosphonium salt, tetrakis(hydroxymethyl)phosphonium sulfate (THPS), to enhance its adsorption capacity for Cr(VI).

WOOD PANEL

Application of surface chemical functionalized cellulose nanocrystals to improve the performance of UF adhesives used in wood based composites - MDF type, Hossein Khanjanzadeh et al, *Carbohydrate Polymers*, Vol.206. The aim of this research was to investigate the effect of functionalised cellulose nanocrystals (CNC) on the performance of urea-formaldehyde (UF) adhesive for the production of medium density fiberboard (MDF). Surface modification of CNC was performed using 3-Aminopropyltriethoxysilane (APTES). Some physical and thermal properties of reinforced and neat UF as well as formaldehyde emission and some mechanical (modulus of rupture (MOR), modulus of elasticity (MOE) and internal bond strength (IB)) and physical properties (thickness swelling (TS) and water absorption (WA)) of the resulting MDF panels were determined.

Quasi-static and dynamic response of oriented strand boards based on balsa wood waste, G.Barbirato et al, *Composite Structures*, Vol.219. This work presents an evaluation of the performance of Oriented Strand Boards (OSB) panels based on balsa wood (Ochroma Pyramidale) waste agglomerated with castor oil polyurethane resin. In this study, were evaluated OSB panels with different densities (300 kg/m^3, 400 kg/m^3 and 650 kg/m^3), with 10 mm thickness and castor oil polyurethane resin in different contents (11% and 15%). The OSB panels were preliminary characterised by physical and quasi-static mechanical tests to identify the class of application of this material according to the recommendations of standard EN 300: 2002. Subsequently, the OSB panels were characterised by low velocity impact tests.

Solid Wood and Wood Based Composites: The Challenge of Sustainability Looking for a Short and Smart Supply Chain, M. Romagnoli et al, *Digital Wood Design*, Chapter, pp.783-807. (Part of the Lecture Notes in Civil Engineering book series (LNCE, volume 24).) The paper takes into account the most important wood based products used in architecture, structural engineering and design. The amount of roundwood, sawnwood and wood panel production is analysed and forest certification is reported as possible tool to ensure a sustainable forest management, fighting illegal logging and deforestation. A smart review of the most used wood-based products is performed together with the chance to activate a modern short supply chain. The state of art of the wood species actually used is considered together with most important actual challenges addressed to obtain sustainable wood-based products referring to eco-friendly process of gluing and increasing durability.

Preparation, characterization and properties of starch-based adhesive for wood-based panels, YongGu et al, *International Journal of Biological Macromolecules*, online. A new biodegradable, renewable, and environmentally friendly starch-based adhesive for wood-based panels was synthesised. The synthesis was conducted by grafting polymerisation of vinyl acetate (VAC) monomer onto corn starch and crosslinking polymerisation with N-methylol acrylamide (NMA). Compared with the traditional starch-based wood adhesive, the water resistance of starch-based adhesive with NMA (SWA-N) was greatly improved to more than 1 MPa; this exceeds the Chinese standard by 40%. The complex network structure was found to inhibit excessive expansion of the adhesive during high temperature pressing and water absorption. As a result, the adhesive remained intact when subjected to hot pressing and placed in wet conditions.

Latex and rosin films as alternative waterproofing coatings for 3-layer sugarcane-bamboo-based particleboards, Erika Yukari Nakanishi et al, *Polymer Testing*, Vol.75. This paper studied two alternative polymeric films based on natural latex and rosin as a waterproofing coating for 3-layer sugarcane-bamboo-based particleboards (3LP). To study the roughness as well as evaluate the coating surfaces on the 3LP, scanning confocal electron microscopy (SCEM) was used. The wettability performance of the coatings was evaluated by the surface energy through the contact angle method. The 3LP coated thermal, physical and mechanical properties were evaluated following ASTM-E1530: 2011 and ABNT NBR 14810 standards, respectively. Latex successfully formed a smooth and continuous film which covered the surface pores of the 3LP, whereas rosin did not form a smooth and continuous, forming only a thin film on the 3LP.

Dynamic accounting of greenhouse gas emissions from cascading utilisation of wood waste, Giorgia Faraca et al, *Science of The Total Environment*, Vol.651 (2). Cascading utilisation of post-consumer wood waste has recently gained increasing attention in the European Union, aiming for a society in which the resource's properties are optimised through sequential uses. To date, material utilisation of wood waste has been limited to particleboard production, with additional niche alternatives being restricted by quality requirements for wood waste. In this consequential life cycle assessment focusing on post-consumer wood collected at Danish recycling centres, Global Warming Potential (GWP) impacts from quality-driven choices for cascading management of wood waste were compared with those from handling mixed wood waste qualities. The results demonstrated that valuing quality over quantity in wood waste management can ensure larger GWP savings, especially if recycling applications have a long lifetime and/or substitute energy-intensive products; such results were confirmed under all scenario analyses. More cascade steps of the wood waste resource ensured larger savings.

Nanocellulose-Reinforced Adhesives for Wood-Based Panels, Elaine Cristina Lengowski et al, *Sustainable Polymer Composites and Nanocomposites*, pp.1001-1025. Considering that the solid wood, being a heterogeneous and anisotropic product, presents several disadvantages such as unsatisfactory mechanical properties for certain uses and limitations of wood due to dimensions of wood pieces, reconstituted wood products have been developed by gluing of veneer, boards, lignocellulosic fibres, etc., which are joined using adhesives. It should be noted that changes in adhesion to wood are desirable in terms of performance improvement and adhesive economy. Within the constant search for better performance of adhesives, the use of nanocelluloses appears as a viable option. Further, identification of reinforcement of adhesives with nanocellulose is being considered as an opportunity among the several opportunities offered by nanotechnology for the forest products industry. Use of nanocelluloses as reinforcements in adhesives for the production of reconstituted wood panels has several benefits such as possibility of altering the properties of adhesives, gain in mechanical and physical properties of panels and reduction in formaldehyde emissions by panels using synthetic adhesives. Despite all the advantages mentioned above, the Chapter ends with the conclusion that there are still some problems to be looked into suggesting need for more research either in the application of nanocellulose and its modification in different types of resin, as well as application technologies appropriate to the new conditions of the adhesives.

Resource quality of wood waste: The importance of physical and chemical impurities in wood waste for recycling, Giorgia Faraca et al, *Waste Management*, Vol.87. Recycling of post-consumer wood waste into particleboard may be hindered by the presence of physical and chemical impurities in the waste stream, therefore calling for increased attention on the quality of wood waste. However, wood waste comprises several uses/types of wood, along with different levels of contamination. This study provides the detailed sampling and characterisation of wood waste according to its source, type and resource quality grade. The results showed that chemical contamination was significantly higher for low-quality wood waste, thus clearly indicating that improvements in separate collection, sorting and handling of wood waste may improve the resource quality of wood waste and potentially achieve cleaner recycling practices.

PAPERmaking!
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"An Introduction to Food Contact for the Paper & Packaging Industry"

What you need to know about Paper & Board Materials for Food Contact

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Cristina is a **Key Account Manager & Consultant** for the paper and board sector at **Ecol Studio**, in particular for the European and International market. She is in charge of the Technical and legislative Support. She has 20 years experience in the paper industry, and she's involved in National and European Working Groups on paper and board, as (CEN) TC 172 / WG3 -Analytical methods for the assessment of Poper ond Board in contact with foodstuffs, Ecolabel (paper products), the Food Contact Materials Working Group of Federchimica (Italian Federation of the chemical industry).

Eugenio is a **Senior Consultant** for **Ecol Studio** in the field of Food Contact Materials & Articles. He graduated in Chemistry and has been working in the Paper Industry for 35 years. Eugenio is also a member of staff at CEPI, acting as the Technical Manager for food contact and safety of paper products.

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- ***Filamentous Bulking Control Strategies:*** *Selectors and chemical addition*

I liked the interactive nature and going through calculations and worked examples to apply the information we had just learnt.

The best aspect of the training was that it helped me to think about treatment in a more holistic way

Many thanks for what was a very well received couple of days. The way you adapted to the audience was excellent, Matt clearly has expertise that we would like to call on at some point

Only £650 (plus VAT) per person for the two day course, including full course notes, refreshments & six months complimentary membership of PITA (member discounts apply)

For further details & to book your place on this course, contact Helen in the PITA Office
(0300 3020 150 / helen@pita.org.uk)

5 Frecheville Court
Bury
Lancashire
BL9 0UF

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If calling from outside the UK: +44 161 764 5858
Fax: 0300 3020 160
E-mail: info@pita.co.uk

PITA Training & Conferences

Paper Industry Technical Association

Mark Smith presents. . . .

"PITA's Introduction to Modern Wet End Chemistry"

Everything you need to know about Colloid Chemistry on a Paper Machine

2nd & 3rd July in the PITA Office (Bury)

Mark gained a PhD in Colloid Science from the University of Bristol and then spent a few years in the oil industry before joining and working (*for over 30 years*) in Paper Industry. Having gained experience at McMillan Bloedel Research, Mead Central Research, UK Paper and Omya, he has been involved in problem-solving around Wet End Chemistry on Paper Machines around the world. By measuring colloidal properties and using these measurements, it is possible to solve a wide range of papermaking issues.

Course Objective:

Gain an understanding of how colloidal materials can be used and controlled to give you desired paper properties and improved paper machine efficiency.

Day 1—Morning:

Understanding & measuring colloidal properties

- *What are colloidal materials*
  How colloidal systems are stabilised & de-stabilised
  Measurements of colloidal properties & other related chemical properties
  Use of these measurements to improve paper machine operations

Day 1—Afternoon:

Use of inorganic colloidal solids - Fillers

- *Type of fillers used in paper making*
  Effect of fillers on paper properties & paper making
  Recent developments to maximise filler use

Day 2—Morning:

Use of colloidal material to give desired paper properties

- *Strength additives*
  Nanocellulose, starch, wet strength & dry strength additives
- *Shade control, Dyes & OBAs*
- *Surface modifications additives*
  Wet end size, size press & coatings

Day 2—Afternoon

Control of colloidal material to improve paper machine efficiency

- *Control of undesirable colloidal materials*
  Pitch, scaling & anionic trash
- *Improve retention of desired colloidal material*
  Retention & drainage aids
- *Control of microbiological contaminants*
- *Yankee dryer chemistry*

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E-mail: info@pita.co.uk

‘The Fundamentals of Papermaking’

An Introduction to the Operator Development Program

OVERVIEW

Date / Venue:

- 16th – 18th July 2019 / Venue – Smurfit Kappa SSK, Birmingham

Outline:

- This 2 ½ day course provides a fast track introduction to papermaking (limited to operations between ‘Mixing Chest’ & ‘Reel Up’). The intention is to raise the knowledge of process, technician & support staff to an intermediate level of shared understanding regarding modern Paper Machine operations.

- In addition to being valid as a standalone course, the course content also provides an introduction to the ‘Operator Development Program’ (ODP).

- Papierzentrum in Gernsbach also provides a bridge between the UK & German Training & Education systems.

Target Audience:

Machine operators, wet end operators, shift supervisors & trainees.

Running a paper production facility efficiently today, requires excellent know how from people involved in the process. This course will give participants up to date knowledge concerning all relevant processes involved. The course contents include:

- Machinery,
- Paper Chemistry
- The interaction of other production areas, including their impact on product, quality & Machine runability.

Course Fees[1]:

- Course Fees, including full course documentation & refreshments

  £ 750.00 *(plus Tax)*

- Travel & Accommodation to be organised by the participant

[1] **Note:**

Cancellation Policy

- Substitutions of Attendee may be made at any time.
- Cancellations made less than 14 days prior to the course date, or failure to appear, will result in forfeiture of the Course Fee.
- All Courses are subject to a ‘Minimum Attendance Level’ & delegates should avoid making non-refundable travel arrangements until their place on the Course has been confirmed.

Tuesday, 16th July 2019 *(Course Commences at 09:00 hrs):*

- Introduction to the Industry
  - Overview to the pulp, paper & packaging industry
  - Main figures of the national & international productions
  - Raw material & resource development
  - Changes in the raw materials, energy & production in the past
  - Paper technology in the future, main barriers & challenges

- Stock Approach Flow
  - Feed flow into the Stock Approach System
    - Stock approach system as a black box: which components are added & removed in the stock approach system & what is their influence on the paper making process.
    - Which parameters can be used for controlling the feed flows into the stock approach system
    - Effects of changes in the feed flows into the stock approach flow processing, overview
  - Stock & water loops
    - Stock flows & main parameters in the stock approach system
    - Water circulation & its effect on the runability & quality, overview
  - Machinery & build-up
    - Machineries used in the stock approach system & goals of them
    - Water circulation & its effect on the runability, wet end chemistry & quality
  - Impact on quality & runability
    - The influence on the stock & paper quality in the stock approach system.
    - Typical runability & quality problems related to wet end

- Head box
  - Distribution systems
    - Cross flow header/tapered header & central distributor differences & functions
    - Pulsation elimination tank
  - Design & types
    - Head box types limited to open, pressurised & hydraulic head boxes
    - Distribution channels, stock dilution system, mixing chamber, turbulence generator & lamellas
  - Efflux ratio
    - Control & adjustment of efflux ratio
    - Effect of the efflux ratio on the paper quality (fibre orientation & formation)
  - Turbulence generation
    - Different techniques for turbulence generation e.g. rectifier rolls & tube banks
    - Influence of the turbulence generation on the formation, paper quality & dewatering
    - Differences between macro & micro turbulences
  - The 'Slice'
    - Functions of the slice
    - Adjustment of the slice & its influence on the stock flow, paper quality & dewatering.
    - Velocity forming vs. pressure forming
  - Impact on paper machine runability & product quality
    - Adjustments of the head box & their effect on the paper machine runability & the paper quality

- Chemical additives in the wet end
  - Chemicals to enhance product quality

- Use of chemicals for improvement of e.g. strength or colour
- Dosage of chemicals: influences on the production

- Chemicals for runability improvement
  - Addition of retention aids, defoaming/de-aerators or bentonite & their influence on runability
- Introduction into fibre & wet end chemistry
  - Fundamentals of fibre chemistry: hydrogen bondages & reactive groups
  - Chemical fundamentals of wet end chemicals, which requirements exist for the use of wet end chemicals

Wednesday, 17th July 2019:

- Forming section
  - Single & multi-layer designs
    - Principles of different forming sections for different paper grades
  - Sheet forming fundamentals
    - Dewatering & concentration of particles through the forming section
    - Two-sidedness & its influence on the quality
  - Dewatering elements & vacuum system
    - Design of the dewatering elements e.g. foils, forming roll, forming table, suction boxes... & their influence on the dewatering & paper quality
    - Pressure impulses & their adjustment to improve the paper quality & runability
  - Retention
    - First pass & total retention, ash retention & influence on the productivity & quality
  - Impact on product quality & runability
    - Wire section impacts on the paper machine runability & the stock & water loops
  - Fabric considerations
    - Forming fabric fundamentals

- The Press Section
  - Press section designs
    - Different press section designs e.g. 3 nip system, 3+1 nip or shoe press system & their influence on the runability & quality
  - Fundamentals of pressing
    - Physics of pressing & dewatering in pressing section
    - Parameters effecting the pressing result
  - Press nips: grooved, blind drilled, shoe press
    - Press cylinder designs & dewatering principles of them
  - Press section impact on product quality & runability
    - Press section adjustments & their impact on the paper quality & runability of the paper machine
  - Press felts & conditioning
    - Fundamentals of press felts

- The Dryer Section
  - Fundamental of paper & board drying
    - Dewatering of bound water & fundamentals of paper drying
    - Paper grades & their impact on the drying result & steam consumption
  - Build-up of dryer groups single/double tier
    - Most typical cylinder drying systems & their differences
    - Water removal from the paper & hood in drying section for different systems
  - The Drying Cylinder
    - Construction of a drying cylinder & principle of heat transfer
  - Steam & condensate systems
    - Fundamentals of a steam-condensate system
    - Units & their principles in a steam-condensate system
  - Pocket Ventilation
    - Importance of pocket ventilation

- Dew point & 0-level
  - Fundamentals of dew point & 0-level in a drying section
  - Influence on the steam consumption & paper quality
- Dryer Section Operations
  - Drying section adjustments
- The Dryer Fabric & cleaning
  - Fundamentals of dryer fabrics
  - Cleaning systems for dryer fabrics

- Finishing
  - Online-Calendering fundamentals
    - Calendering effects on the paper quality
    - Parameters for adjusting calendering results

- Reel Up Systems
  - Reeling up systems & their function

Thursday, 18th July 2019:

- Introduction to Process Control
  - Computer Aided Process Simulation
  - "From mixing chest to reel-up"
  - Start-up the paper machine
  - Working with closed control loops
  - Adjust various machine parameters to improve product quality

- 12:30 hrs – Lunch

- 13:30 hrs – Course Review & Feedback

- 14:30 hrs – Departure

Registration & Booking Form

Course: Fundamentals of Papermaking (UK) - 2½ Days

Course Date / Venue: 16th to 18th July 2019 / Venue TBC

Details of Attendees:

Name	Position	Years in Paper Industry	E-mail Address

Do you have any Special Dietary requirements, if so please specify:

Specific Interests *(please feel free to list topics on a separate sheet)*:

What are you looking to gain from this Course? *(please feel free to continue on a separate sheet)*:

Invoicing Details:

Invoice Address: *Purchase Order / Reference:*

Invoice Contact: *Telephone:*

E-mail Address:

Note

- *All Courses are subject to a 'Minimum Attendance Level' & delegates should avoid making non-refundable travel arrangements until their place on the Course has been confirmed.*
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PITA Training & Conferences

Paper Industry Technical Association

"Pumping Systems Energy Efficiency Workshop"

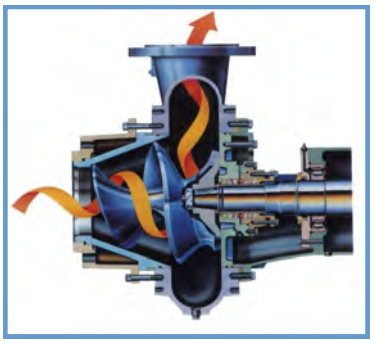
Essential Knowledge for Everyone Working with Pumps

15th October 2019 / PITA Office, Bury

Who should attend:

Energy Managers & Coordinators
Operations Supervisors & Managers
Plant & Process Engineers
Maintenance Personnel

Energy efficiency of pumping systems is important in that energy efficiency is one of the most important factors in determining pump reliability and maintenance costs. Consequently, energy inefficiency in pump systems increases operating costs due to:



- Higher energy use and cost
- Increased maintenance costs
- Failure (reduced reliability affecting production schedules)

There are many reasons for low energy efficiency of pump systems. Several of these can be identified by simple measurements such as flow, power consumption and total pump head. Other reasons for low efficiency may require a detailed analysis of the pump system to identify specific issues and what steps to take to resolve these issues.

This course is designed to show how to measure pump efficiency so that pump systems are operated at high efficiency following remedial action when the data shows that there is a cost benefit from this action.

Contents

- The relationship between Energy Efficiency and Reliability
- How to assess Pump System Efficiency; what measurements need to be taken and the possible problems in taking these
- How to use the data generated
- What surveys show in terms of Pump System Efficiency - typical efficiency in pump systems
- Options to improve efficiency after finding that a system is inefficient
- The pros and cons of Variable Speed Drives
- How to measure pump failure rates, so that improvements can be tracked

Only **£440 per person** including full course notes, refreshments and six months complimentary subscription to Paper Technology. Member discounts apply

For further details or to book your place on this course, contact Helen in the PITA Office
(0300 3020 150 / info@pita.co.uk)

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PITA Training & Conferences

Paper Industry Technical Association

Kate Leach presents . . . .

"Energy Optimisation"

Essential Cost Saving Knowledge for All involved in the Paper Industry

5th & 6th November 2019 / PITA Office / Bury

*This **Intensive Two Day Course** focuses on **Modern Energy Optimisation Techniques** specifically relevant to the production of Paper, Fibre-based Packaging Products and Converting. Starting from an up to date overview of the Energy Market, the course provides essential background knowledge for anyone (manufacturer or supplier) who is involved in the implementation of **Energy Saving / Carbon Emissions Reduction** strategies throughout the Fibrous Forest Products Sector. The content of this course is highly interactive, allowing the discussion to focus on the key areas of interest relevant to the attendees.*

A great primer/motivator for those looking to increase Energy Efficiency.

Day One:

- ***Energy & Trends:*** *A look at energy trends locally and globally.*
- ***Motors:*** *Understanding how motors work, to make them work more efficiently in our mills.*
- ***Context & Scale:*** *Looking at energy use in the Home, Office and Industry.*
- ***Processing & Pumping Efficiency****: Learning how to spot process inefficiencies in pumps.*

Day Two:

- ***Dewatering:*** *Relative costs of water removal throughout the papermaking process, how small changes can bring about big savings.*
- ***Employee Engagement:*** *The importance of involving the whole workforce in energy optimisation and some tools to do this.*
- ***Compressed Air:*** *How to ensure one of the largest single energy users in the mill is working optimally.*
- ***Refining:*** *A background to refining leading on to an understanding of how to optimise refining results whilst minimising energy requirements.*
- ***Energy Generation:*** *Generation options for the paper industry (including: heat exchangers and steam systems).*

Only £650 (plus VAT) per person , including full course notes, refreshments & six months complimentary membership of PITA. Member discounts apply.

For further details & to book your place on this course, contact Helen in the PITA Office (0300 3020 150 / helen@pita.org.uk)

Kate is an effective and entertaining trainer with a thorough and grounded knowledge of papermaking processes with good insight into the world of soft tissue manufacture.

I can honestly say that after 38 years in the paper industry and having attended a large number of courses this was truly one of the best both in terms of content and supporting material.

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PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 5, Number 1, 2019

PAPER & BIOREFINERY

Events

PAPER & BIOREFINERY

messe congress graz

CONFERENCE 5 - 6 June 2019, Graz TRADE SHOW

PROGRAMME | PROGRAMM

CIRCULAR BIOECONOMY. *Being the forerunner!*

A JOINT INITIATIVE BY: APV austropapier ZEPA

PROGRAMME OVERVIEW / PROGRAMMÜBERBLICK

TUESDAY, 4 JUNE

GET TOGETHER @ TU GRAZ MENSA "ROOFTOP"

19.00 Get-together on the evening before the conference

WEDNESDAY, 5 JUNE

OPENING

9.00-10.15 Welcome & Award Ceremony

ECONOMY.FORUM

10.45-12.30 **CIRCULAR BIOECONOMY**
Statements and dialogue featuring renowned experts from different fields

12.30-13.40 Lunchtime **RECEPTION BY THE MAYOR**

	TECHNOLOGY. FORUM 1	KNOWLEDGE. FORUM	SCIENCE. FORUM
13.40-15.20	PULP PRODUCTION	FORESTRY AND CLIMATE CHANGE	LET'S TALK SCIENCE
15.50-17.30	INDUSTRIAL INTERNET OF THINGS (IIOT)	BIO-BASED PRODUCTS	-

CONFERENCE DINNER @ ALTE UNIVERSITÄT

20.00 Festive dinner at the end of the first conference day

THURSDAY, 6 JUNE

	TECHNOLOGY. FORUM 2	TECHNOLOGY. FORUM 3
9.00-10.40	PAPER PRODUCTION, ADDITIVES AND COATING	BIO-BASED MATERIALS
11.10-12.50		
13.15-14.30		GLOBAL TRENDS AND ENERGY

from 14.30 Food & drink is served at the **CLOSE** of the conference

OPENING

9.00-10.15 WELCOME / AWARDS — ROOM 12

CHAIR: Ernst Sittinger – Kleine Zeitung

WELCOME:

Hosts:
- Wolfgang Bauer.....Chairman of APV Graz
- Kurt Maier .....President of ÖZEPA
- Christian Skilich .....President of Austropapier

Hermann Schützenhöfer – Governor of Styria

SIMULTANEOUS TRANSLATION PROVIDED

AWARD CEREMONY:

ÖZEPA Occupational Safety Awards

Heinzel-Mondi-Sappi Award

10.15-10.45 PAUSE

ECONOMY.FORUM

POWERED BY: synthomer

10.45-12.30 CIRCULAR BIOECONOMY — ROOM 12

CHAIR: Ernst Sittinger – Kleine Zeitung

KEYNOTE STATEMENTS & DIALOGUE:

SIMULTANEOUS TRANSLATION PROVIDED

Emmanuelle Maire
Directorate-General for Environment, European Commission/B

Tanja Dietrich-Hübner
Director Sustainability, REWE International AG/A

Herbert Anzenberger
Business Manager Pulp & Paper, Kemira/A

12.30-13.40 **RECEPTION BY THE MAYOR:** Lunchtime reception by invitation of Siegfried Nagl, Mayor of Graz (PAUSE)

Parallel sessions: KNOWLEDGE.FORUM (Forestry and Climate Change, Bio-based Products) -> S. 5
SCIENCE.FORUM (Let's talk science) -> S. 6

TECHNOLOGY.FORUM 1

POWERED BY: ABB

PULP PRODUCTION — ROOM 12

TF1/01	**13.40**	**Recovery boiler chemistry optimization utilizing green liquor analyzer and combustion cameras** • Timo Laurila, Jarmo Mansikkasalo, Mikko Leskinen – Valmet Automation Oy/FIN
TF1/02	**14.05**	**Economic Fundamentals of Ozone Bleaching** • Emil Germer – Saint-Petersburg State Forest Technical University/RUS • Alexis Métais – Xylem/F
TF1/03	**14.30**	**Using a refractometer for measuring the performance of fiberline processes** • Riku Kopra – South-Eastern Finland University of Applied Sciences (XAMK)/FIN • Simo Karjalainen – Andritz Oy/FIN • Aalto University, School of Chemical Technology/FIN
TF1/04	**14.55**	**HMS Award Winner Presentation – PULPING PROCESS**

15.20 PAUSE

INDUSTRIAL INTERNET OF THINGS (IIOT) — ROOM 12

TF1/05	**15.50**	**Details to follow**
TF1/06	**16.15**	**Industry 4.0 – a holistic approach to industrial manufacturing** • Klaus Glatz, Klaus Blechinger – ANDRITZ AG/A
TF1/07	**16.40**	**Collaborative Operations for performance improvement in the Pulp and Paper Industry** • Steven St-Jarre – ABB AG/A
TF1/08	**17.05**	**An Open IIoT Ecosystem in a Board Production** • Engelbert Schrapp – Siemens AB/S

17.30 **End of the first conference day**
(8 pm: CONFERENCE DINNER @ ALTE UNIVERSITÄT)

Parallel sessions: TECHNOLOGY.FORUM 1 (Pulp Production, Industrial Internet of Things (IIoT)) -> S. 4
SCIENCE.FORUM (Let's talk science) -> S. 6

KNOWLEDGE.FORUM 1+2

1: FORESTRY AND CLIMATE CHANGE — ROOM 11

13.40	KF1/01	**Geänderte Rahmenbedingungen der Waldbewirtschaftung durch die Klimaveränderung** • Günter Rössler – Federal Research Centre for Forests (BFW) Vienna/A
14.05	KF1/02	**Wood production through a tree breeders' eye: current challenges and future prospects** • Jan-Peter George – Federal Research Centre for Forests (BFW) Vienna/A
14.30	KF1/03	**Climate change in the alpine region: What do we have to expect in the coming decades?** • Andreas Gobiet – Central Institution for Meteorology and Geodynamics/A
14.55	KF1/04	**Climate smart forestry in Europe** • Kauppi Pekka – University of Helsinki/FIN

15.20 PAUSE

2: BIO-BASED PRODUCTS — ROOM 11

15.50	KF2/01	**Details to follow**
16.15	KF2/02	**Biobased raw materials in coating industry: hype or reality?** • Christoph Auner – Rembrandtin Lack GmbH Nfg. KG/A
16.40	KF2/03	**New applications for lignin: Property design for polymeric binders by chemical modification** • Lydia Alexandra Heinrich, Stefan Friebel – Fraunhofer WKI Institute for Wood Research/D
17.05	KF2/04	**Evolution to a modern biorefinery** • Andreas Praznik, Josef Schuberth, Ralf Gericke – Agrana Stärke GmbH/A

17.30 **End of the first conference day**
(8 pm: CONFERENCE DINNER @ ALTE UNIVERSITÄT)

Parallel sessions: TECHNOLOGY.FORUM 1 (Pulp Production) -> S. 4
KNOWLEDGE.FORUM 1 (Forestry and Climate Change) -> S. 5

SCIENCE.FORUM

POWERED BY: TU Graz

LET'S TALK SCIENCE — ROOM 14

SF1/01 **13.40** **Adsorption and desorption of organic molecules from thin cellulose films**
- Robert Schennach, Elias Henögl – Graz University of Technology/A

SF1/02 **14.05** **Enzymes in Circular Cellulose Fibre Biorefinery**
- Oskar Haske-Cornelius, Renate Weiß, Sara Vecchiato, Gibson S. Nyanhongo – University of Natural Resources and Life Sciences (BOKU)/A
- Wolfgang Bauer – Graz University of Technology/A
- Georg M. Guebitz – Austrian Centre for Industrial Biotechnology (ACIB)/A

SF1/03 **14.30** **Oxidative treatment of TEMPO modified cellulose fibers using potassium peroxymonosulfate for enhancing color stability and fibrillation yield**
- Jaka Levanič, Ida Poljanšek, Primož Oven – University of Ljubljana/SLO

SF1/04 **14.55** **The Role of Endo-Cellulase's Binding Affinity in Modification of Cellulose Fibers for Bio-based Products**
- Sachin Badakh – Mercer Pulp Products/D
- Helga Zollner-Croll – Hochschule München/D

15.20 PAUSE

Parallel session: TECHNOLOGY.FORUM 3 (Bio-based Materials, Biorefinery, Global Trends and Energy) -> S. 8

TECHNOLOGY.FORUM 2

POWERED BY: ANDRITZ

PAPER PRODUCTION, ADDITIVES AND COATING /1 — ROOM 12

TF2/01	**9.00**	**Photographic Online-Wear-Measurements of Forming Fabrics for Evalution of Wear and Power Consumption** • Stefanie Hänisch – J. M. Voith SE & Co. KG/D • Till Hänisch – Duale Hochschule Baden-Württemberg/D
TF2/02	**9.25**	**Improved Paper Mill Performance via Advanced Data Analytics and Advance Process Controls** • Hannu Lätti, Samuli Lehtonen – Valmet Oy/FIN • Wolfgang Schuessler – Valmet GmbH/D
TF2/03	**9.50**	**Voith NipcoFlex shoe press & press-sleeve, a combination for success** • Frank-Michael Raab – J. M. Voith Paper SE & Co. KG/D
TF2/04	**10.15**	**Laakirchen PM10. Transformation – results after one year of operation** • Jan Reibert – Laakirchen Papier AG/A • Michael Pichler – ANDRITZ AG/A

10.40 PAUSE

PAPER PRODUCTION, ADDITIVES AND COATING /2 — ROOM 12

TF2/05	**11.10**	**PrimeLineTIAC – A birthplace for innovations** • Klaus Gissing – ANDRITZ AG/A
TF2/06	**11.35**	**Foam as a carrier fluid in papermaking** • Jani Lehmonen, Antti Koponen, Elias Retulainen – VTT Technical Research Centre of Finland/FIN • Karita Kinnunen-Raudaskoski – Paptic Ltd/FIN • Jouni Paltakari – Aalto University/FIN
TF2/07	**12.00**	**Multilayer Curtain Coating-concept for perfect contour coating** • Erich Kollmar – Bellmer GmbH/D • Maick Nielsen – TSE Troller AG/CH
TF2/08	**12.25**	**HMS Award Winner Presentation – PAPER AND BOARD MAKING PROCESS**

12.50 PAUSE

PAPER PRODUCTION, ADDITIVES AND COATING /3 — ROOM 12

TF2/09	**13.15**	**Mineral recovery from pulp and paper mill waste streams** • Johannes Kritzinger – Omya International AG/CH • Michael Pohl – Omya GmbH/A
TF2/10	**13.40**	**Developments in Pea Starch and derivatives** • Eric Khater, Nicolas Leroy – Roquette Frères/F
TF2/11	**14.05**	**Deposit control with Functional Bacterias** • Frank Dürkes, Stefan Franke – Servophil AG/CH

14.30 CLOSE OF THE CONFERENCE

Parallel session: TECHNOLOGY.FORUM 2 (Paper Production, Additives and Coating) -> S. 7

TECHNOLOGY.FORUM 3

BIO-BASED MATERIALS /1 — ROOM 11

TF3/01	**9.00**	**Comparative Study of MFC Production using Various Pulp Types** • Laura Vargas Aguero – Enhanced Compliance Inc./CR • Anke Lind, Helga Zollner-Croll – Hochschule München/D
TF3/02	**9.25**	**Using nanocellulose to improve paper properties** • Janja Juhant Grkman, Bojan Borin – Pulp and Paper Institute/SLO • Matjaž Kunaver – National Institute of Chemistry/SLO • Primož Oven – University of Ljubljana/SLO
TF3/03	**9.50**	**Biopolymers used as Functional Barriers – An Analytical Point of View** • Andrea Walzl, Samir Kopacic, Wolfgang Bauer, Erich Leitner – Graz University of Technology/A
TF3/04	**10.15**	**Biobased barriers on paper substrates and their impact on recyclability** • Marcel Haft, Lydia Tempel – Papiertechnische Stiftung/D

10.40 PAUSE

BIO-BASED MATERIALS /2 — ROOM 11

TF3/05	**11.10**	**HMS Award Winner Presentation – CASCADED USE OF WOOD**
TF3/06	**11.35**	**Towards a simulation model to explore the economic framework conditions and challenges for novel lignin applications and innovative lignin-based products** • Julia Wenger, Tobias Stern – University of Graz/A
TF3/07	**12.00**	**Yield of talloil as a significant value stream for a kraft pulp mill biorefinery** • Hannu Hämäläinen, Timo Oja – Solenis Finland Oy/FIN • Reidar Öberg – Solenis Sweden Ab/S
TF3/08	**12.25**	**Kraft Lignin based Redox-Flow Batteries** • Werner Schlemmer, Stefan Spirk – Graz University of Technology/A • Philipp Nothdurft, Wolfgang Kern – Montanuniversität Leoben/A

12.50 PAUSE

GLOBAL TRENDS AND ENERGY — ROOM 11

TF3/09	**13.15**	**China's waste ban and impacts on the circular bio-economy with a focus on the pulp and paper industry** • Arne Kant – Pöyry Management Consulting/D • Lei Wang – Pöyry Management Consulting/FIN
TF3/10	**13.40**	**Effect of structural changes on energy efficiency in the Finnish pulp and paper industry** • Satu Kähkönen, Katja Kuparinen, Esa Vakkilainen – Lappeenranta University of Technology/FIN
TF3/11	**14.05**	**Digitalization enhanced efficiency of steam generation in paper mills** • Roman Klug – AutomationX GmbH/A • Peter Fisera – CF ProcSim GmbH/A

14.30 CLOSE OF THE CONFERENCE

SOCIAL EVENTS (NETWORKING)

GET TOGETHER @ TU GRAZ (MENSA "ROOFTOP")

Early bird participants are welcome to join us for a get-together on the evening before the conference – a wonderful opportunity to meet and greet new and old friends in a pleasant and relaxed atmosphere. The meeting point this year is the Graz University of Technology. Here the Mensa "Rooftop" offers the setting for a convivial evening with panoramic view.

Date: **Tuesday, 4 June at 7 pm**

Place: TU Graz – Mensa „Rooftop"
Stremayrgasse 16, 8010 Graz

Charge: € 30.00 per person (incl. VAT)
Participation is NOT included in the conference fee

Please register by 25 May!

Früh anreisende TeilnehmerInnen treffen sich traditionell bereits am Vorabend der Tagung zum Get-together, um in angenehmem Umfeld Kontakte zu knüpfen oder zu vertiefen. Ihr Treffpunkt wird dieses Jahr die Technische Universität Graz sein. Die Mensa „Rooftop" bietet den Rahmen für einen gemütlichen Abend mit herrlichem Ausblick.

Termin: **Dienstag, 4. Juni um 19 Uhr**

Ort: TU Graz – Mensa „Rooftop"
Stremayrgasse 16, 8010 Graz

Kosten: € 30,00 pro Person (inkl. USt.)
Die Teilnahme ist NICHT in der Tagungsgebühr inkludiert

Anmeldung bis 25. Mai erforderlich!

CONFERENCE DINNER @ ALTE UNIVERSITÄT

We will let the first congress day end in good company and a special setting: The 17th century "OLD UNIVERSITY" is a gem in the historical heart of Graz. The event centre offers superb catering and friendly service in an impressive ambience.

The governor of Styria, Hermann Schützenhöfer, warmly invites you to an aperitif.

Date: **Wednesday, 5 June**
at 8 pm (Admission: 7.30 pm)

Place: ALTE UNIVERSITÄT GRAZ
Hofgasse 14, 8010 Graz
www.alte-universitaet.at

Charge: € 66.00 per person (incl. VAT)
Participation is NOT included in the conference fee

Please register by 25 May!

Lassen Sie den ersten Kongresstag in bester Gesellschaft und besonderem Rahmen ausklingen: Die im 17. Jahrhundert errichtete "ALTE UNIVERSITÄT" gilt als Juwel im historischen Herzen von Graz. Das Haus überzeugt mit erstklassigem Catering und herzlichem Service vor einem zeitlos beeindruckenden Ambiente.

Zum Aperitif lädt Hermann Schützenhöfer, Landeshauptmann der Steiermark.

Termin: **Mittwoch, 16. Mai**
um 20 Uhr (Einlass: 19.30 Uhr)

Ort: ALTE UNIVERSITÄT GRAZ
Hofgasse 14, 8010 Graz
www.alte-universitaet.at

Kosten: € 66,00 pro Person (inkl. USt.)
Die Teilnahme ist NICHT in der Tagungsgebühr inkludiert

Anmeldung bis 25. Mai erforderlich!

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 5, Number 1, 2019

TECHNOLOGIE KRING

Events

INTERNATIONAL SEMINAR 2019

TECHNOLOGIEKRING Paper & Board Industry

'Raw materials and stock preparation'

Location: Van der Valk Hotel Apeldoorn-De Cantharel, Van Golsteinlaan 20 7339 GT Apeldoorn

June 19th (Wednesday afternoon) | June 20th (Thursday morning)

Preliminary program

June 19th (Afternoon, Day 1)

13:00		Welcome and opening by Jan Pille, Royal VNP Introduction new website Technologie Kring
13:10		Setting the theme 'Raw materials and stock preparation' by the chairman of the day, Walter Hulshof, managing director Industriewater Eerbeek
Masterclass		**Young Talent & General issues**
13:30		**Brexit** – The Effect of the Big Blue Monster on Papermaking in the UK by Andrew Large (Director General of the CPI)
13:50		3D printing of lignocellulosic materials: from nanofibre hydrogels to structured biocarbons by Dr. Davide Beneventi, CNRS, Laboratoire de Génie des Procédés Papetiers
14:10		Plant properties of the various wood fibers by Andries van Eckeveld, Van Hall Larenstein/Innovita-Advies
Masterclass		**Water as raw material**
14:30		Polishing bio-effluent to liner processwater by Walter Hulshof, Industriewater Eerbeek Making polished bio-effluent and paper machine production fit for liner production purpose by Alfons Koelen, DS Smith Discussion afterwards
15:15		**Break & telsell**
Masterclass		**Pulpers as raw material**
15:45		Up-date pulpers by Oliver Lüdtke, Voith
16:05		Small investment with a big impact by Harald Bauer, ANDRITZ Pulping Rebuilds
16:25		Repulping Aids – New opportunities for the Recovered Paper Industry by Bernhard Nellessen, Solenis Technology Germany GmbH
16:45		Junk Trap or Trashwell? Reducing maintenance costs in pulper detrashing by using fewer but better valves by Francois Rui, Kadant lamort

16:55		**Break & Snack**
17:15 ***Workshop Pulping***		* DS Smith De Hoop, Ben Kortekaas * Neenah Coldenhove, Gert van Beek * ESKA, Bert Uil * Stora Enso Langerbrugge, Patrick de Wilde * VPK, Ann Deschildre * PF Doetinchem, Frank Uittenbogaard
18:15		**Networking at the technology market**
19:00		**Informal BBQ in first class networking atmosphere** **and official ceremony Technologie Kring Award June 2019**

INTERNATIONAL SEMINAR 2019

TECHNOLOGIEKRING Paper & Board Industry

'Raw materials and stock preparation'

Location: Van der Valk Hotel Apeldoorn-De Cantharel, Van Golsteinlaan 20 7339 GT Apeldoorn

June 19th (Wednesday afternoon) | June 20th (Thursday morning)

Preliminary program

June 20th (Morning, Day 2)

8:45		Opening by the chairman of the morning session by Leon Joore, Natural fiber Application Center
Masterclass		**Starch**
9:00		Effect of water quality on starch performance by Koen Homburg, ADM
9:30		Cationic starch booster by Franco Faleschini, Kemira
Masterclass		**Sorting, screaning & cleaning**
9:50		Reconsidering screening technologies & fractionation with BoosTEK desruptive innovation by Francois Rui, Kadant Lamort
10:20		**Break & telsell**
10:40		Profile control in relation to customer problems by Hugo Geerdinck, Neenah Coldenhove
Masterclass		**Refining**
11:00		Pulping and refining in combination with our new Mill Process Solution (since the acquisition of GL&V) by Valmet
11:20		Robotization in paper industry by Improvia
11:40		**End of seminar and take away lunch**

Program updates: www.technologiekring.nl - Program is subject to changes

We Papertechnology
Technologie Kring

Millvision
Partners in Strategy and Business Innovations

VNP

VNP Millvision seminar
19th en 20th of June 2019

Registrationform

Name:		Invoice adress (in case different)	
e- mail:			
Company:		Company:	
Adress:		Adress:	
PC&City:		PC&City:	
Tel.no.		Tel.no.	
VAT no.		VAT no.	

☐ **I register for the seminar of the 19th and 20th of June 2019 and pay € 490,-**

☐ **I will attend the dinner on day 1 (inclusive)**

☐ **I register for the takeaway lunch on day 2 (inclusive)**

☐ **Please make a hotelreservation for me (exclusive)**

Dinner 19th of June and lunch 20th of June are included, excl. VAT. Please note: hotel rooms can be reserved through us until Wednesday, May 22nd 2019, after this day your room is not guaranteed!
Overnight stay hotel NOT included. Cancelling costs: hotelroom charges, if booked.

Signature:

E-mail to: e.freriks@vnp.nl

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 5, Number 1, 2019

CPI HEALTH, SAFETY & INDUSTRY CONFERENCE

CPI Biennial Health, Safety and Industry Conference

'Keeping our people safe, motivated and informed'

Tuesday 9 July 2019

Chesford Grange Hotel, Kenilworth

PROGRAMME

Key Speakers

Opening Key Note Address
Miles Roberts, Group Chief Executive,
DS Smith plc

PABIAC Strategy 2019 – 2023 Official Launch
Martin Temple CBE,
HSE Chair

Plenary Session

Richard Stanton MBE

Richard (Rick) is a British civilian cave diver who specialises in rescues through the Cave Rescue Organisation and the British Cave Rescue Council.

In 2018 he played a leading role in the Tham Luang youth soccer team cave rescue. Rick and diving partner John Volanthen were the first to make contact with the team and played a leading role in the successful rescue thereafter.

Rick will give an unforgettable presentation, drawing on his experiences as a diver over many years. He will use the cave rescue last year to illustrate how he managed the risks, planning, emergency planning, teamwork, leadership, and the importance of the support needed to carry out this delicate rescue.

Main Event Sponsors:

HYSTER

PILZ
THE SPIRIT OF SAFETY

Programme Sponsors:

Ardent
Vehicle fire protection

Marquarie Investment Bank

cpi confederation of paper industries

CPI Biennial Health, Safety and Industry Conference

'Keeping our people safe, motivated and informed'

Programme of Events

Monday 8 July 2019

Garden and Terrace

18:30 – 19:30 Drinks Reception
19:30 – 21:30 BBQ

Tuesday 9 July 2019

Kenilworth Foyer | The Grange

08:00 – 09:00 Registration and Exhibition

Events Centre Foyer

08:00 – 09:00 Sponsors Breakfast Sessions

Kenilworth Suite

09:15 – 09:20 **Conference Introduction**
Andrew Braund, Director of Health & Safety, CPI

09:20 – 09:50 **Opening Key Note Address**
Miles Roberts, Group Chief Executive, DS Smith plc

09:50 – 10:15 **PABIAC Strategy 2019 – 2023 Official Launch**
Martin Temple CBE, HSE Chair

10:15 – 10:40 **The Future of UK Manufacturing**
Niall Mackenzie, Director, Infrastructure & Materials, BEIS
Seamus Nevin, Chief Economist, Make UK

The Grange

10:40 – 11:10 Coffee Break and Exhibition

Syndicate Rooms

11:15 – 12:30 Pre-booked sessions (see sessions opposite)

The Grange

12:30 – 13:30 Lunch and Exhibition

Syndicate Rooms

13:35 – 14:45 Pre-booked sessions (see sessions opposite)

The Grange

14:45 – 15:10 Coffee Break and Exhibition

Kenilworth Suite

15:15 – 16:00 **Plenary Session**
Richard Stanton MBE

16:00 – 16:15 **Challenges Ahead**
Andrew Large, Director General, CPI

16:15 – 16:30 **Closing Address**
Richard Coward, CPI President

HEALTH AND SAFETY PROGRAMME

SESSION 1 **11:15**
Leadership, engagement and collaboration

It is recognised that health, safety and well-being management systems are most successful if they're embedded in an organisation's culture – if everyone, from the shop floor to the boardroom is engaged and committed to making it work. Top management leadership ensures that an organisation has in place a sound, functional management system that incorporates commitment, responsibility and accountability.

In this session you will hear how you can develop, lead and promote a positive health and safety culture within your company, and how one company gained ISO 45001 accreditation, and is applying the new standard within the organisation.

Speakers:

Paul Freeman
Director
Paul Freeman Enterprises

Terry Stears
Risk Director
Portals Overton

George Craig
EHS Manager
Portals Overton

INDUSTRY PROGRAMME

SESSION 4 **11:15**
Labour | Skills | Diversity

Changes in manufacturing technology, together with the impact of Brexit on cross-European labour movement and the challenges of attracting new recruits into manufacturing are all impacting on the future prospects of the UK's Paper-based Industries.

This session will look at how the industry will meet its future needs for labour and skills, with particular reference to improving diversity and enabling the industry to recruit from all sections of society.

Speakers:

Phillipa Foster Back CBE
Director, Institute of Business Ethics

David Nicholson
Group HR Director, James Cropper PLC

Professor Bill Sampson
Head of School of Materials, University of Manchester

Janet Marshall
HR Manager
Arjowiggins

HEALTH AND SAFETY PROGRAMME

SESSION 7 **13:35**
Leadership, engagement and collaboration

Leadership, engagement and collaboration extends to more than just safety, and if we are to embrace ill-health, stress and mental well-being as part of our agenda, we need to ensure we have the right attitude and necessary skills.

The speakers in this session will discuss leadership, engagement and collaboration in its broadest terms, and how a different approach to measuring a company's health and safety performance goes beyond measuring accident/incident rates.

Speakers:

Dr Carolyn Yeoman
Highley Yeoman Limited

Bud Hudspith
National H&S Advisor
Unite the Union

INDUSTRY PROGRAMME

SESSION 10 **13:35**
Recyclability & Extended Producer Responsibility

Since the last CPI Conference, a swathe of environmental legislation has been passed or is being considered, which will impact our industry. Driven by public and political sentiment, the EU Circular Economy Package, which the UK Government has indicated it will transpose come what may with Brexit, demands increasing paper and board recycling rates and a significant additional contribution to the funding of collections by producers.

In addition, the Resources and Waste Strategy, Deposit Return Schemes, the Single Use Plastics directive, Consistent Collections and proposed changes to the current EPR system are all likely to have impact and bring change.

Speakers:

Dr Adam Read
External Affairs Director, SUEZ

Phil Conran
Chair, Defra Advisory Panel on Packaging (ACP)

Kevin Vyse
Director, OPRL Ltd

SESSION 2 — 11:15
Work-related stress, health and well-being

We shouldn't see health and well-being as something different than safety. With a safety issue we look at protecting the person from a physical hazard, but organisations should look closely at what they are doing to protect the person from a psychological hazard.

Dr Sarah Hattam is a practicing GP with a special interest in workplace health, well-being and especially mental health and work (and non-work) related stress. In this interactive session, Sarah will talk about the common issues she deals with on a daily basis, while Cristina will highlight the impact of fatigue and shift work on performance, and the countermeasures that organisations can introduce.

Speakers:

Dr Sarah Hattam
Concilio Health

Dr Cristina Ruscitto
Senior Researcher
Clockwork Research

SESSION 3 — 11:15
Vehicle, material movement and storage stability

Over recent years there has been a steady increase in the number of transport and material related incidents, some of which have resulted in serious injury. Vehicle and material movement doesn't stop when loads leave the site, and companies still have a responsibility for the material they transport when on the road.

This session will start with a case study and how, following an incident, one company reviewed its whole internal transport procedures and the measures it has since implemented. This will be followed by Andy Binns who will give an insight into the role of Highways England and dealing with the aftermath of a load shift incident.

Speakers:

Mark Ryan
Group Health, Safety and Environment Manager Logson Group

Andy Binns
Traffic Officer
Highways England

SESSION 5 — 11:15
Environmental Permitting

With high impact changes to environmental permitting on the horizon, this session will discuss the way forward for sector permits with the integration of Abstraction Licencing into mill permits, defining UK BAT & BAT AELs, requirements for hitherto exempt activities such as waste paper depots, to apply for permits.

Changes to sector permits brings in a requirement for sites to produce Fire Prevention Plans. The session will hear from the Wood Recyclers Association who have produced a Sector Guide on writing Fire Prevention Plans in collaboration with the EA.

Speakers:

Julie Dracup
Senior Advisor; Abstraction, EA

Spence Seaman
Senior Advisor; Paper, Pulp & Textiles, EA

Julia Turner
Executive Director, Wood Recyclers Association

Peter Buckley
Senior Fire Advisor - FPPs, EA

SESSION 6 — 11:15
Paper & Board in Food Contact

Producers of food contact materials have always had a responsibility to manufacture their materials in accordance with the 'Framework' Regulation. But in the absence of specific (EU) legislation for paper & board, how does industry demonstrate the suitability of paper & board for food contact?

In this session you will hear how the industry has revised the longstanding voluntary Guideline and Good Manufacturing Practice (GMP) as well as the other steps that are being taken to demonstrate compliance and prepare for potential legislation. And, importantly, where do we stand in terms of UK legislation as we leave the EU? Hear the position from experts as it develops post-Brexit.

Speakers:

Adam Hardgrave
Head of Food Contact Materials, FSA

Tim Chandler,
Senior Scientific Officer – Food Contact Materials, FSA

Jori Ringman
Deputy Director General, CEPI

Krassi Kazashka
Technical Director
FEFCO

SESSION 8 — 13:35
Work-related stress, health and well-being

Every year the Chartered Institute of Personnel and Development (CIPD) publish an annual survey that examines trends in work-related absence in UK workplaces.

Drawing on the survey results, Rachel will discuss the main reasons for absenteeism, including the effect of 'presenteeism' and 'leaveism', while Dan will address the big issues around mental health and well-being.

Speakers:

Rachel Suff
Senior Policy Advisor
CIPD

Dan Shears
Safety & Environment Director, GMB National Health

SESSION 9 — 13:35
Machine procurement, safe interventions and control standards

Each year the industry invests heavily on purchasing machinery. Unfortunately, some equipment when it arrives in the UK does not meet the required level of safety standards.

New PABIAC guidance for the Procurement and Installation of Machinery is designed to assist all sites in the planning and implementation of purchasing new machinery. In this session, delegates will have an opportunity to ask questions to a panel of experts on machinery procurement issues relative to the guidance.

Speakers:

Paul Grady
Specialist Mechanical Inspector, HSE

Matt Androsiuk
Principal Safety Consultant, PILZ

Andy Godbold
Head of Health, Safety and Environment
DS Smith Packaging North Europe

SESSION 11 — 13:35
Supply Chain

A consequence of the ubiquity of paper is the high degree of complexity and wide range of both suppliers and customers that must be engaged.

The session will hear from stakeholders as diverse as finance directors and food industry customers and will examine how the UK's Paper-based Industries can improve their interaction across the totality of their supply chains.

Speakers:

Angela Coleshill
Competitiveness Director, Food and Drink Federation

Jane Bevis
Chair, OPRL Ltd

Isabelle Maddock
Group Finance Director
James Cropper PLC

Julian Freeman
Group Sales and Marketing Director, Rigid Containers Ltd

SESSION 12 — 13:35
Energy efficiency in a bio-based economy

With a mandatory 2050 target for the UK to reduce emissions by 80%, pressure to decarbonise production continues to grow. Added to rapidly increasing energy cost, and a Roadmap charting potential opportunities, there's a refocused attention on energy efficiency.

The speakers in this session will discuss the current energy efficency options and what industry is doing. From a policy perspective, we will find out about Government support, and what additional support is available through the Industrial Energy Efficiency Accelerator and other funds.

Speakers:

Paul Nobel
Principal Consultant, Sustainable Energy Use Europe, DNV GL

Arjan Geveke
Assistant Director of Energy Policy, BEIS

Ulrika Wising
Head of Solar & Battery Storage Macquarie Investment Bank

William Hudson
Manager, Policy & Innovation
The Carbon Trust

Confederation of Paper Industries

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PAPERmaking!
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DITP

Events

Gospodarska zbornica Slovenije

Združenje slovenske papirne industrije
Slovenian Chamber of Commerce and Industry - Paper Association

DITP
Društvo inženirjev in tehnikov papirništva Slovenije
Pulp and Paper Engineers and Technicians Association of Slovenia

PRVA NAJAVA IN VABILO ZA AKTIVNO UDELEŽBO

na 46. Mednarodnem srečanju slovenskega papirništva, ki bo letos potekalo pod naslovom

"MED KROŽNIM, BIO IN DIGITALNIM"

20. – 21. november 2019 I Slovenija

Teme na letošnjem simpoziju bodo z naslednjih področij:
> moderna priprava in čiščenje recikliranih vlaken
> tehnološke novosti pri papirnih in kartonskih strojih
> novi koncepti pri premazovanju papirja in kartona
> novi trendi v tiskarskih in dodelavnih tehnikah
> možnosti znižanja porabe energije v papirništvu
> uporabnost papirniških muljev in pepelov
> šolanje za prihodnost
> poti do novih znanj
> pogled tržnikov na svetovni trg papirja
> financiranje papirne industrije

Predstavniki industrije, inštitutov in univerz izkoristite priložnost in se aktivno udeležite Simpozija
• s predavanjem ali
• s posterjem

Prosimo vas, da pošljete izvleček predavanja/postra v slovenskem in angleškem jeziku (največ 25 tipkanih vrstic) najkasneje do 15. junija 2019 na naslov: ditp@icp-lj.si.

Uradna jezika bosta slovenski in angleški s simultanim prevajanjem.

Za organizacijski odbor:
Marko Jagodič, univ.dipl.ing.

Vabljeni na Bled!

FIRST ANNOUNCEMENT AND INVITATION FOR AN ACTIVE PARTICIPATION

at the 46th International Meeting of Slovene Paper Industry under the heading

"BETWEEN CIRCULAR, BIO AND DIGITAL"

21 – 21 November 2019 I Slovenia

Topics from the following areas:
> *modern preparation and cleaning of recycled fibers,*
> *technological novelties on paper and paperboard machines,*
> *new coating concepts,*
> *trends in printing and finishing technics,*
> *possibilities of reducing the energy consumption at papermaking processes,*
> *usability of sludges and ashes,*
> *education for the future,*
> *ways to new knowledges,*
> *commercial views on the global paper market,*
> *financing in paper industry.*

Representatives from the industry, institutes and universities are invited to participate with
• a paper or
• a poster

To present your paper/poster you need to send a short abstract in English (25 typed lines max) to ditp@icp-lj.si, by 15 June 2019 at the latest.

The official languages are Slovene and English with simultaneous translation.

For the Organizing Committee:
Marko Jagodič, B.Sc.

Welcome to Bled!