PAPERmaking!

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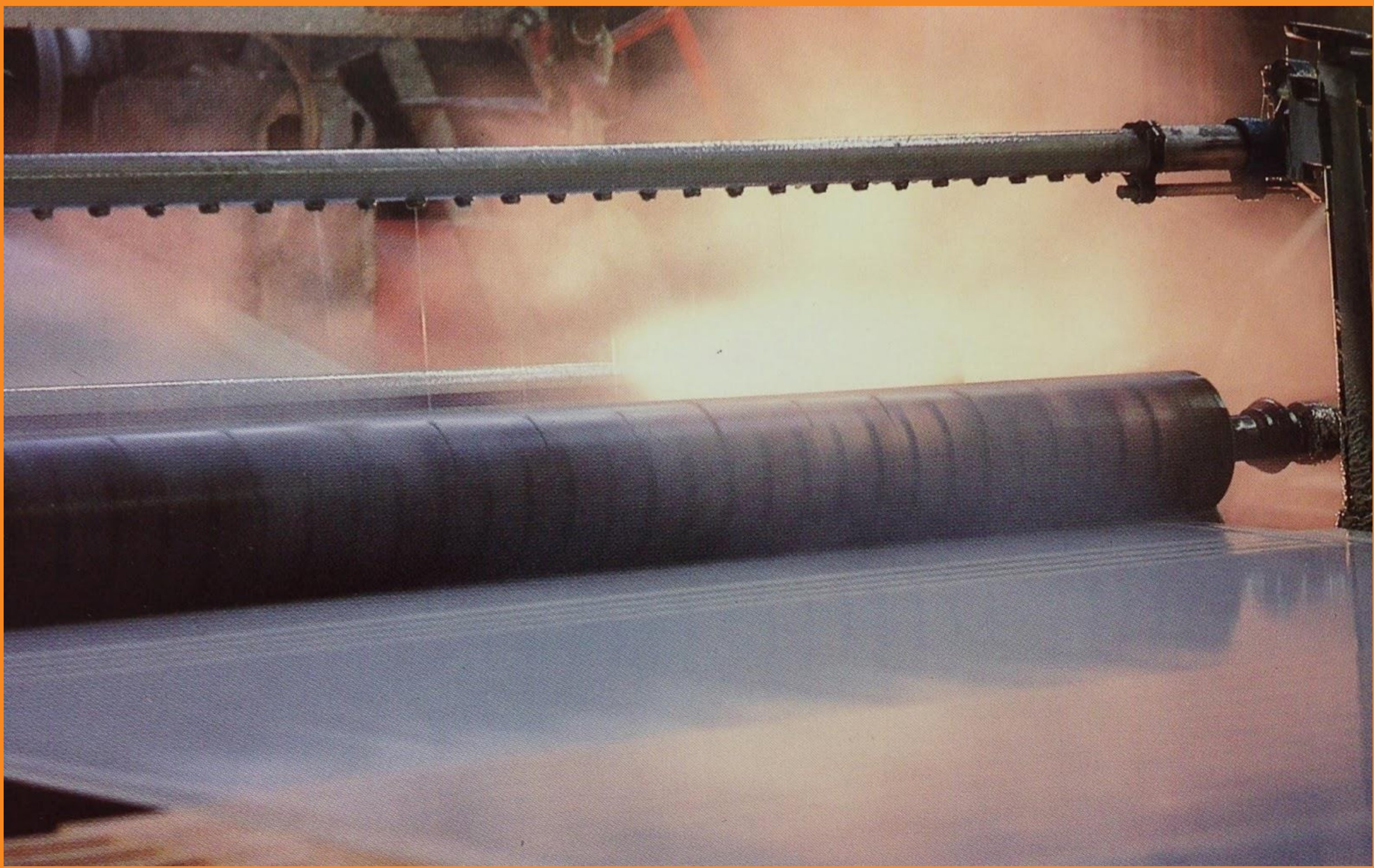

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PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
Volume 4, Number 1, 2018

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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* 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*.

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Towards natural-fibre-based thermoplastic films produced by conventional papermaking

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Materials based on cellulose are predicted to be of great importance in a sustainable society. However, for materials such as paper to replace materials with a higher ecological footprint, they need to be strong, ductile, provide a gas barrier, and, sometimes, also be transparent. Improved properties, or even novel properties, are also important for use outside the conventional markets. This paper describes how cellulose fibres partly derivatised to dialcohol cellulose can be used to fabricate high-density materials by conventional papermaking techniques that simultaneously display all the above-mentioned features.

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Towards natural-fibre-based thermoplastic films produced by conventional papermaking†

P. A. Larsson*[a,b] and L. Wågberg[a,b]

Materials based on cellulose are predicted to be of great importance in a sustainable society. However, for materials such as paper to replace materials with a higher ecological footprint, they need to be strong, ductile, provide a gas barrier, and, sometimes, also be transparent. Improved properties, or even novel properties, are also important for use outside the conventional markets. This paper describes how cellulose fibres partly derivatised to dialcohol cellulose can be used to fabricate high-density materials by conventional papermaking techniques that simultaneously display all the above-mentioned features. The materials produced were characterised with respect to X-ray diffraction, dynamic mechanical thermal behaviour, visual appearance, oxygen permeability and tensile properties. The highest degree of modification studied, resulted in a material with thermoplastic features, a tensile strength of 57 MPa, a strain-at-break of 44% and an oxygen permeability at 80% RH of 23 ml µm (m^2 kPa 24 h)$^{-1}$. At a thickness of 125 µm, these films have a total light transmittance of 78% (87% haze). However, by hot pressing the film for 2 min at 150 °C under a pressure of 16 MPa, and thereby increasing the density, the total transmittance increases to 89% (23% haze). The hot pressing can also be used to fuse individual pieces together, which is useful in many modern packaging applications. Altogether, this work shows how chemical modification of cellulose fibres can be used to induce novel properties and improve the range of application, and consequently provide an interesting bio-based material with a good potential to replace less sustainable materials.

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Introduction

Our society is gaining an increased environmental awareness at the same time as producers are continuously focusing on production efficiency and customers are demanding better product and material performance. Cellulose, which is the most abundant polymer on earth, is a fascinating and versatile biopolymer which in different forms can be expected to be extremely important in a sustainable bioeconomy.[1] However, for cellulose really to be a competitive option in advanced applications, it cannot be used directly in its natural state but needs to be refined or chemically modified to attain suitable properties. An example of such a refinement is to individualise the strong and highly ordered cellulose nanofibrils (CNFs) and cellulose nanocrystals (CNCs) constituting the native cellulose fibre, an approach that has resulted in thousands of scientific papers over the last 15 years.[2–5] In several of these papers, CNFs and CNCs have been applied in advanced electronic devices, film and barrier applications, and nanocomposites.

Since all forms of native cellulose have limited ductility and are non-thermoplastic, the material processing is typically limited to particle-in-water systems. However, since cellulose is also hydrophilic and has a high propensity to form high-viscosity slurries and hydrogels, especially in the molecular or nanoparticle form, wet processing into the above-mentioned nano- and mesostructured materials can be very complicated on a large scale. It is therefore desirable to find a cellulose-based system which benefits from the high strength of native cellulose, but can be processed by large-scale water-based papermaking-type processes followed by dry-state processing such as hot pressing or hydroforming.

Recently, we have shown that a heterogeneous conversion of cellulose to dialcohol cellulose, presumably by forming a shell of dialcohol cellulose that surrounds the crystalline core of each CNF, can be an interesting way to form an *in situ* composite with high strength and ductility.[6,7] If the modified CNFs

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† Electronic supplementary information (ESI) available: FTIR spectra of the final materials. Light transmittance and density of modified papers pressed under various pressures, temperatures and times. Full spectrophotometer data in support of Fig. 5b. Additional information regarding the *t*-peel test. See DOI: 10.1039/c5gc03068d

are individualised, oxygen-barrier films with high ductility and formability can be fabricated.[7] However, since pure dialcohol cellulose is thermoplastic,[8,9] it is of interest to study whether a core–shell structure is sufficient to induce thermoplastic features in the material while retaining the good mechanical properties of the native cellulose. The present study therefore aims at exploring a higher degree of derivatisation, and characterising the mechanical properties, thermoplastic behaviour and structure of papers and films made by a conventional papermaking technique, with the deliberate goal to produce high-performance materials from cellulose without the energy-consuming liberation of the fibres into CNFs, and to apply a simple form of heat processing, in this case hot pressing, to prepare highly transparent and strong films.

Experimental

Fibres

Bleached softwood kraft fibres (K46) were supplied by SCA Forest Products (Östrand pulp mill, Timrå, Sweden). One part of the material was left unbeaten and one was mechanically beaten in a Voith mill to an energy input of 160 W h kg^{-1} (about 30 SR). This increases the swelling of the fibres and makes them more flexible. Mechanical beating also produces small-particle material, so called fines. To ensure that only long macroscopic fibres were used during the modification, thereby easing the processing and data interpretation, the small-particle material was removed from both the non-beaten (3–4%) and the beaten (8–10%) fibres by filtration through a 200 mesh metal screen, using a Britt Dynamic Drainage Jar (Paper Research Materials, Seattle, USA).

Chemicals

Sodium (*meta*)periodate was provided by Alfa Aesar (98%), and sodium borohydride and hydroxylamine hydrochloride were supplied by Sigma-Aldrich. Other chemicals such as hydrochloric acid, sodium hydroxide, isopropanol (≥99.8% purity) and sodium phosphate were all of analytical grade.

Fibre modification

Cellulose fibres were sequentially oxidised and reduced according to an earlier established protocol.[6] The fibres were partly oxidised to dialdehyde cellulose by adding 5.4 gram of periodate per gram of fibre to a gently stirred beaker at a fibre concentration of 4 g l^{-1}. To limit the formation of radicals and unwanted side reactions, the reaction was performed in the dark. After the desired time of oxidation, 6, 12 or 24 h, the reaction was stopped by filtration and washing of the fibres. The fibres were then suspended to 4 g l^{-1} and the dialdehyde cellulose formed was reduced to dialcohol cellulose by adding 0.5 g sodium borohydride per gram of fibres. To limit the pH increase to about pH 10 upon addition of sodium borohydride, monobasic sodium phosphate was added together with the borohydride in an amount corresponding to 0.01 M. The reduction time was kept constant at 4 h, followed by filtration and thorough washing.

Carbonyl content determination

The carbonyl content of the oxidised fibres was determined by reaction with hydroxylamine hydrochloride.[6,10] The fibres were suspended in water and adjusted to pH 4, followed by dewatering to a gel-like consistency. Then, approximately 0.25 g (dry basis) of these fibres were stirred with 25 ml of 0.25 M hydroxylamine hydrochloride solution at pH 4 for at least 2 h before the fibres were separated from the solution by filtration using a pre-weighed filter paper. The exact mass of the fibres was then determined by oven drying of the filter paper and the carbonyl amount was determined by titration of the filtrate back to pH 4 with 0.10 M sodium hydroxide. Two to three independent oxidations were performed at each oxidation time, and each reaction with hydroxylamine hydrochloride was performed in triplicate.

X-ray diffraction

The crystallinity of the non-modified and modified materials was evaluated by collecting X-ray diffraction (XRD) patterns using a PANalytical X'Pert PRO X-ray diffraction system. Data were recorded in the reflection mode in the angular range of 5–50° (2θ) using CuKα radiation (1.5418 Å). The XRD data were analysed by calculating the ratio between the diffraction of the (002) lattice peak at about 22.5° and the minimum found between the (002) and (101) lattice peaks at about 18.5°, commonly referred to as the crystallinity index,[11] and the crystallite width was estimated using the Scherrer formula on the (002) lattice peak, assuming a shape factor of 0.9.

Paper preparation

Handsheets with an approximate grammage of 150 g m^{-2} were prepared using tap water in a Rapid Köthen sheet former (Paper Testing Instruments, Austria). The dewatering time ranged from 20 to 40 s. The sheets were dried at 93 °C under a reduced pressure of 95 kPa, first for 15 min between 400 mesh woven metal wires attached to regular sheet-former carrier boards, and then for 2 min between ordinary carrier boards. The sheets were then stored at 23 °C and 50% RH until further testing.

Pressing

Circular samples with a diameter of 40 mm were hot pressed between two bright annealed steel discs in a Fontijne TP400 press (Fontijne Grotnes, The Netherlands) for all further analysis, except for peel testing where rectangular (20 mm wide and 63 mm long) steel plates of the same area were used. The typical combination of pressure, temperature and time was 16 MPa, 150 °C and 2 min, but other combinations were also tested (see ESI†).

Thickness and density

Thickness was determined, before and after pressing, as the average structural thickness according to the SCAN-P 88:01

standard. This thickness value was then used together with the area and the mass of the test piece to calculate the material density.

Dynamic mechanical thermal analysis

DMTA was performed with a TA Instruments Q800 operating in the tensile mode. The oscillation frequency and amplitude were 1 Hz and 10 μm, respectively, and temperature scans were performed at a rate of 3 °C min^{-1} in the temperature range of 20–300 °C (or until sample failure). For each degree of modification, four replicates were tested; using test pieces that had an approximate width of 3 mm, a thickness of 100–180 μm and a distance between the clamps of about 8 mm.

Tensile and peel testing

Tensile and *t*-peel testing were performed with an Instron 5944, equipped with a 500 N load cell, in a controlled climate of 23 °C and 50% RH.

For tensile testing, test pieces, 5 mm wide and 100–180 μm thick, were clamped with a free span of 20 mm and strained at a rate of 2 mm min^{-1}. The strain was determined by measuring the grip displacement; the Young's modulus was calculated as the initial linear slope of the stress–strain curve, and the yield point was determined by the offset method, using an offset of 0.3%.[12] A total of ten pressed and ten non-pressed test pieces were tested at each degree of modification.

Prior to *t*-peel testing, two 20 mm wide strips of modified cellulose were hot pressed as described above, fusing them in the middle and leaving four free ends (see ESI† for further information). The fused strips were then cut in half to give two T-shaped test pieces with a 20 mm wide and approximately 30 mm long fused area. *t*-Peel testing was performed using a strain rate of 20 mm min^{-1}. A total of four test pieces were evaluated.

Electron microscopy

A Hitachi S-4800 high-resolution field-emission scanning electron microscope (SEM) was used to acquire micrographs of the pressed and non-pressed papers. In order to suppress specimen charging during imaging, the specimens were sputtered (208 HR Cressington Sputter Coater) for 20–30 s using a platinum–palladium target.

Cross-sections of modified samples were prepared using a microtome (RMC MTXL, Boeckeler Instruments Inc., AZ, USA) equipped with a glass knife. The papers were first clamped between two 0.8 mm polystyrene plates and the assembly was then "polished" by cutting 50 nm thin sections for a total thickness of a few micrometres. This procedure could unfortunately not be used for the reference papers due to their high porosity and low stiffness and a sharp knife was therefore used for cross-sectioning of these samples.

To study whether the hot pressing damages the macroscopic fibres, papers were soaked in water and gently strained until failure. After drying, the failure zone was then imaged as top view micrographs.

Optical properties

The optical properties of the papers were studied with a Shimadzu UV-2550 UV-vis spectrophotometer equipped with an integrating sphere accessory. Each sample was studied at three random positions, and three non-pressed and two pressed samples were evaluated for each degree of modification.

Oxygen permability

The oxygen permeability was evaluated on 5 cm^2 samples using a MOCON OX-TRAN 2/21 according to the ASTM D3985 standard. The oxygen permeability measurements were performed at 23 °C and 50% RH or 80% RH, using the same relative humidity on both sides of the sample. For samples exhibiting measurable barrier properties, four samples were evaluated at each relative humidity.

Results and discussion

Molecular and supra-molecular characterisation

Non-beaten and beaten cellulose fibres were oxidised with sodium periodate, which is known to selectively oxidise vicinal diols, for up to 24 h. Fig. 1 shows that the rate of conversion was relatively slow and remained fairly constant throughout the studied time frame, decreasing only slightly as the degree of oxidation increased. This is well in accordance with other studies on the periodate oxidation of cellulose.[6,13–15] The results also indicate that the oxidation rate is slightly higher in beaten fibres, which is plausible since beating is known to soften the fibre wall and to increase the swelling and hence the accessibility of cellulose molecules inside the fibre wall.[15,16] It should, however, also be stressed that periodate oxidation is significantly faster and more industry-applicable at high temperature, and that the sodium periodate is not to be considered as a consumable, but would in an industrial process be regenerated.[14,17,18]

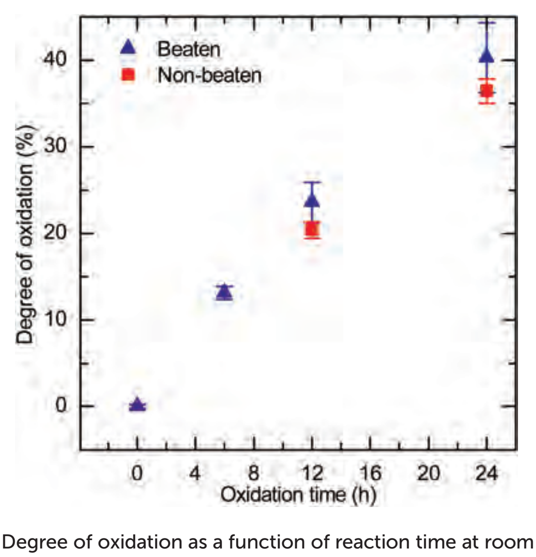

Fig. 1 Degree of oxidation as a function of reaction time at room temperature for beaten and non-beaten fibres.

Directly after the periodate oxidation, the fibres partly containing dialdehyde cellulose were reduced with borohydride (complete reduction was concluded by a non-measurable reaction with hydroxylamine and further supported by the absence of a carbonyl peak in the FTIR spectra of the final papers; the spectra can be found in the ESI†), which in the same way as the sodium periodate would be regenerated in an industrial process,[19] to dialcohol cellulose. According to our earlier findings,[6,7] this gives fibres in which the CNFs constituting the fibre wall have been modified into a core–shell structure, *i.e.* as periodate works its way into the CNF, its surface is transformed into a shell of highly derivatised and amorphous cellulose surrounding the inert and highly ordered CNF core. Papers were rapidly made from the modified fibres by a conventional laboratory technique and analysed by XRD. Fig. 2 shows how the X-ray diffraction and crystallite width decreased with increasing degree of oxidation, in line with the core–shell hypothesis. Fig. 2a also shows that the ordered structure was unaffected by further hot pressing.

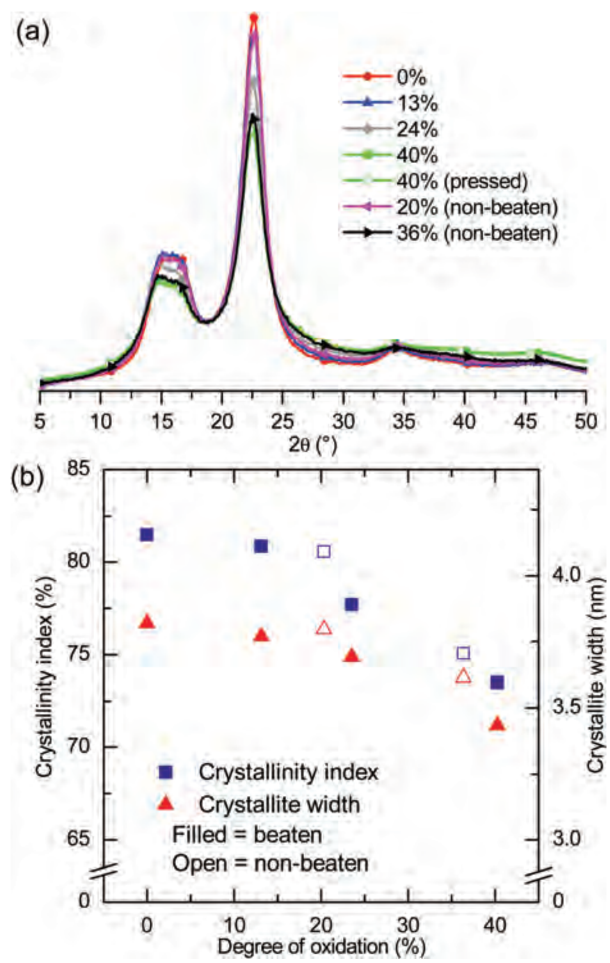

Fig. 2 XRD data of oxidised-reduced fibres; (a) diffractograms, (b) crystallinity index and crystallite width as functions of the degree of oxidation.

Thermoplasticity, pressability and structure

Cellulose is an example of a technically non-thermoplastic polymer, *i.e.* it decomposes before it readily softens. However, there are cellulose derivatives that are thermoplastic, typically various cellulose esters,[1] but also dialcohol cellulose.[8,9,20] Therefore it is interesting to study how cellulose fibres partially transformed into dialcohol cellulose are affected by temperature. Fig. 3 shows DMTA of the different samples and clearly shows that the untreated material is more or less unaffected by temperature while the thermoplasticity increases with increasing degree of modification. For samples with a degree of oxidation of 24% or greater, Fig. 3 shows two rather sudden changes in storage modulus, one at 70–120 °C and one at 160–180 °C, where the first change can presumably be linked to the glass transition of dialcohol cellulose and the latter to its flow region.[9] Furthermore, Fig. 3 shows that hot pressing at 150 °C prior to the DMTA did not affect the thermoplastic behaviour of the material, *i.e.* such a pre-treatment did not induce any significant permanent chemical or structural

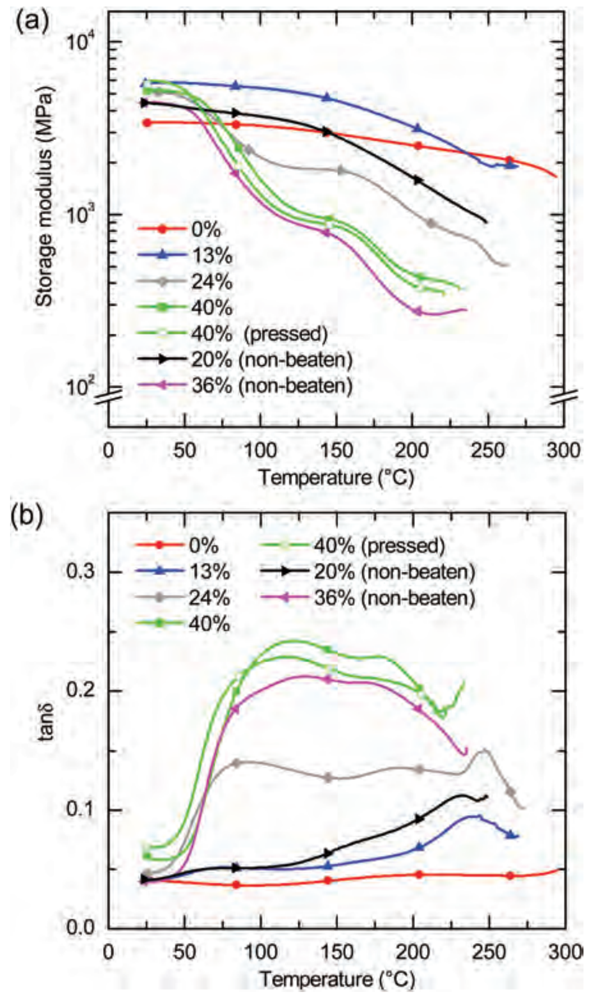

Fig. 3 DMTA of papers and films made of oxidised-reduced fibres; (a) storage modulus, (b) tan δ. Each curve is the average of four measurements.

changes affecting the thermoplasticity. This also implies that the mechanical properties of the non-pressed samples are controlled predominantly by the properties of the fibre wall, and not by the fibre network. Altogether, the data in Fig. 3 indicate that the material can be heat processed in different ways, such as hot pressing.

To further study and utilise the thermoplastic features of the modified cellulose materials, samples were hot pressed between two smooth steel plates. The optimal pressing conditions, in terms of visual appearance and light transmittance, were found to be 16 MPa and 150 °C for 2 min (all the conditions tested can be found in the ESI†). Fig. 4 shows the material density before and after hot pressing of the differently modified materials. The density of the modified papers/films was high already before hot pressing, ranging from 1100 to 1300 kg m^{-3}, which by far exceeds the density of conventional papers, including greaseproof papers,[21] and was similar to the density of fibre materials subjected to extended hot pressing at high pressures (45 MPa for 20 min).[22] The densities of the papers presented here is, to the best of our knowledge, surpassed only by so-called nanopapers made from CNFs or CNCs, which can have densities of about 1500 kg m^{-3}, *i.e.* close to that of solid cellulose.[23,24] However, compared to nanopapers, the current papers were formed and dewatered by conventional papermaking methods in a matter of a few tens of seconds whereas it takes hours to dewater (or solvent cast) a nanopaper.[25,26] When the papers were hot pressed, the density increased by 10–20% to densities greater than 1400 kg m^{-3} for the papers with a degree of oxidation greater than 24%, *i.e.* densities not far from that of solid cellulose. This indicates that the modified fibres are soft and flexible and form a novel, highly consolidated type of paper, more resembling a transparent film.

Another indicator of a highly consolidated paper is a high optical transmittance, which is an indicator not only of a high density of a cellulose-based material but also of good barrier properties. In this work, a spectrophotometer equipped with an integrating sphere was used to measure both direct and diffuse transmittance. The visual appearance and optical transmittance of the different papers are shown in Fig. 5, where Fig. 5a shows how the fibre modification transforms the papers from being opaque to being fairly transparent. This transparency of the modified samples was further improved by hot pressing, especially for the beaten, most modified fibres which resulted in a more or less homogeneously transparent paper/film. Fig. 5 (and Fig. S3†) also shows that the non-beaten fibres were not as susceptible to the hot pressing as the beaten fibres, indicating a synergetic effect between beating and the oxidation-reduction treatment of the fibre, where both treatments soften the fibre wall and facilitate a good consolidation

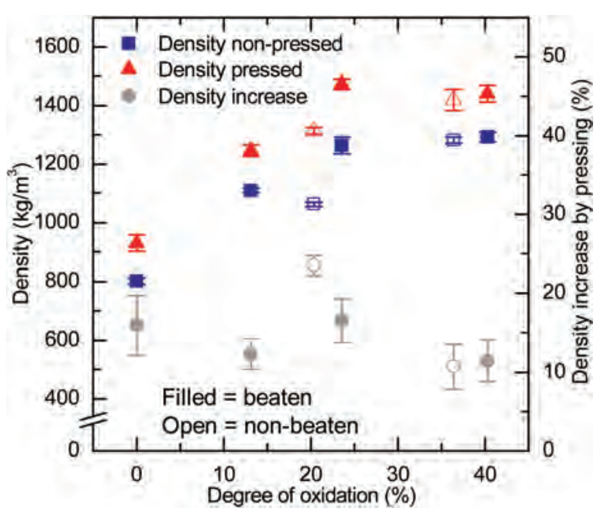

Fig. 4 Density before and after hot pressing for 2 min at 150 °C and 16 MPa. Values are means of at least eight measurements and are given with 95% confidence limits.

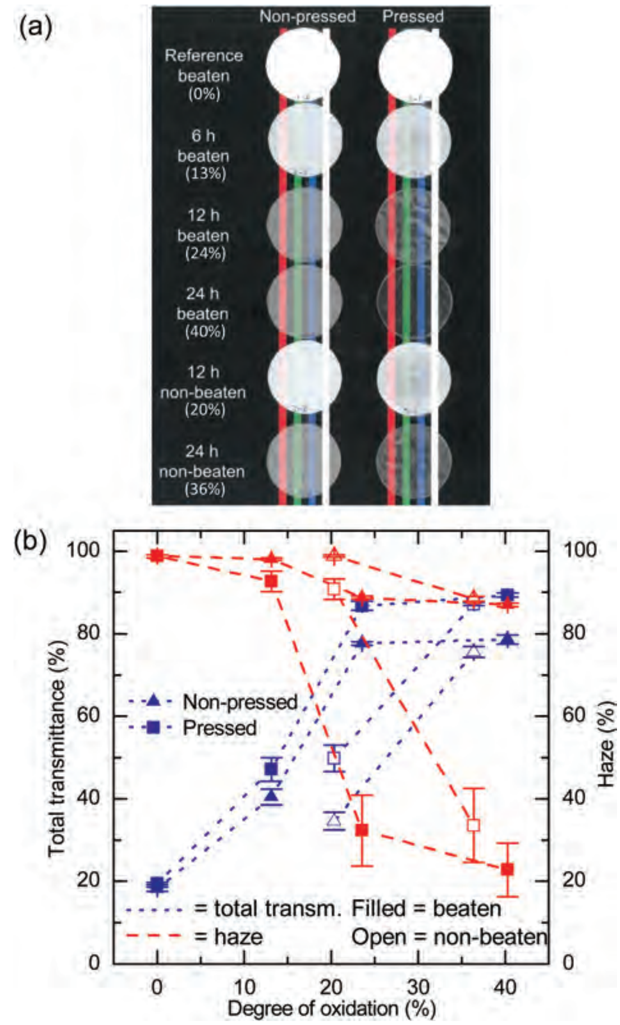

Fig. 5 Optical appearance of non-pressed and pressed samples; (a) scanned image, (b) total transmittance and haze, *i.e.* percentage of diffuse transmittance, measured at a wavelength of 550 nm (full spectra can be found in the ESI†). The average sample thickness was 183 and 150 µm for the non-pressed and pressed reference, respectively, and the thickness of all the modified samples was in the range of 120–150 µm before pressing and 100–120 µm after pressing.

during drying. Fig. 5b shows that the total light transmittance increased significantly upon chemical modification; the three most modified samples had a total transmittance of about 80% at a sample thickness of about 120 μm. However, most of the transmitted light, about 90%, was measured as diffuse light. After hot pressing the total transmittance increased to nearly 90%, and the transmittance mode was changed into mainly direct transmittance, with a haze value of only 20–40%. This possibility of tailoring the optical haze indeed open the way for applications outside the traditional pulp, paper and packaging arena. Recently, hybrid materials between highly beaten fibres and CNFs were identified as interesting materials in solar cell devices due to their combination of high total transparency and high haze.[25]

The structure of the papers was further studied by SEM. Fig. 6 shows micrographs of reference papers and papers made from the most modified fibres and, as can be seen, the pressing had little effect on the structure of the reference paper (first and second column). However, if the reference and modified paper, both before and after pressing, are compared, remarkable differences can be observed (first row): the reference fibres form an expected ribbon-like structure where individual fibres can easily be identified, whereas the modified fibres are merged together making it difficult to distinguish individual fibres from each other (the repeating pattern, that can be mistaken for individual fibres, are imprints from the drying mesh). Upon hot pressing, the uneven structure of the modified paper is more or less completely transformed to a smooth film surface without distinct features (at higher magnification, however, nanofibrils can be seen; results not shown), which largely explains the significant decrease in haze upon pressing since haze is in many materials largely due to surface roughness.[27–29] Quite remarkably, if the non-pressed or pressed, modified papers are soaked in water and strained until failure, fibres become clearly visible as they protrude from the failure surface (Fig. 6g and h), showing that the modification and hot pressing do not significantly affect the macroscopic fibre structure but makes possible a very close contact between individual fibres, still leaving the fibres as discrete entities. The last row in Fig. 6 shows cross-section images and agrees well with the densities and transmittance values reported in Fig. 4 and 5, showing a porous reference sheet and a basically non-porous modified paper.

Barrier properties

High density (Fig. 4), high transparency (Fig. 5) and a highly consolidated network structure (Fig. 6) are typical traits of a polymer-based gas barrier. Therefore, and since non-porous

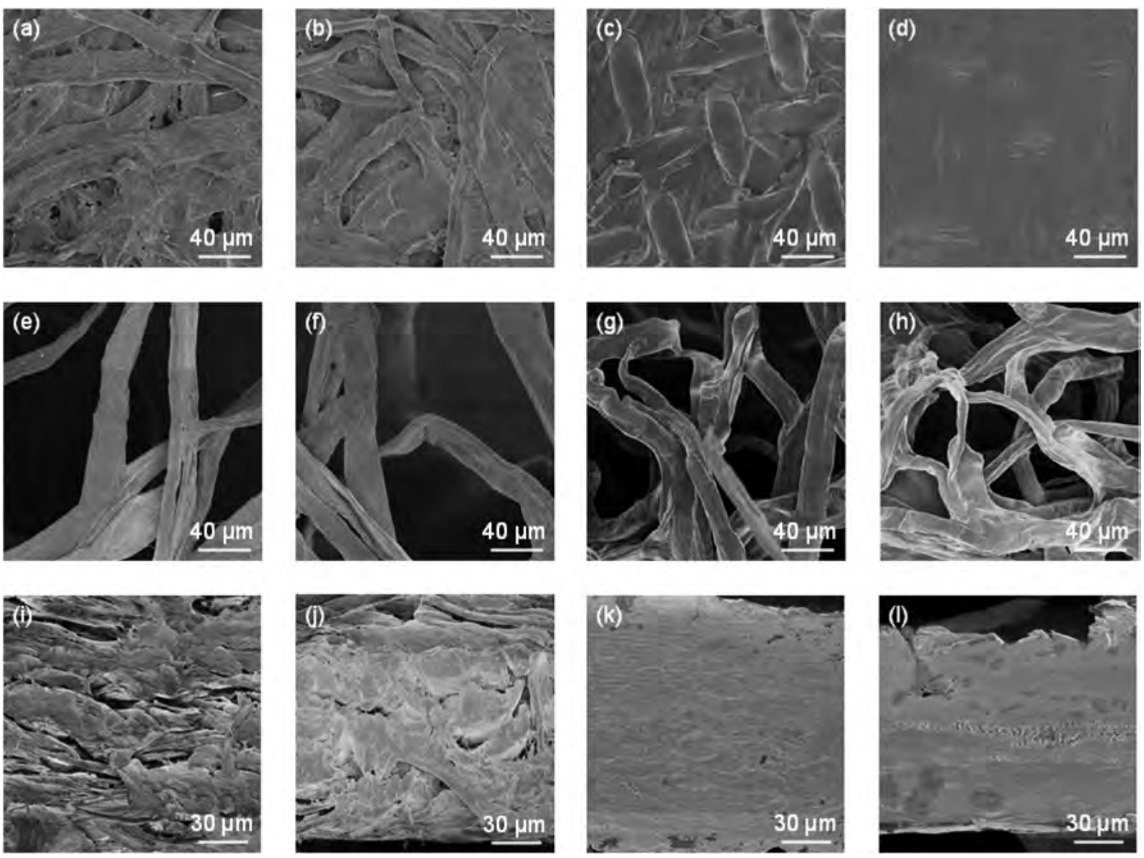

Fig. 6 Micrographs of the reference paper and the most modified paper; the first and second columns are non-pressed and pressed reference papers, respectively, the third and last columns are non-pressed and pressed modified papers, respectively. (a–d) Top-view images, (e–h) top-view images of the failure surface of wet-strained papers, (i–l) cross-section images.

cellulose materials are known to be good oxygen barriers,[4,30,31] especially at low relative humidity, oxygen permeability measurements were performed before and after pressing. The results are presented in Table 1 and, as expected, the non-modified papers did not provide an oxygen barrier but the papers formed from beaten fibres with a degree of modification greater than 24% did indeed provide an oxygen barrier. Since greaseproof papers do not provide any measurable gas barrier,[32] this is, to the best of our knowledge, the first report of a non-coated paper produced by conventional papermaking methods that constitutes a gas barrier.

Hot pressing did not improve the (non-existing) barrier properties of the reference paper; but, pressing of the modified paper sheets tended to further decrease the oxygen permeability. As long as the pressing does not cause any damage to the fibre network, it is expected that an increase in density (Fig. 4) and hence a decrease in void fraction should lower the permeability. Interestingly, pressing of papers made of the most modified non-beaten fibres transformed the paper from a non-barrier to a barrier. This not only shows that hot pressing of the modified papers leads to a smaller void fraction, but also supports the above-mentioned observation of a synergetic effect between beating and chemical modification (since the modified beaten fibres provided a barrier already before pressing).

The oxygen permeability of all the papers/films exhibiting oxygen-barrier properties increased with increasing relative humidity. This is a well-known phenomenon, not only for cellulose and dialcohol cellulose but for polysaccharides in general.[7,31,33,34] It is also interesting to note that the barrier films made from beaten fibres with a degree of oxidation of 24% had a lower permeability than films made from beaten fibres having a 40% degree of oxidation. Apparently 24% oxidation is enough to soften the fibres enough to facilitate a film without interconnected pores, providing a gas barrier, and presumably due to the higher degree of crystallinity (Fig. 2) these films also exhibit lower oxygen permeability than the more modified samples. Regardless, the oxygen permeability at 80% RH was, both for the 24 and 40% oxidised papers, still below a level allowing the material to be used in, for example, packaging applications, especially considering the rapid dewatering and the presumably good and fast processability in a paper machine, which is a prerequisite for economic large-scale material production.

Mechanical performance

Dialcohol cellulose in its pure form is very ductile, but unfortunately it is also very weak.[8,9,20] However, our earlier studies have shown that it was possible to combine both ductility and strength by a heterogeneous modification of CNFs in a core–shell structure.[6,7] Fig. 7 shows that this approach can be taken even further by the extended modification described here. As shown in Fig. 7b, an increasing degree of modification results in a steadily increasing strain-at-break whereas the ultimate strength, Young's modulus, yield stress and hardening modulus pass through a maximum at a degree of modification of 10–25%, reflecting the increasing influence of the more ductile, but weaker, dialcohol cellulose. It is also worth emphasising that the chemical modification has a dramatic effect on the tensile strength of the papers made from fibres subjected to the lowest degree of modification (13%), where the strength is about three times greater than that of the untreated reference. Interestingly, the toughness defined as the work of fracture, *i.e.* the area under the stress–strain curve, reached about 21 MJ m^{-3} for the most modified papers, which surpasses not only all kinds of conventional paper grades by about an order of magnitude but also most nanopapers and nanocomposites made from CNFs.[35,36] This emphasises the remarkable properties of this new material, which would presumably facilitate the advanced hydroforming and deep-drawing of the papers into complex 3D structures.

Table 1 Oxygen permeability of oxidised-reduced papers/films before and after hot pressing. Permeability values are means of four measurements given with 95% confidence limits

Beaten fibres	Pressed/non-pressed	Degree of oxidation (%)	Average sample thickness (μm)	Permeability (ml μm (m^2 kPa 24 h)$^{-1}$) 50% RH	80% RH
Reference	Non-pressed	0	185 ± 15	Over range	Not measured
	Pressed	0	158 ± 13	Over range	Not measured
6 h oxidation	Non-pressed	13	139 ± 1	Over range	Not measured
	Pressed	13	115 ± 4	Over range	Not measured
12 h oxidation	Non-pressed	24	118 ± 5	<0.6[a]	11.8 ± 0.9
	Pressed	24	99 ± 2	<0.5[a]	9.6 ± 0.9
24 h oxidation	Non-pressed	40	118 ± 4	<0.6[a]	22.9 ± 2.1
	Pressed	40	113 ± 5	<0.6[a]	20.5 ± 2.0
Non-beaten fibres					
12 h oxidation	Non-pressed	20	144 ± 2	Over range	Not measured
	Pressed	20	118 ± 3	Over range	Not measured
24 h oxidation	Non-pressed	36	118 ± 1	Over range	Not measured
	Pressed	36	107 ± 4	< 0.6[a]	23.4 ± 3.4

[a] Below the detection limit of the instrument.

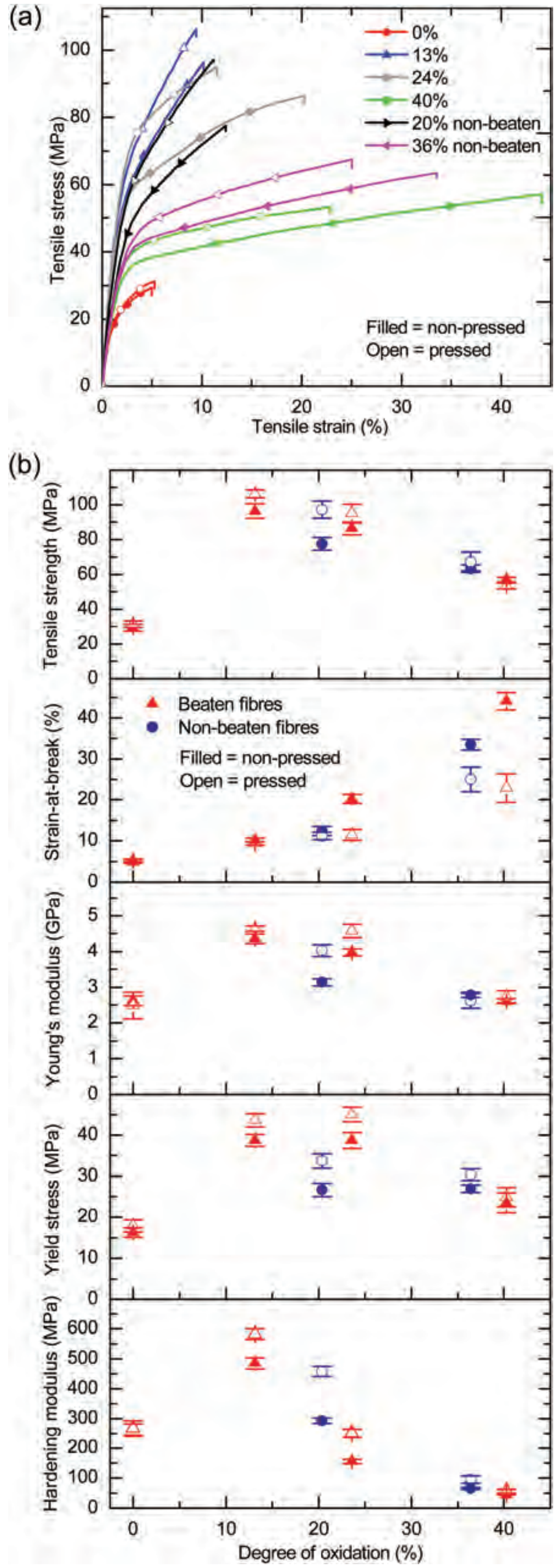

Fig. 7 Tensile data for oxidised-reduced papers/films; (a) average stress–strain curves, (b) tensile strength, strain-at-break, Young's modulus, yield stress and hardening modulus as functions of the degree of oxidation. Values are the means of ten test pieces given with 95% confidence limits.

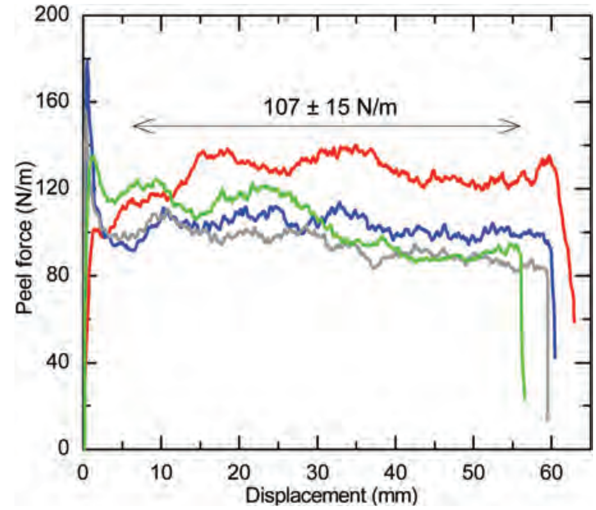

Fig. 8 *t*-Peel force-displacement curves for the separation of two strips made of the most modified fibres fused together by hot pressing for 2 min at 150 °C and 16 MPa.

Hot pressing of the papers affected the mechanical properties in the opposite way to an increasing degree of oxidation, *i.e.* the strain-at-break decreased and the strength, modulus, yield stress and hardening modulus increased in papers that had been hot pressed (Fig. 7). There are at least two possible explanations of this observation: heat-induced chemical degradation, supported by the earlier sample failure seen in Fig. 3 for the modified samples, or a significant decrease in the free volume in the material.[37] Regardless of mechanism, the hot pressed material still shows a very high ductility for a wood-fibre-based network.

From the DMTA data (Fig. 3) and the SEM micrographs (Fig. 6) it can be concluded that the modified cellulose has an increased molecular mobility. This implies that it is possible to fuse two separate pieces by hot pressing. Therefore two paper strips placed on top of each other were hot pressed, followed by a *t*-peel test to quantify the force needed to separate the strips. A force of about 110 N m^{-1} was needed for separation (Fig. 8), showing that it was indeed possible to "weld" two modified papers by hot pressing. Besides showing good adhesion, the merged strips were highly transparent (Fig. S4†). These features demonstrate how the material, in combination with 3D forming, could, for example, be a biorenewable alternative to the often difficult-to-open heat-sealed blister and clamshell packages made of plastic.

Conclusions

Cellulose fibres were heterogeneously converted to different contents of dialcohol cellulose, where the modified cellulose forms an amorphous shell surrounding an intact core of highly ordered cellulose of each nanofibril. Papers and films can then be formed from these fibres in a few tens of seconds by conventional papermaking methods, ultimately resulting in dry materials with tensile strengths ranging from 50–100 MPa and a strain-at-break of up to 44%; the highest work of fracture observed being almost 21 MJ m^{-3}, which surpass by far any earlier reported paper. Materials made of fibres with a degree of modification of at least 24% showed distinct thermoplastic features in DMTA and could be hot pressed so that the fibres were completely fused together, after which no individual fibres could be seen by SEM, demonstrating a high molecular mobility upon heating. This indicates that these novel thermoplastic papers and films can find a use in new value-added applications such as complex-shaped, heat-sealed 3D-formed packaging. Furthermore, films from highly modified fibres had a high density and high transparency, and both properties were further increased by hot pressing; the most modified material had a density of 1450 kg m^{-3} and a light transmittance of 89% after hot pressing. In fact, the densities of the most modified materials were so high that they could act as oxygen barriers. Films with a degree of oxidation of 24 and 40% showed, at 80% RH, oxygen permeabilities of 12 and 23 ml μm (m^2kPa24 h)$^{-1}$, respectively. This is, to the best of our knowledge, the first report of an oxygen barrier formed by a conventional (laboratory) papermaking protocol, with production times similar to those of the reference papers, which presumably facilitates large-scale industrial production of this novel high-performance cellulose material.

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PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

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Rethinking the Determination of Wet Strength of Paper

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The wet strength of paper is an important physical property, especially for household paper, e.g., paper towels, as well as for some functional paper grades. However, in the literature, various conditions of immersing the samples in water before testing have been reported, resulting in differences in their extent of saturation and inconsistency in the testing results. In this editorial, the methods of examination for both the temporary and permanent wet strength are discussed, and a more reasonable method is proposed.

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Rethinking the Determination of Wet Strength of Paper

Zicheng Chen,[a,b] Lanhe Zhang,[a,]* and Zhibin He [b]

The wet strength of paper is an important physical property, especially for household paper, *e.g.*, paper towels, as well as for some functional paper grades. However, in the literature, various conditions of immersing the samples in water before testing have been reported, resulting in differences in their extent of saturation and inconsistency in the testing results. Also, the dryness of paper specimens before the wet-strength testing is a critical parameter for the wet strength of paper; however, this aspect has been neglected in the literature. In this editorial, the methods of examination for both the temporary and permanent wet strength are discussed. A more reasonable method is proposed, such that the wet strength is reported according to the immersion time and the initial dryness of the paper. As an option, the results may be expressed as a function of immersion time and initial dryness. In this way, the trend of temporary wet strength related to the immersion time in water can be expressed clearly and the permanent wet strength also can be evaluated comprehensively.

Keywords: Wet strength; Paper; Testing; Water immersion time; Dryness

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Wet Strength of Paper and Its Determination Method

Thanks to the recyclable, green, sustainable, and cost-effective nature of paper, it has found applications in many fields, such as printing and writing, packaging, household use (*e.g.*, towels), and some special applications. The strength properties of paper are key factors that determine how widely and how well paper is able to be used. The wet strength is very important for such paper products as kitchen towels, paper currency, and various specialty products, such as bags and filters.

As its name suggests, the wet strength of paper is its strength after it gets wet. Likewise, the relative wet strength can be defined as the strength of the wet paper divided by the original strength when it was dry. The list of wet strength properties can be as long as the list of dry strength properties, *i.e.* tensile, tear, folding endurance, and so on. However, some of these wet strength properties are meaningless due to their low values. In TAPPI Method T456 om-3, which has been broadly adopted by global papermakers, the wet strength of paper is mainly defined as wet tensile strength. For paper grades with permanent wet strength, such as napkins and paper towels, applying a water immersion time longer than necessary to saturate the paper sample may not affect the test results of wet strength, as the wet strength of these paper grades are provided by crosslinking resin such as polyamide-epichlorohydrin (PAE), which is not affected by water. However, for some paper grades with temporary wet strength, such as facial tissue, the wet strength decays with increasing water immersion time. The specified temporary wet strength values of these paper products are usually achieved by addition of glyoxalated polyacrylamide (GPAM) chemistry, the effect of which lasts only seconds or minutes after moistening with water. Therefore, water immersion time is a critically important parameter in testing the wet strength of such paper grades.

T456 om-3 details the specimen preparation, process of examination, and method of data collection and calculation. The suggested immersion time ranges from 5 to 40 s for easily saturated paper products, such as tissue, and from 2 to 24 h for other grades, such as paperboard, which can be difficult to saturate. These suggested periods of time are intended to make sure that the paper samples are fully saturated by water so that the variation in strength is less than 10%. On the other hand, the varying conditions of sample immersion time in water in the T456 om-3 method can lead to inconsistency in the wet strength results. We have reviewed relevant published literature regarding the wet strength of paper and found that the immersion time in water for wet strength examination of paper varied greatly, namely, 2 s, 5 s, 1 min, 100 s, 5 min, 10 min, 30 min, 1 h, 2 h, 12 h, 24 h, and overnight (Yang *et al.* 1996; Yang and Xu 1998; Lund and Felby 2001; Xu *et al.* 2004; Vander Wielen *et al.* 2005; Khampan *et al.* 2010; Sun *et al.* 2010; Aracri *et al*. 2011; Chen *et al.* 2013; Su *et al.* 2014; Ichiura *et al.* 2017). Another important factor affecting the paper wet strength, which has been neglected in the literature, is the dryness of paper specimens just before testing. It is well known that the initial dryness determines the paper strength of not only wet web but also rewetting phenomena (Hamzeh *et al.* 2013).

A Suggestion to Improve the Determination of Wet Strength of Paper

Based on the above discussion, we suggest to report the wet strength of paper as functions of the immersion time and initial dryness of paper. As an option, the wet strength may be expressed as a function of immersion time and the dryness of paper specimens. For instance, there could be a 3 D plot, in which the X-axis corresponds to the immersion time, the Y-axis is for the initial dryness of the paper specimen, and the Z-axis is for the measured wet strength. In this way, the temporary wet strength of paper may fully convey the specific information, which can also have direct comparisons with other results in the literature. Different immersion times in water for the sample can bring about undesired experimental errors. The inclusion of dryness of the paper specimen in the reported results also can give important information related to how the dryness of the sample affects the measured wet strength.

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Effect of Cold Plasma Surface Pre-treatment of Wheat Straw Particles on Straw Board Properties

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Effects of the plasma treatment were evaluated for particles from winter wheat stalks relative to the properties of particleboards manufactured from such treated particles. Using urea-formaldehyde adhesive, boards with a nominal density of 540 kg/m3 and a thickness of 6 mm were manufactured. The physical properties (equilibrium moisture content and thickness swelling depending on relative humidity) and mechanical properties (bending strength and tensile strength perpendicular to the plane of the board) were determined. The results showed that the plasma pre-treatment of particles had a statistically significant effect on the resulting composite properties.

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Štěpán Hýsek,[a,]* Milan Podlena,[a] Martin Böhm,[a] Henry Bartsch,[b] and Christoph Wenderdel [b]

Effects of the plasma treatment were evaluated for particles from winter wheat stalks relative to the properties of particleboards manufactured from such treated particles. Using urea-formaldehyde adhesive, boards with a nominal density of 540 kg/m^3 and a thickness of 6 mm were manufactured. Two degrees of plasma treatment were selected: cold plasma applied at atmospheric pressure by jet system, with a generator output voltage of 26.9 V and a current of 6.9 A; and in the second treatment, a maximum voltage of 28.6 V was used with a current of 8.7 A. The physical properties (equilibrium moisture content and thickness swelling depending on relative humidity) and mechanical properties (bending strength and tensile strength perpendicular to the plane of the board) were determined. The results showed that the plasma pre-treatment of particles had a statistically significant effect on the resulting composite properties. The mechanical properties of the boards increased with both plasma treatments, but the physical properties changed negatively. Boards manufactured from particles treated with a higher degree of plasma treatment resulted in significantly higher equilibrium moisture contents and thickness swelling than the reference boards.

Keywords: Cold plasma; Wheat straw; Particleboard; Surface modification; Water uptake

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INTRODUCTION

Cellulose and lignin-based plant materials are often used in composite materials, where they can act as fillers and reinforcing materials. It is always important to ensure the thorough bonding of the plant particle and the polymer. It has been proposed that a basic prerequisite for solid particle-polymer bonding is the presence of reactive groups on the interface of both materials to provide high surface energy (Mwaikambo and Ansell 2002; Bekhta *et al.* 2013). In composites hardened by plant materials, the opposite phenomenon is usually encountered, in which the solid bond between polar cellulose and nonpolar polymer is not easily formed. The wettability of a natural fibre or a particle by polymer is further worsened by the waxy substances that natural fibres often contain. In addition, the presence of water and free hydroxyl groups, in particular in amorphous portions, reduce the possibility of creating a strong bond between plant materials and most adhesives. Furthermore, a high water and moisture uptake causes dimensional changes in plant fibres, implying a reduction in the mechanical and physical properties of the composite material (Mwaikambo and Ansell 2002; Xie *et al.* 2010; Gajdačová *et al.* 2018).

Chemical modification of the fibre not only can improve the adhesion between the surface of the fibre and the polymer, but the specific fibre strength can increase, the water absorption by the composite can be decreased, and the mechanical properties of the entire composite material can also be improved (Li *et al.* 2007). However, the disadvantage of traditional methods of chemical surface modification is the production of hazardous substances that may endanger the environment and human health. From this perspective, surface treatment using plasma is a more benign method toward the environment.

Plasma is an ionized gas containing ions, electrons, neutral and excited molecules, and photons (Baltazar-y-Jimenez *et al.* 2008). Two methods of surface treatment using plasma can be distinguished at low pressure and at atmospheric pressure. Plasma surface treatment at atmospheric pressure is less demanding for instrumentation and has been a progressive method in recent years (Cheng *et al.* 2010). The interaction of plasma with a solid surface results in varying changes in surface properties depending on the type of gas used. Surface energy may be increased or decreased, cross-linking of cellulose in the surface layer may occur, or the forming of free reactive groups may take place (Podgorski *et al.* 2000; Baltazar-y-Jimenez *et al.* 2008).

Cold plasma does not cause any changes deeper in the material, but rather only affects the surface layers (Mahlberg *et al.* 1999). The most important parameters when treating a surface with plasma are the plasma surface contact time, the distance between nozzle and surface, and the size of the current (Baltazar-y-Jimenez *et al.* 2008). Primarily the following gases are used to modify the surface of lignocellulosic materials to better bond with the polymer: oxygen (Mahlberg *et al.* 1999), air (Baltazar-y-Jimenez *et al.* 2008), and argon (Zanini *et al.* 2005).

The aim of this research was to clarify the effect of a cold plasma surface treatment of crushed winter wheat stalk particles, prior to board manufacturing, on the physical and mechanical properties of thereof produced particleboards. Specifically, this is a determination of the impact of plasma treatment on the bending strength, tensile strength perpendicular to the plane of the board (internal bonding), vertical density profile, water uptake, and thickness swelling of boards manufactured from plasma-treated wheat straw bonded with urea-formaldehyde adhesive.

EXPERIMENTAL

Materials

Straw particles

Commercially-sold chopped wheat straw particles were used to manufacture the boards (Mikó Stroh, Borota, Hungary). Using digital image analysis, the proportion of individual fractions was defined per 100 g of material sample using a particle analyzer CAMSIZER (Retsch Technology GmbH, Haan, Germany). The sample was poured into the feed chute, allowing the material to enter the measurement field through the feed guide, which prevented unwanted turbulence of the particles and gave the particles the correct orientation. The maximum range was set to 50 mm. The shortest (width) and the longest particle distance (length), measured by the Feret diameter during the projection, was assessed.

Methods

Plasma application method

The wheat straw surface was modified by atmospheric cold plasma in a mixing agent designed to treat particles and other loose materials (Fig. 1). The base consisted of an iron vessel (outer diameter of 415 mm) attached to a rotating platform. At the top, the container was covered with transparent polycarbonate (PC) to close the plasma application environment and to enable visualization of the course of the modification. Inside the container was an eccentrically-positioned cylinder (outer diameter of 110 mm) that was attached to a fixed arm that held it in a stable position relative to the bowl.

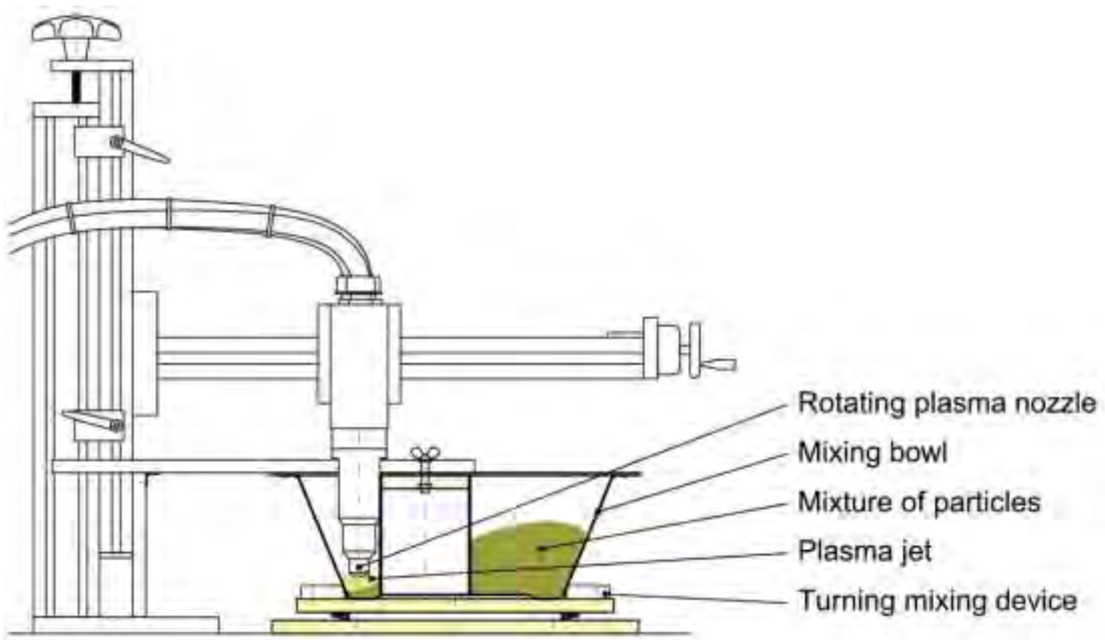

Fig. 1. Side view of the set-up of the stationary plasma aggregate with designed mixing agent

The plasma beam was generated by a high-voltage discharge from the FG 1001 generator (PlasmaTreat GmbH, Steinhagen, Germany) with a maximum output of 1000 VA, and it was distributed to the surface of the particles using compressed air (2 bar). Cold air plasma generated at atmospheric pressure was used. The rotary system of the nozzle of plasma aggregate RD1004 (PlasmaTreat GmbH, Steinhagen, Germany) with the standard AGR 131A (25°) nozzle produced a conical beam shape. To compare the effect of the treatment on wheat-straw using plasma, two variants of surface treatment and one reference variant without treatment (R) were proposed. The variants of plasma application are shown in Table 1.

Table 1. Variants of Plasma Modifications

	Voltage (Generator Set Up)	Current (Generator Set Up)
Modification A	26.9 V	6.9 A
Modification B	28.6 V	8.7 A

The plasma was applied to 100 g of wheat straw for 4 min, and during the treatment, the Alther 2590 digital thermometer (Ahlborn Mess- und Regelungstechnik GmbH, Holzkirchen, Germany) recorded the maximum temperature inside the particle blend.

The degree of plasma surface activation of particles was evaluated with the use of Arcotest (Arcotest GmbH, Moensheim, Germany) test inks designed to measure surface tension. The ink value was identified 2 s after it was applied to the surface, and then an image was recorded using the DTX 90 digital microscope (Levenhuk, Tampa, USA). Testing was conducted until the ink started to coalesce into drops. When it coalesced, a lower-value ink was used, and the boundary between the two inks was sought out.

Adhesive mixture application

After activation of the surface, the particles were resinated with a preformed urea-formaldehyde (UF), hardener (ratio solids hardener / dry adhesive was 10%), and paraffin emulsion mixture (ratio solids hydr. agent / dry particles was 1%). The solid content was 50%. A resin dosage of 10% solids on wood dry mass was applied in a planetary mixer M 301 (Bonnet, Mitry-Mory, France). The mixture was subsequently placed in a drying chamber EHR-K 15/40/20 II (Helios Ventilatoren GmbH, Villingen-Schwenningen, Germany), where it was dried at 30 °C to a moisture content of 8%. The ISI10 scale (Sartorius AG, Göttingne, Germany) was used to continuously monitor water loss, and the final moisture was determined on a moisture tester Ultra X 3011 instrument (A&P instruments, Detmold, Germany). *Via* gradual pouring, the prepared mixture (175 g) was manually layered into a mold with internal dimensions of 128 mm × 355 mm. The layer was spread evenly along the horizontal guiding lines on the inside of the mold.

Pre-pressing and hot-pressing

The mold was then closed and a cold pre-press was performed on the HLP350 hydraulic press (Höfer Presstechnik GmbH, Taiskirchen, Austria). The pressing conditions were set manually by means of the controller to an initial pressure of 4 bars for 1 min. The pre-pressed board was then removed from the mold and continued to be pressed by two heated plates set to 165 °C. The pressing plates were always separated on both sides using waxed paper to avoid adhesion of the boards to the press plate. The pressing was performed according to the pre-set program on the resulting board thickness of 6 mm. The press cycle is shown in Table 2. The total number of six boards for each variant was manufactured. The boards were then allowed to cool down and, further on, they were conditioned at 20 °C and a relative humidity (RH) of 65% for 14 days.

Table 2. Pressing Cycle

Phase No.	Thickness at the End (mm)	Moving Time (s)	Remaining Time (s)
1	40	0.1	0
2	9	4	0
3	5.9	4	6
4	6	5	5
5	6.3	3	0
6	6	3	50
7	6.5	25	0
8	500	0.1	0

Physical and mechanical properties estimation

Test samples were made from the manufactured boards with a rectangular shape for four-point bending, internal bonding, vertical density profile measurement, and samples for water uptake with thickness swelling. Before the mechanical properties measurement, the test specimens were air-conditioned at 65% RH and a temperature of 20 °C.

Strength tests (Fig. 2) were performed on a TIRA test 2850 (TIRA GmbH, Schalkau, Germany) universal testing machine. The maximum force, F_{max}, was always recorded with 1% accuracy. The maximum load was always achieved within 60 s ± 30 s. Before loading, the test specimens were placed in an air-conditioned chamber at 65% RH and a temperature of 20 °C.

The basis of the bending test was to place the test specimen (50 mm × 300 mm) flat on two parallel cylindrical supports (d = 30 mm). Another two supports (d = 30 mm) had a constant loading force, F, cantered above the axis of the board and the maximum force, F_{max}, derived by the machine was measured. The total bending strength was calculated as the arithmetic mean of the values of the following equation for each group of specimens,

$$f_m\ (N * mm^{-2}) = \frac{3 * F_{max} * l_m}{2 * b_m * t_m^2}, \quad (1)$$

where l_m is the length (mm), b_m is the width (mm), and t_m is the thickness (mm) of the test specimen for four-point bending. Tests were not performed according to EN 798 (2004) because no characteristic values of board properties were determined. Using this measuring method, it is possible to compare measured strength values with previously obtained data from the authors' research.

The internal bonding of boards was estimated according to EN 319 (1993) on samples with dimensions of 50 mm × 50 mm.

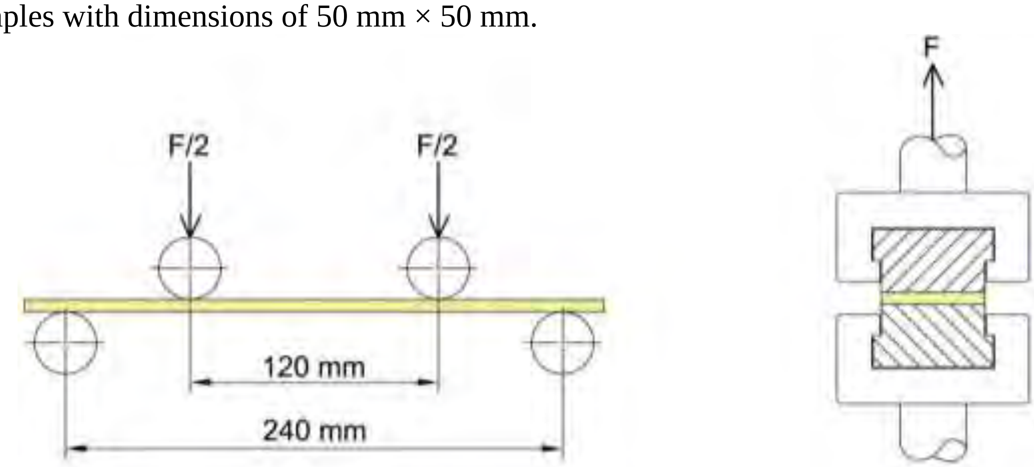

Fig. 2. Diagram of mechanical properties testing

According to Eq. 2, dimensional changes at different air-conditioning stages were determined for water uptake and thickness swelling. The test specimens were first dried to 0% board moisture at 103 °C (air-conditioning stage 0). The samples were then air-conditioned at 20 °C and 65% RH (air-conditioning stage 1) and then at 85% RH (air-conditioning stage 2).

This was reverted to desorption at 65% RH (air-conditioning stage 3), and the last phase was the reverse drying of the samples back to 0% moisture at 103 °C (air-conditioning stage 4). Weight with dimensions of test specimens at marked points was determined at each stage.

$$\beta_x(\%) = \frac{l_x - l_0}{l_0} \text{ x } 100 \quad (2)$$

Measuring points were indicated to ensure repeatability by measuring (mm) in the same position for all air-conditioning stages (x = 0 to 4). Furthermore, the moisture content of samples w_x (%) according to Eq. 3 was determined, where m_0 is the dry sample weight (g) and mass m_x is the weight of the samples at air-conditioning levels (g). The density of the samples ρ_x (kg/m^3) was again calculated from the mass m_x and the sample volume V_x according to Eq. 4:

$$w_x\ (\%) = \frac{m_x - m_0}{m_0} \text{ x } 100 \quad (3)$$

$$\rho_x\ (kg * m^{-3}) = \frac{m_x}{V_x} \quad (4)$$

The vertical density profile of boards was measured on a Compact X-ray density profile Analyser DPX300-LTE (Imal, Modena, Italy). The test samples had dimensions of 50 mm × 50 mm and were air-conditioned at 20 °C and 65% RH.

Scanning electron microscopy (SEM) of ruptured samples, after internal bonding tests were performed using a MIRA 3 electron microscope (Tescan Orsay Holding, Brno, Czech Republic) with a secondary electron detector, operated at 15 kV acceleration voltage.

Statistical methods

Besides descriptive statistics, an analysis of variance was used to determine whether any of the pairwise differences from the number of means were significant. The Tukey *post hoc* test was employed to determine the significant differences between group means. A significance level of $\alpha = 0.05$ was selected and all computations were performed using Statistica12 software (StatSoft CR s.r.o., Prague, Czech Republic).

RESULTS AND DISCUSSION

Particle size analysis

A digital imaging analysis revealed a heterogeneous proportion of the used wheat straw particles from which the boards were made. As shown in Fig. 3, there are also a number of dust particles in addition to the wheat straw stalks. Nevertheless, it was found that from 100 g of the sample, 30.9% of the particle was from 1.657 mm to 2.696 mm wide. In terms of length (Feret diameter), 29.1% of particle sizes ranged from 8.393 mm to 13.656 mm.

The projection of some deformed particles may result in inaccuracies in measurements, which may be due to the processing of, for example, broad and thin or narrow and long stalks. To avoid distortion of the results, a sufficiently large set of 100 g was chosen to cover these inaccuracies.

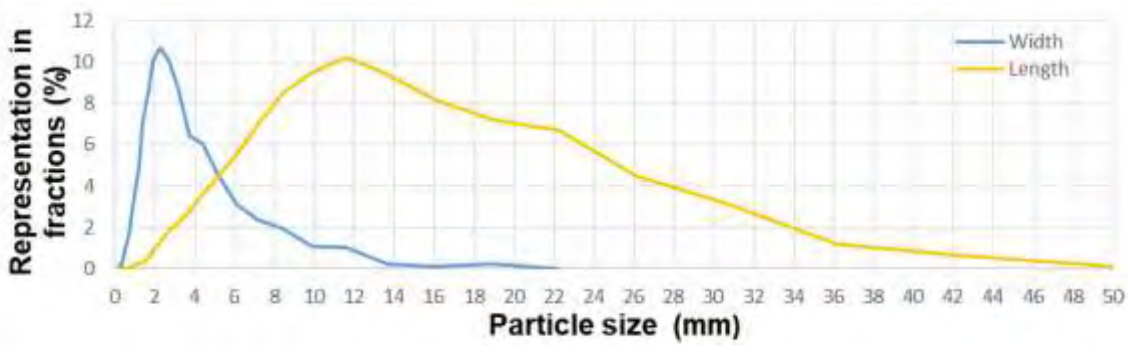

Fig. 3. Results of the particle size analysis

Plasma application and surface tension changes

Due to the designed enclosed mixer, it was possible to modify the particle mixture homogeneously using plasma. Two modification degrees of lower (26.9 V/6.9 A) and maximum power (28.6 V/8.7 A) were used to treat the straw. Despite the fact that cold plasma was used, the maximum average vessel temperature reached 81 °C at lower power, while at maximum power it increased up to 86 °C. As a result, most likely a small effect of thermal treatment has to be taken in consideration in addition to the plasma treatment of the wheat straw. This effect led to a pre-drying of the particles.

After plasma treatment, test inks on the outer sides of the straw determined a change in the surface energy of the modified particles, which were compared with the reference particles without modification. The surface tension on the outside of the reference straw covered range values from 24 mN/m to 28 mN/m. Wheat straw with a lower degree of plasma treatment (A) ranged from 28 mN/m to 30 mN/m, and at a higher degree of modification (B), the surface tension was from 30 mN/m to 32 mN/m. The variability of the unmodified particles was thus higher than that of the plasma-treated particles. Therefore, the testing inks confirmed that both degrees of cold plasma treatment increased the surface wettability and changed the surface energy. However, these results could be affected by the different moisture of particles. Plasma-treated particles in the missing agent were partly dried and then immediately examined by test inks. The treated particles were not conditioned because the effect of cold air plasma on the physical properties of modified material decreases with time after the plasma application (Klímek *et al.* 2016).

Density and vertical density profile

The average density of the reference boards was 540.0 kg/m^3. Boards with a lower degree of modification reached 524.9 kg/m^3 and boards with a higher degree of modification had an average density of 545.7 kg/m^3. Due to manual layering, the density also exhibited considerable variability (Table 3). Further, it was noticed that the boards manufactured from the reference particles had the steepest density profile (Fig. 4a). The different average density, the variability of the density, and the shape of the density profile have to be taken into consideration while interpreting the physical and mechanical properties measured. Figure 4b shows a cross-sectional cut of the board showing individual particles of winter wheat stalk.

Table 3. Density of Straw Board at 25 °C and 65% Relative Humidity

Density	Ref.	Modification	
		A	B
Mean (kg/m^3)	540.0	524.9	545.7
Median (kg/m^3)	540.5	528.8	553.4
Standard deviation (kg/m^3)	27.9	31.5	31.0
Minimum (kg/m^3)	486.2	473.8	491.8
Maximum (kg/m^3)	613.2	586.4	607.1

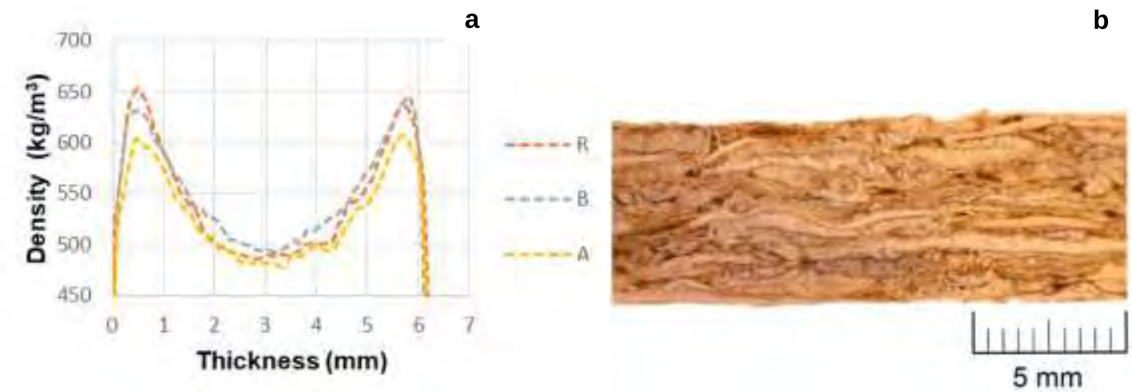

Fig. 4. (a) Vertical density profile of straw boards at 25 °C and 65% relative humidity; (b) side view of pressed board with nominal thickness of 6 mm

Equilibrium moisture content and thickness swelling

Figure 5 shows a graph of the dependency of equilibrium moisture content of the boards on relative humidity, and Fig. 6 shows a graph of the dependency of thickness swelling on relative humidity, and these average values are subsequently specified numerically in Table 4. The highest values of equilibrium moisture and thickness swelling were obtained from boards manufactured from particles modified by a higher degree of plasma treatment (type B), and all of the differences in the given moisture level were statistically significant (Table 5). Adversely, the lowest values of equilibrium moisture were obtained from the boards manufactured from unmodified particles. In terms of the equilibrium moisture of boards manufactured from particles treated with a lower degree of plasma treatment and untreated particles, a statistically significant difference only appeared in the first air-conditioning stage (20 °C/RH 65%, absorption cycle).

Type B boards once again exhibited the highest thickness swelling. As expected, the lowest values of thickness swelling were not reached by boards from the reference particles (Fig. 6). Except for in the first air-conditioning stage (this difference was not statistically significant (Table 6)), a higher thickness swelling in the reference boards was ascertained than in the boards manufactured from modified particles with a lower degree of plasma treatment. This was explained by a variation in the average density of boards, where the average density of the reference boards was 540.0 kg/m^3 and boards with a lower degree of modification reached 524.9 kg/m^3.

Table 4. Average Values of Thickness Swelling and Equilibrium Moisture of Boards on the Given Level

Board Type	Relative Humidity (%)	Thickness Swelling (%)	Moisture (%)
R	0a	0.0	0.0
R	65a	8.3 (0.7)	8.8 (0.4)
R	85	45.9 (5.7)	19.3 (0.6)
R	65d	37.9 (5.5)	11.0 (0.6)
R	0d	30.7 (4.8)	0.0
A	0a	0.0	0.0
A	65a	9.4 (1.6)	9.8 (0.8)
A	85	39.9 (4.5)	19.7 (0.7)
A	65d	33.8 (4.2)	11.4 (0.8)
A	0d	27.9 (2.6)	0.0
B	0a	0.0	0.0
B	65a	10.1 (1.3)	10.8 (0.3)
B	85	53.1 (4.2)	23.0 (0.4)
B	65d	45.3 (3.9)	13.1 (0.3)
B	0d	36.6 (3.3)	0.0

Note: a = absorption, d = desorption, values in parentheses are standard deviations

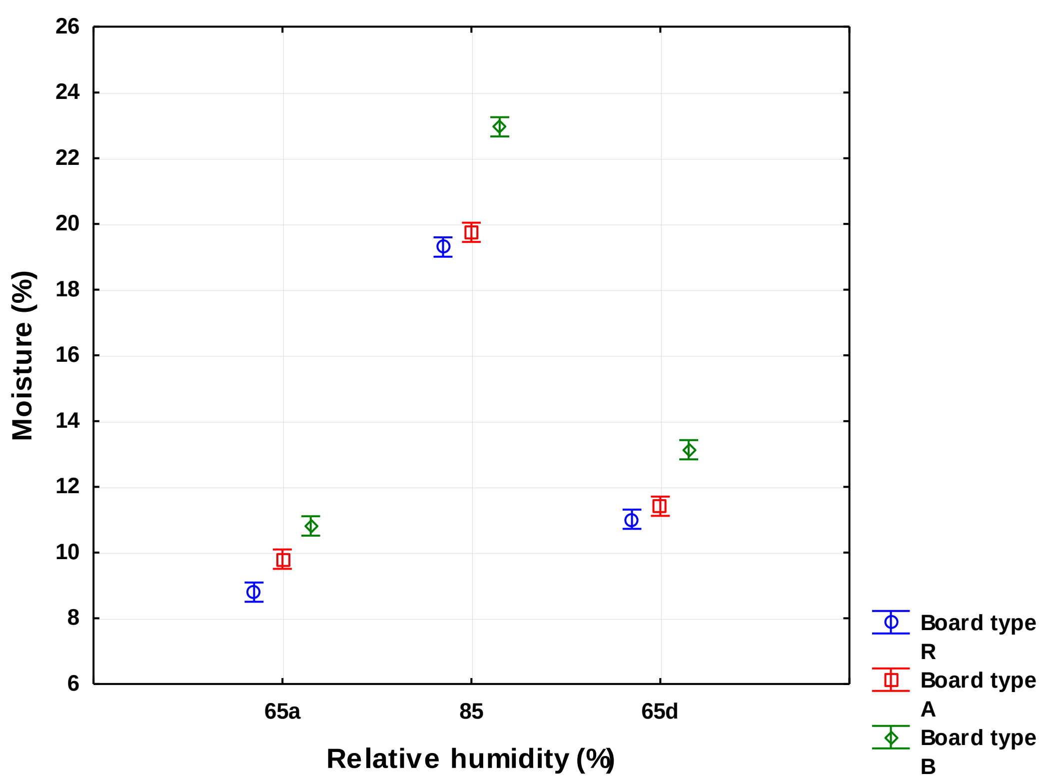

Fig. 5. Graph of the dependency of equilibrium moisture of the boards on relative humidity, a = absorption, d = desorption

Table 5. Appropriate Statistical Significances of Differences in Fig. 5

T = 20°C, RH = 65%, Absorption			
	R	A	B
R		s.	s.
A	s.		s.
B	s.	s.	

T = 20°C, RH = 85%			
	R	A	B
R		n.s.	s.
A	n.s.		s.
B	s.	s.	

T = 20°C, RH = 65%, Desorption			
	R	A	B
R		n.s.	s.
A	n.s.		s.
B	s.	s.	

Note: s. = statistically significant, n.s. = not significant, and α = 0.05

In comparison with commercially produced particleboards, non-recoverable thickness changes of produced boards reached relatively high values. This was explained by the material used. From the authors' previous study it is already known that boards produced from after harvest remains reached non-recoverable thickness changes higher than 30% (Hýsek *et al.* 2018). It was concluded that the plasma treatment of the particles had a statistically significant effect on the equilibrium moisture content of the boards and their thickness swelling; however, the thickness swelling values were negatively affected by the different average densities of the boards. In contrast, when non-recoverable changes were compared with the bending strength results, it can be assumed that modification A was the better level of plasma pre-treatment for the purpose of this study. These boards reached lower non-recoverable thickness changes as well as higher bending strength. Therefore, it was assumed that the lower level of plasma modification caused better adhesion, in comparison to the more aggressive modification B.

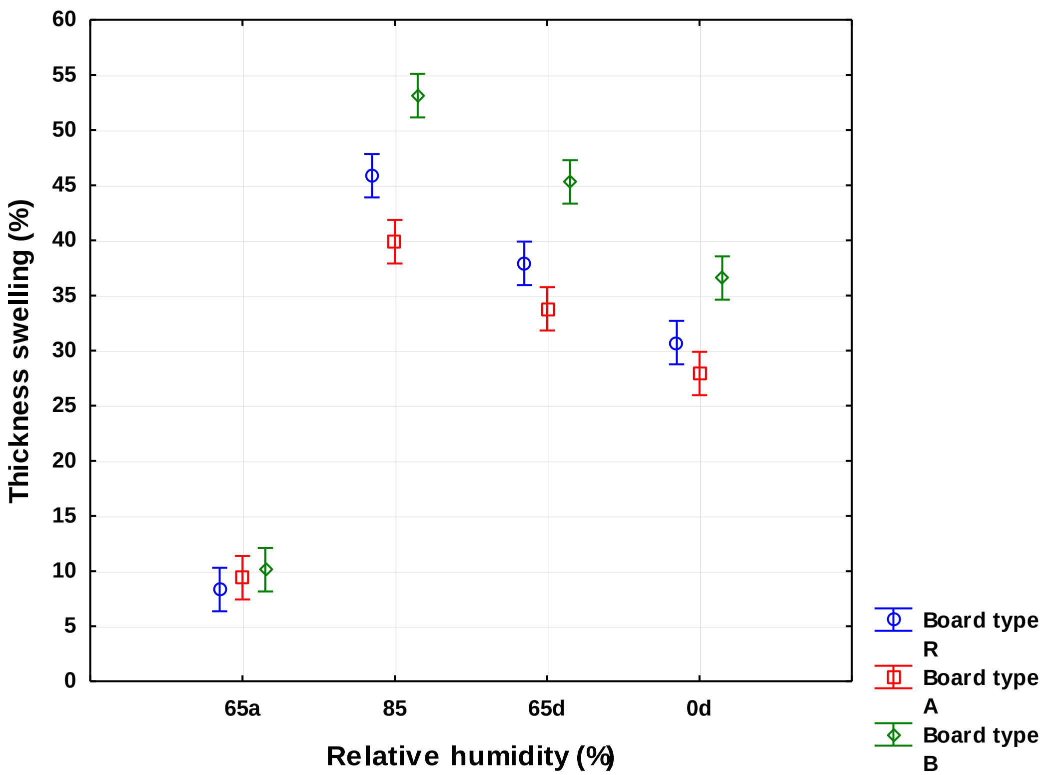

Fig. 6. Graph of the dependency of thickness swelling on relative humidity, a = absorption, d = desorption

Table 6. Appropriate Statistical Significances of Differences in Fig. 6

T = 20°C, RH = 65%, Absorption			
	R	A	B
R		n.s.	s.
A	n.s.		n.s.
B	s.	n.s.	

T = 20°C, RH = 85%			
	R	A	B
R		s.	s.
A	s.		s.
B	s.	s.	

T = 20°C, RH = 65%, Desorption			
	R	A	B
R		s.	s.
A	s.		s.
B	s.	s.	

T = 103°C, Desorption			
	R	A	B
R		n.s.	s.
A	n.s.		s.
B	s.	s.	

Note: s. = statistically significant, n.s. = not significant, and α = 0.05

Bending strength and internal bonding

Table 7 shows the average values with basic descriptive statistics for the bending strength of boards. Figure 7 shows the bending strength variation analysis and Table 8 shows data on the statistical significance of the differences. The results show that in both cases of plasma treatment of the particles there was an increase in flexural strength compared to the reference material, but the increase was only statistically significant for modification A. There was also no statistically significant difference in the flexural strength between the two different plasma treatments.

Table 7. Average Values with Basic Bending Strength Descriptive Statistics

Bending Strength	Ref.	Modification	
		A	B
Mean (MPa)	4.9	5.5	5.1
Median (MPa)	4.8	5.5	5.4
Standard Deviation (MPa)	0.5	0.3	0.7
Minimum (MPa)	4.2	5.0	3.9
Maximum (MPa)	5.6	6.0	5.9

Table 8. Appropriate Statistical Significances of Differences in Fig. 7

	R	A	B
R		s.	n.s.
A	s.		n.s.
B	n.s.	n.s.	

Note: s. = statistically significant, n.s. = not significant, and α = 0.05

Table 9 shows the average values with the basic descriptive statistics for the internal bonding of the boards. Figure 8 shows the internal bonding variation analysis and Table 10 shows data on the statistical significance of the differences. The results showed that in both cases of plasma treatment there was a statistically significant increase in internal bonding. There was no statistically significant difference between the different plasma treatments. Both observed mechanical properties reached lower values than the boards made form rapeseed stalk particles, where internal bonding was 0.34 MPa to 0.50 MPa and the bending strength was 5 MPa to 10 MPa (Hýsek *et al.* 2018). However, in previous research, boards with an average density of 600 kg/m^3 and with an inverse vertical density profile (maximal density in the middle of the board) were produced.

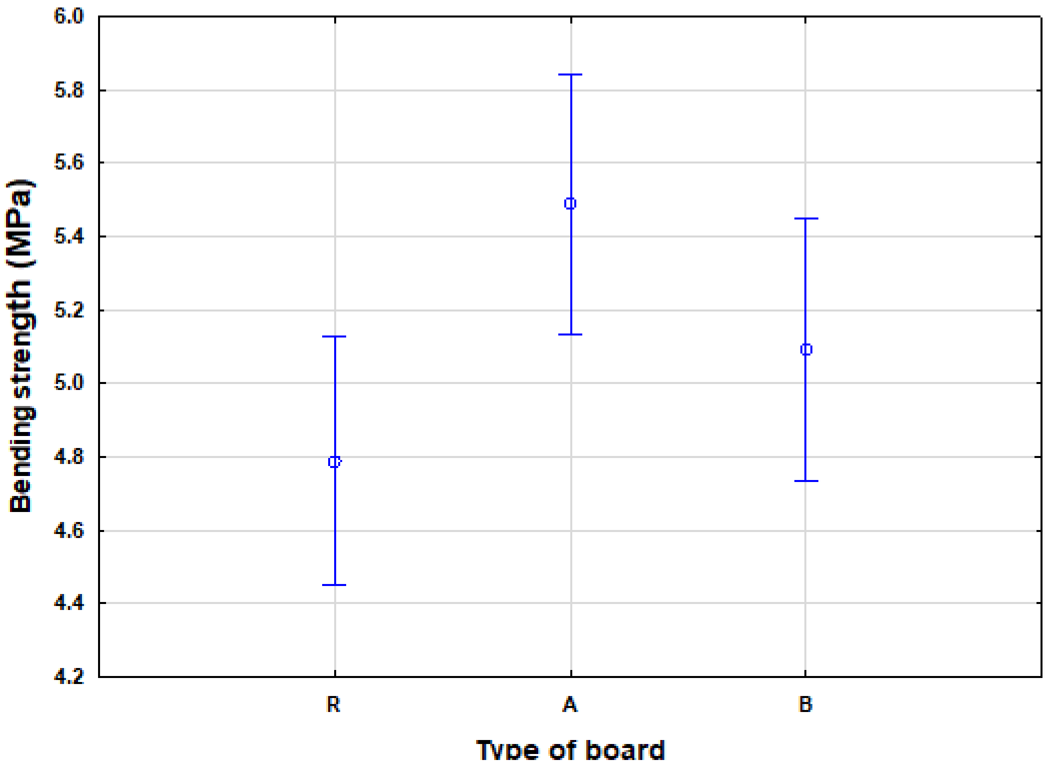

Fig. 7. Analysis of variance - dependence of flexural strength on modification of particles

Table 8. Appropriate Statistical Significances of Differences in Fig. 7

	R	A	B
R		s.	n.s.
A	s.		n.s.
B	n.s.	n.s.	

Note: s. = statistically significant, n.s. = not significant, and α = 0.05

Table 9. Average Values with Basic Internal Bonding Descriptive Statistics

Transverse Tensile Strength	Ref.	Modification	
		A	B
Mean (MPa)	0.037	0.058	0.061
Median (MPa)	0.036	0.054	0.063
Standard deviation (MPa)	0.006	0.019	0.017
Minimum (MPa)	0.028	0.033	0.039
Maximum (MPa)	0.050	0.092	0.098

Table 10. Appropriate Statistical Significances of Differences in Fig. 8

	R	A	B
R		s.	s.
A	s.		n.s.
B	s.	n.s.	

Note: s. = statistically significant, n.s. = not significant, and α = 0.05

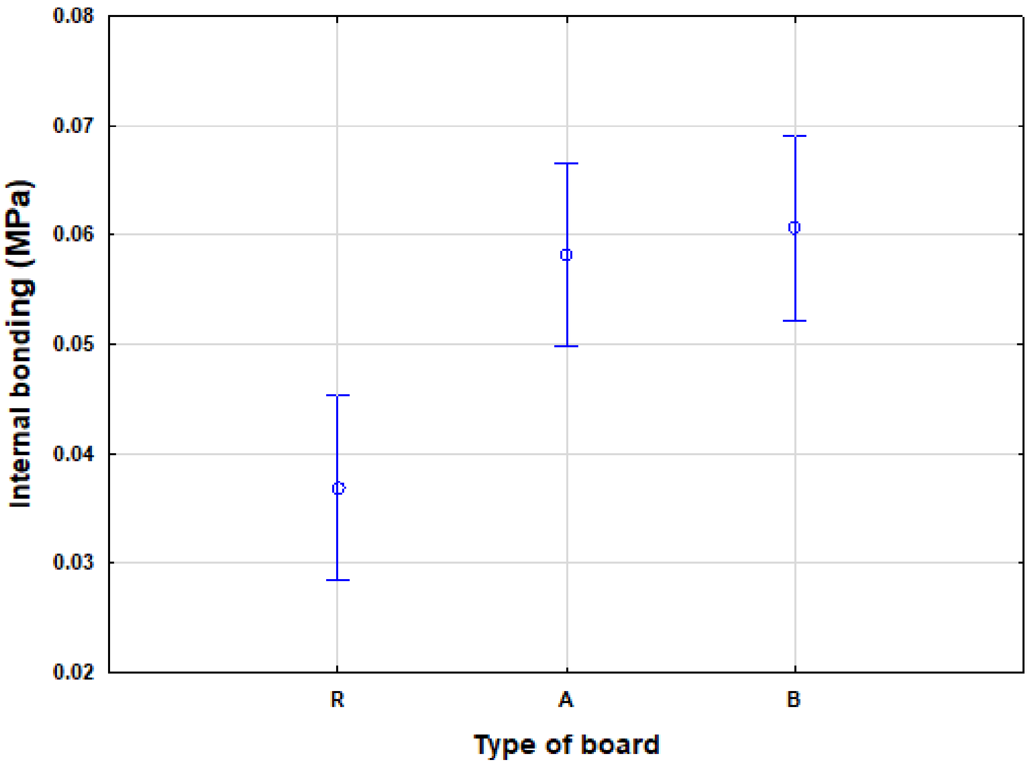

Fig. 8. Analysis of variance – dependence of internal bonding on modification of particles

Figure 9 shows a SEM microscopic image of the damaged joint from the tensile test perpendicular to the plane of the boards. The image shows the noticeable impact of the modification on the nature of the damage. In terms of boards manufactured from the reference unmodified particles (Fig. 9a), there was only adhesion damage between the adhesive and the particle surface. In terms of boards made from plasma-modified particles (Figs. 9b, 9c), cohesive breakage in the particle material was also observed, which indicated a better joint of the modified particle-adhesive.

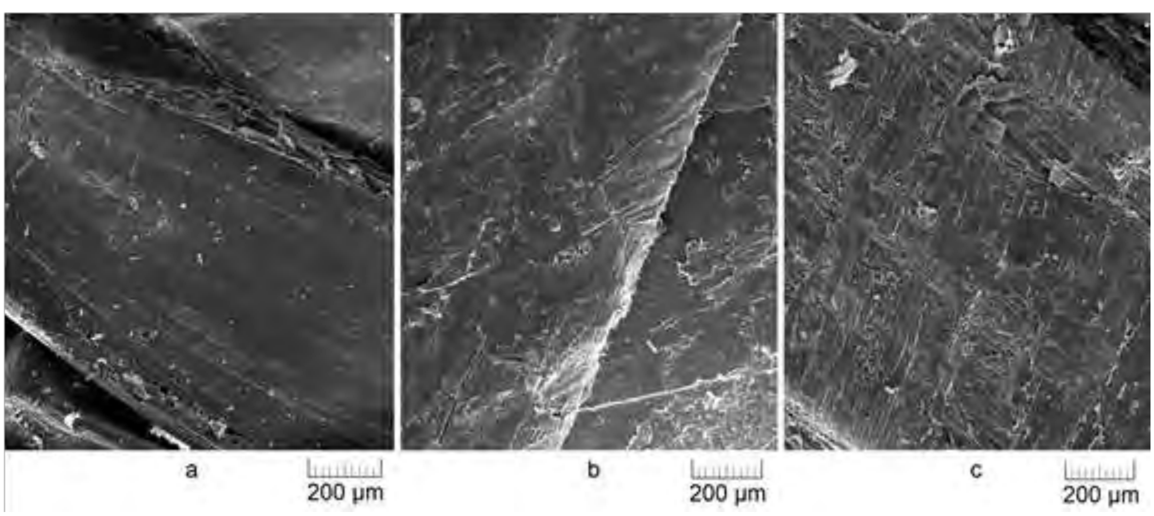

Fig. 9. SEM analysis of particle of boards after strength testing: (a) reference, (b) modification A, and (c) modification B

CONCLUSIONS

1. The effect of plasma treatment on the properties of composite material made from winter wheat stalk particles was investigated. Test inks showed an increase in surface energy and confirmed that plasma treatment influences surface properties of the particles.
2. The plasma treatment of the particles had a statistically significant effect on the equilibrium moisture content of the boards and on their thickness swelling, with increased degrees of plasma treatment the equilibrium moisture content also increased.
3. Opposite of the physical properties, the positive effect of plasma pre-treatment of the particles was observed in the mechanical properties. Both the flexural strength and internal bonding of the boards were increased. The highest increase in flexural strength was achieved by the type A plasma treatment, whereas a difference between the individual types of plasma treatment was not observed in the internal bonding.
4. A better joint of the modified particle-adhesive was reached by the plasma treatment. A noticeable impact of the modification on the nature of the damage in produced composite materials was observed through SEM analysis.

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Present Status and Development of Algal Pulp for Hand-Made Paper Making Technology: A Review

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Unwanted blooms of algae throughout the World are not entirely without a positive side. Algae as a raw material for paper making are an innovative solution to Global environmental issues dealing with deforestation and global warming. Algae contain cellulose and hemi-cellulose but no lignin. This review tries to summarise the pros and cons of algal paper making along with a thorough description of the additives and various ratios and roles of different additives that can be combined with algal pulp for paper making.

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Present Status and Development of Algal Pulp for Hand-Made Paper Making Technology: A Review

Abstract

Unwanted blooms of algae throughout the World are not entirely without a positive side. Algae as a raw material for paper making are an innovative solution to Global environmental issues dealing with deforestation and global warming. Algae contain cellulose and hemi-cellulose but no lignin. Thus, they are suitable as raw materials for paper pulp, to be used as wood substitutes but algae alone cannot prove a sole substitute for making paper of good quality. This review tries to summaries the pros and cons of algal paper making along with a thorough description of the additives and various ratios and roles of different additives that can be combined with algal pulp for paper making; besides a critical viewpoint on the pre- and post- preparatory techniques used so far for overall development of the process. Commercialization of the process for development of algal pulp for handmade paper technology has also been discussed with a reference to patent development and evaluation of the Indian Handmade paper industry.

Keywords: Algae; Pulp; Paper; Additives; Techniques; Commercialization

Review Article

Volume 8 Issue 1 - 2018

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Introduction

Algae are highly diverse in their habitat and properties: unicellular such as *Chlorella sp.* [1]. And the diatoms, to multi-cellular forms, such as the giant kelp, a large brown alga. Algae are eukaryotes though Cyanobacteria or Blue-green algae (like Lyngbya) [2], are Prokaryotic; but some researchers don't consider Cyanobacteria as algae [3,4]. Algal Collection of the US National Herbarium (National Museum of Natural History 2008) consists of approximately 320,500 dried specimens, which, although not exhaustive, gives an idea of the order of magnitude of the number of algal species (that number remains unknown). Algae play a promising role in carbon sequestration [5] and accounts for 50 % of global photosynthesis [6]. Algae grow fast and efficiently absorb solar energy by means of major antenna pigments like chlorophylls, phycobiliproteins and carotenoids to convert it to chemical energy as triacylglycerols. The role of algae in Greenhouse gas diminution is inevitable. On the other hand, Algae growing in paddy fields have become an unwanted nuisance for the local farmers as the weeds compete for the soil nutrients and a lot of energy and labour is wasted in removal of these weeds through hand-picking or manual efforts. It was reported that after fertilizer applications (ammonium sulfate), Spirogyra [7] and Euglena [8] was so abundant that rice farmers had to inter-fill their crops to prevent algae from smothering their rice plants [9]. Thus, alternate biomass utilization of these algae as substitutes in pulp formulation for the production of handmade paper can pave the way for productive usage of these algae as a means of alternate income generation to the rural people.

The word "paper" is etymologically derived from papyros, Ancient Greek for the Cyperus papyrus plant [10]. Papyrus is a thick, paper-like material produced from the pith of the Cyperus papyrus plant which was used in ancient Egypt for writing long before the making of paper in China. Before the industrialization of paper production, the most common fibre source was: recycled fibres from used textiles, called rags. The rags were from hemp (Cannabis sativa) plant [11], linen and cotton [12]. Rare Islamic papers were made from hemp or grass stems in Rajasthan, India, colored with vegetable dyes and sheets were burnished by rubbing with a smooth stone (Khadi papers). Invention of paper is mostly credited to the Chinese Eunuch Ts'ai Lun (AD 105), from macerated vegetable fiber [13]. No definite clue is available as to the date paper was first manufactured in India; though, some people believe paper was invented independently in India in Buddhist times around 250 BC.

Archaeological findings at "Gilgit" in the valley of Kashmir indicate that paper was already made in the Himalayas in the sixth century AD. The reports on the grasses: munj (Saccharum munja), discovered by Roxburgh [14] and bhabar (Ischaemum angustifolium) [15] show the most promising results. With the discovery of bamboo digestion method, it became a very popular raw material for the steam driven paper plants in India. India had a vast quantity of bamboo forests at that time. With the Bamboo Paper Industry Act of 1925 the colonial government protected the local paper mills. It was on the premises of the Satyagraha ashram in Ahmadabad, India that the first paper mill, the Kalam Kush Paper Mill, based on Gandhian ideas was established. The first paper-machine entered the Indian continent as early as 1832, two years earlier than in the Netherlands.

Dr. William Carey, a Baptist missionary, started to make paper by machine in Serampore. The Khadi Village and Industries Commission (KVIC), founded in 1957, had the difficult task to stimulate and protect the cottage industry, production of fancy papers and training of artisans. Khadi paper mill uses cotton as the raw material and is located just outside the village of Tarihal near Hubli in Karnataka, South India, which is a cotton growing area and Hubli has the biggest open air cotton market in Asia, an amazing sight. Around 1980, the Indian government realised that the demand for paper had outpaced the supply so much that a paper famine was feared in the future. Its true paper consumption per capita in India is very low (1.4 kg) compared to 285 kg in the USA. But the economy is prospering. With marketing receiving increasing attention, the Indian papers are now appreciated all over the World. Over the last five years, the export of Indian handmade papers to Amsterdam, Berlin, Brussels, New York, Sydney, Tel Aviv and Tokyo has steadily risen. The time is ripe to search the raw materials for development of handmade paper technology in the Indian subcontinent. Thus Indian hand-paper making has great possibilities.

Algae as Raw Materials for Paper

Ubiquitous distribution and fast growth of algae mark their easy availability as natural resources and possibility of harvesting all year round cuts down the costs involved in farm land cultivation or resource import or transport [16]. Another important point to consider is the lignin deprivation in algae, although some cases of lignin content in algae (intertidal red algae Calliarthron cheilosporioides) have been documented [17]. Conventional pulp production from wood as basic material is done through mechanical or chemical process. Mechanical method gives high yield of pulp (90%) but large amount of energy is wasted to mechanically remove lignin from wood (20-35% of wood is lignin) whereas in chemical method, yield of pulp is low (50%). Rice straw, oat/ sugarcane residue: bagasse is used as substitute for wood pulp but these also have 12-19% lignin.

Hence, for development of paper pulp, most energy is wasted on lignin removal. Exploitation of well bonded algal pulp can yield paper that requires no artificial treatments for lignin removal. It was claimed that paper production from red sea weeds algae like Gelidium [18] (compared to wood pulp) takes shorter time, lower cooking temperature and minimum chemical usage. Compared to wood fibres, algal fibres are finer, more uniform in length, smoother, also have absorbent properties and may not require fillers as determined from lab scale studies undertaken by Prof Dr Phang Siew Moi, director of the university's Institute Of Ocean And Earth Sciences, Malaysia, though no large scale studies have been done. If we consider hemp, it is a high nitrogen crop requiring as much fertilizer as corn: up to 120 lbs N per acre whereas algae have the ability to fix atmospheric nitrogen and transfer them to plants.

Algae cellulose is different from terrestrial plant cellulose. Cellulose in plants is produced by rosettes of synthesizing enzymes extruding ribbons of cellulose strands in crystalline groups excluding water [19]. The ribbons have less surface area whereas algae cellulose has many times more surface area to volume thus making a very different product. Plant cellulose has specific surface area of 1 square meter per gram while surface area of cellulose from algae *Cladophora sp*. [20] can be up to 100 times larger because the cellulose is extruded as single strands [21]. Furthermore, cellulose from some genera of filamentous green algae exhibit particularly high degree of crystallinity and exhibit preponderance of I-alpha; cellulose as opposed to I-beta cellulose, making them more thermodynamically reactive in comparison to cellulose derived from woody or plant biomass. Another usage of algae in paper can be found in litmus paper made from lichen Rocella tinctoria [22] that is a symbiosis of fungus (mycobiont) with algae (phycobiont). Cellulose or algae flour from Cladophora algae have been used as reinforcement fibers in construction materials [23,24]. Raw material evaluation work conducted by the Kumarappa National Handmade paper Institute (KNHPI), India in 2013-14 used Bagasse (Saccharum officinarum) [25], Coconut palm (Cocos nucifera) [26], Jute (*Corchorous sp.*) [27], Gunny Bags, Bajra (Pennisetum glaucum) [28], and Guar plant fiber (Cyamopsis tetragonoloba) [29]. Raw material evaluation for 2014-15 was successfully completed for cow dung, Thor (Euphorbia royleana) fiber [30] and mustard (*Brassica sp.*) [31], shell waste but could not be completed for Turmeric plant (Curcuma longa) [32] and rayon grade pulp from banana (*Musa sp.*) [33] Fiber due to non availability of raw material [34]. Nordiah et al. [35] used aquatic plants like Cyperus digitatus [36], Cyperus halpan and Cyperus rotundus [37], Scirpus grossus [38], and Typha angustifolia [39] for producing handmade paper of permissible strength and quality. The idea of using algae as raw material has not yet been explored yet by the Indian handmade paper making units.

Algae have come up as a valuable raw material for paper besides bioplastics and furniture building in the US and Japan. For designers Jacob Douenias and Ethan Frier, Spirulina [40] algae also have a role in our homes as lighting and furniture, producing food, fuel, heat and light. Designers Jonas Edvard and Nikolaj Steenfatt have used a new material made from Danish brown Fucus [41] seaweed and paper to create a chair and a collection of pendant lamps. Thus, algae as a raw material have a long way to go. The continuous lumbering of forests to meet the ever increasing needs of the paper industry is posing an international threat to our environment, partly contributing to global warming. Thus, switch to non-wood material like algae is an urgent issue to consider for the paper industry. Thus algae in paper research pose large possibilities for projects, tests and university-industry co-operations.

Using algae as paper pulp has certain extra advantages. For example:

I. An alga is fast growing and annual crops could be utilized causing no damage to the existing flora thus saving a large part of perennial biomass.

II. Since algae have great roles in carbon sequestration, it helps to reduce the carbon dioxide levels of atmosphere. When paper making is the aspect to focus on, the tough points with algae are pigment and water removal: bleaching and drying; production and energy costs related to pilot or large scale production (which have not been tested), financing and market value. Paper made from pure algae fibre suffers from poor bursting strength, tearing strength and folding strengths [42]. Thus, mixing of algal pulp with other raw materials like softwood fibers needs to be exploited to improve paper properties (comparable to Kraft paper).

The Indian handmade paper industry is now facing stringent parameters set forth by developing countries for environment protection. One of the main requirements is dye used for colouring paper should be azo-free as azodyes contain carcinogenic amines.

Though vegetable dyes are safe and non-toxic, handmade cardboard industries are causing pollution related problems. Kulshreshtha et al. [43] studied the mutagenic effect of effluents from cardboard and handmade paper industries to nearby water bodies through Ames test conducted on Salmonella typhimurium TA 98 and TA 100 strains [43]. To make the rural people aware that alga can be used as a means of alternative livelihood generation is another challenge from the economic perspective.

Natural Additives to Algal Pulp in Paper-Making

Improvement of paper quality need pulp improvisations relative to the application of the paper. This involves additives to the algal pulp prior to the cooking process. Rice husk (RH) or hull is the outermost layer of the paddy grain accounting for 20% of paddy weight having good absorbent properties. High silica contents of rice husk (20-50 %) increases its Pozzolanic effect that determines cementations' properties responsible for increasing the rate at which a material gains strength [44]. Asia produces about 770 million tons of husks annually obtained from milling of rice grains which can be put to low cost productive usage as algal pulp additive. Saw dust does not have a proper texture and hence is not suitable for writing/painting paper but can e used in making of thick material like egg cartons.

Nature hosts a large repertoire of dyes that can be easily extracted and used in production of coloured paper. For red colour, flowers of Rose (*Rosa sp.*) [45] or Hibiscus (Hibiscus rosa-sinensis) [46]; Beetroot (Beta vulgaris) [47] for violet, tea leaves (Camellia sinensis) [48] for brown, Palash flower (Butea monospermous) [49] petals for orange, yellow from turmeric and henna leaves (Lawsonia inermis) [50] for green are some simple home remedies to make natural dyes. Blus et al. [51], reported 3-carboxypyridinetriazine, hex methyl-diamine and octamethylene-diamine as reactive eco-friendly dyes that could bind to hydroxyl groups of cellulose under neutral conditions without changing the strength, optical and dimensional properties of paper [51]; (Table 1) lists the natural dyes for hand-made paper industry.

Table 1: Natural dyes from plants and insects that can be used in hand-made paper industry.

Source	Extraction Process	Colour	Reference
Dactylopus coccus beetle	Boiling dried beetles in water	Red	[52]
Kerria lacca: a scale insect - Southeast Asia	Colour extracted from resin secreted from the insect	Deep pink	[53]
Haematoxylum campechianum (Logwood)	Colours develop best in slightly hard water	Purple and shades of grey with iron	[54]
Rubia tinctorium (Madder Rich)	Extracted from root	Range of reds, browns, purples	[55]
Punica grantum (Pomegranate)	Skin of the fruit	Red	[56]
Acacia arabica (Babool tree)	Microwave assisted extraction from bark	From yellow to red	[57]
Bougainvillea glabra	From flower with ivory white bracts	Yellow, green, orange	[58]
Tagetes erecta (Marigold)	Extracted from flowers	Golden yellow	[59]
Wedelia chinensis (Merril)	Extracted from root	Black	[60]
Tectona grandia (Linn)	Extracted from macerated leaves	Red	[61]
Peristrophe tinctoria	Whole plant	Red	[62]
Nyctanthes arbortristis	Flower tube	Orange	[63]
Lawsonia inermis	Macerated leaves	Reddish brown	[64]
Erythrina suberosa	Stem bark	Dark brown	[65]
Enhydra fluctuans	Leaves	Light green	[66]
Curcuma longa	Rhizome	Yellow	[67]
Clitoria ternatea	Flower	Blue	[68]
Butea monosperma	Flower	Yellow	[69]
Bixa orellana	Seed	Orange	[70]
Strobilanthes flaccidifolius	Used in Manipur, Nagaland	Blue and black	[71]

Plant based natural absorbents were reported from Pinus needles and Lantana camara shoots [72]. Bamboo shoots have been reported to be a safe and eco-friendly herbal antibacterial absorbent in baby diapers compared to chemical absorbents [73]. India is vested with the mosquito problem that causes hundreds of deaths each year, infecting people with the deadly Malaria or Encephalitis. Natural mosquito repellents like Nishinda (Vitex negundo) extract, Lemon- Eucalyptus globulus [74] oil, Citronella (*Cymbopogon sp*.) [75] Oil, oil of Lavender (*Lavandula sp*.) [76] Or Neem (Azadirachta indica) [77], Garlic (Allium sativum) [78], Apple cider vinegar and camphor can be added to the algal pulp prior to cooking process for manufacture of anti-mosquito fast cards. Addition of saw dust to the pulp can help in production of thick egg-carton like fast cards that will burn for a long time, thus keeping out the mosquitoes.

No doubt such hand-made efforts will hit the Indian mosquito repellent industry due to their eco-friendly and safe nature compared to the smoke evolved from chemical repellents, which harm the respiratory system in humans causing breathlessness and nausea in many cases. Lists of various additives are known to enhance paper quality. Agalite or Talc (Silicate of Magnesia) gives paper a greasy or soapy feel and enables it to take a high finish. AKD (Alkyl ketene dimer) or ASA (Alkyl Succinic Anhydride) are currently used by paper manufacturers as sizing agents although Abietic acid rosin and sodium abietate (rosin soap) in conjunction with Alum (sulphate of alumina) are also used as sizing agents. Though algal pulp may not require fillers or coating, Lime stone or chalk and Dolomite may be used as fillers and Alganic acid (sodium alginate) for coating and surface treatment, if required. Titanium dioxide is also used in the paper industry as coating agent to increase opacity and brightness of paper. Alabaster (Calcium sulphate anhydrate) is used as paper loading material and Albarine (natural sulphate of lime/gypsum/plaster) is used in building materials like gypsum boards. The application of caustic soda (sodium hydroxide) in pulping is to increase the pH in fibre pulp that causes the fibres to smoothen and swell that is important for the grinding/beating process. When handmade paper is the project of concern from the economic point of view, the target is to minimise chemical treatment.

Algal fibres soaked in water are smoother and also have a swelling effect thus negotiating the possibility of alkali treatment. Bleaching with ozone rather than conventional chlorine dioxide reduces costs by 25-30% with highly improved brightness levels (92-93% ISO); reduction in COD load to wastewater treatment plant by 40% compared to CP and improved pulp strengths (Xylem Global Inc., NY, USA). Certain dry and weight strength additives may be experimented with. Guar Gum being a natural polymer or carboxy methyl cellulose and cationic starch are better options as dry strength additives compared to polyacrylamide derivatives. Cationic starch gets its positive charge from quaternary salts like EPTAC (2-3 epoxy trimethyl ammonium chlorides) that is also quite costly. Research has opened a new side of possibility to replace costly chemicals like Melamine or Epichlorohydrin known as wet strength additives with one of the most abundant proteins in nature: wheat gluten [79]. Addition of 2-4% by weight of agar solutions were prepared by heating agar powder in deionised hot water at 90-95ºC under rigorous mechanical stirring till the solution turns clear), has shown to increase wet strength of paper.

Cross linker (AmZrCarb) was added to the agar solution 30 seconds prior to spraying on the wet paper sheets before pressing [80]. Soy flour was reacted to DTPA (Diethylenetriaminepentaacetic acid) and sodium hypophosphite, complexed with chitosan to develop a new class of dry strength additives [81]. For many years, the principle binder has been synthetic latex (styrene butadiene latex) but natural binders constitute oxidised potato starch or Dextrin. Gelose prepared from algae designated as agar-agar differs from gelatin, starch and gum from being insoluble in cold water and greater gelatinizing power. Gelose contains 42.7% carbon, 5.7 % hydrogen and 51.4 % oxygen that swells up in cold water and dissolves completely in boiling water to form a jelly 500 times the weight of water to the amount of gelose added, on cooling. Advantage of Gelose is that it imparts a body and gloss to fabrics without stiffening them – a defect with starch and dextrin [82].

9% Gelatin besides soy protein, zein, pectin and Salix lignin with Horseradish peroxidase provided significantly higher tear strength (>900 g) than commercial binders used in CP (>=700 g) [83]. Corn starch is also a good option but may reduce ink absorption capacity of paper and has been documented in bioplastic research (Patent-US 5288318 A). Cow dung, newspaper waste and wheat flour have also been shown to act as natural binders [84]. Thus possibility of improvising various additive combination ratios remains the main area of challenge in paper quality and design.

Hand-Made Paper Technology: Process Development

There are a few reports on the use of green algae as an alternative to wood pulp in paper manufacture. “Shiro Algae Carta” - was a type of paper produced in the European LIFE project to remove algal clogging of a Vincentian lagoon, dating back to the early 90s. The manufacturing process of Shiro Alga Carta is patented by Favini. The raw algae were first washed, dried and milled in a paper mill to obtain seaweed flour. The flour was mixed with FSC (Forest Stewardship Council) fibres and cooked with water at 100ºC for two hours resulting in a boiling jelly that sets into a thin film.

It has been reported that the alginic acid of polysaccharide extracted from the sea weed, such as the giant kelp (a brown algae) and wood pulp were mixed and made into radio cone paper (Paper and Pulp Technic Times, February, 1968, by Yoshio Kobayashi). Another method produced cellulose acetate using acetic acid bacteria as a source of pulp, containing substantially no lignin. (Japanese Patent Provisional Publication No. 212295/1986 or 61-212295). *Rhizoclonium sp*. [85] was shown to be a good source of paper pulp in Taiwan [42] but no color or optical property was evaluated and large scale process was also not done to determine economic feasibility. Cooking pre-beaten pulp with 20% NaOH at for 30–120 min gave high algal pulp yields (70-80%). This cooking process was sulphur-free, but the water requirement was high. There is another non-wood pulp production method in which pulp is produced from algae including green, red, yellow algae, etc., such as Spirogyra [7], Chaetophora [86], Ulothrix [87], Coralline [88], Tribonema [89], etc. (Japanese Patent Provisional Publication No. 38901/1979 or 54-38901). Paper from rhizoidal filaments of red algae Gelidium amansii and Gelidium corneum were reported by Seo et al. 2010a [90].

For a basis weight of 60 g/m2, 90% opacity was observed in pulpsheets made from red algae fibers whereas wood fibers gave 70-80% opacity [91]. Previous work includes addition of other fibre sources to algal pulp but this invention used algae as the sole source of fibre although chemical bleaching with ozone or chlorine and acid/alkali treatment was employed. There is a method of pulp production using a combination of physical and chemical treatment of angiosperm, such as Brazilian waterweed (Japanese Patent Provisional Publication No. 1319/1980 or 55-1319). Another method describes bleaching through light irradiation or chemical treatment of Ulothrix [87], Hydrodictyon [92] and Tribonema [89], and freshwater algae, such as blue algae, yellow flagellous plant, and Chlorophyta [93] and production of paper sheet singly or by mixing these with other materials for pulp (Japanese Patent Provisional Publication No. 520/1989 or 54-520).

Cardboard and paper manufacture from Sea weeds have also been reported (US patent 1367279 and US1675244). Pegasus Research Inc, US – Owns a patented process for the production of pulp and paper made from Red Algae (Gracilaria and Gelidium elegans) [94,95], "Plant pack" funded by the European Commission (2012-2014), was a project undertaken to replace conventional petroleum derived waxes and polymers as food-pack coatings in cardboard or paper with a sustainable, eco-friendly food-pack coating material derived from seaweed.

Development in terms of sustainable technology for manual paper sheet pressing was undertaken. (Figure 1) demonstrates a hand-operated hydraulic press designed in our laboratory for the pressing of hand-made paper sheets made from algae. Upper chamber/plate had heating coils linked to the temperature controller enabled with temperature range of 50ºC to 170ºC. Lower chamber was a stainless steel plate slightly larger than A4 size paper. Heating coils were not set in the lower plate to ensure insulation and safety as wet paper sheets were to be placed on this plate.

The lower plate could be hand-pulled on the water drainage chamber to facilitate sheet loading and unloading. Another advantage of the chamber was that it could collect any residual water that might drip from the paper sheets after pressing. The Hydraulic tank had an aperture at its base for adjustment of the hand pump. Rotation of the pump anti-clockwise within the aperture moved the lower plate up for pressing. Anticlockwise movement of hand-pump within the aperture brought the lower plate down in a smooth hydraulic movement. 50 sheets could be pressed at a time with a maximum pressure load of 5 tons in this press.

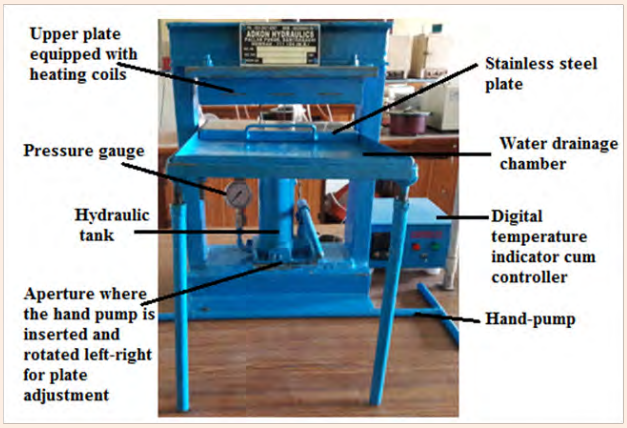

Figure 1: A simple hand-operated Hydraulic press designed in our lab for pressing of hand-made paper sheets from algae.

Suitability of Algae Pulp as An Alternative to Conventional Pulp

Ververis et al. [95], attributed presence of proteins and chitin in algae as factors responsible for significant improvement in mechanical properties of paper from algae (A) compared to conventional pulp (CP) [96], as presented in (Table 2). Although, brightness was adversely affected by chlorophyll in algae; the cost of raw materials was 45% lower than that of conventional pulp. Addition of never-dried Rhodophyta algae fibers to CP provided pulp sheets with improved tensile and burst strength properties, with minimal deterioration in Canadian standard freeness (>200 ml).

Table 2: Comparative evaluation of paper strength properties of conventional pulp versus algal pulp as cited in literature.

Paper Pulp	Breaking Length (Km)	Bursting Strength (KPa m^2/g)	Tear Resistance (mN m^2/g)	Brightness (%)	References
Conventional pulp	1.63	0.75	97	85	[96]
Algae	2.5	1.7	106	60	
Closterium	5	1.8	45 times folding endurance	75	[97,98]

A pulp sheet comprising 30 weight percent never-dried macroalgae pulp fibers, had moisture content less than about 15 percent, a basis weight of at least about 150 grams per square meter and an MD Tensile Index of 10-40 Nm/g [99]. Breaking length of red algae pulp (4.75 Km) sheets were found to be similar to CP made from Hanji fibers (4.65 Km) with marked improvements in brightness for red algae pulp (35sec) compared to Hanji (3sec) [100].

10% red algae fibers added to 70 % CP hardwood pulp resulted in a tensile index of 29.87 N*m/g and Burst index of 1.75 KPa; whereas 20% red algae pulp without any hardwood fibers but 80% straw pulp gave considerable increased tensile index of 58.10 N*m/g and Burst index of 3.02 KPa [101]. Shi et al. [102], also demonstrated marked improvement in CP on addition of Gelidium corneum, Gelidium amansii, Gelidium robustum, Gelidium chilense, and Gelidium asperum pulp: CP

(70% hardwood pulp with 30% OCC - old corrugated containers) gave a tensile index of 17.3 N. m/g and ring crush of 0.46 KN/m. Pulp-sheets containing 20% red algae fibers with 40% wheat straw and 40% blended Kenaf (Hibiscus cannabinus) gave a ring crush of 3.78 KN/m and tensile index of 45.9 N. m/g that further increased to 73.6 N.m/g on addition of 80% corn Stover with 20% red algae fibers. Additives of 0.2% Carrageenans (sulfated gums) found in red algae, to pulpsheets were shown to increase tensile index by 13.53% and precipitated calcium carbonate (PCC) retention increased by 57.06% [103]. Hand sheets containing CP (hardwood kraft pulp) and Cladophora algal cellulose showed almost no improvement in tensile strength and folding endurance but improved dimensional stability and comparatively higher Young's modulus although bacterial cellulose improved tensile strength and folding endurance as well [104]. On the other front, Cladophora cellulose has a very high degree of crystallinity (118.7 nm crystalline length and 11.3 nm crystalline width) that imparts inertness to chemical reactions, maintains a high specific surface area on drying without any hornification or agglomeration, causing an improved redispersibility in comparison to CP (Eucalyptus pulp) having crystalline width of only 3.6 nm and crystalline width of only 37 nm [105-107]. Red algae biomass of Gelidium elegans have also been shown to contain nanocellulose fibers of high crystallinity index (73%) suitable for nanocomposite materials [108].

Machmud et al. [109], showed tensile properties of the sheets made of *Gracilaria sp*. such as tensile elongation, ultimate strength and absorbed energy were even better than those of both the recycled and office copy paper sheets made from conventional wood pulp. Elongation % of pulpsheets from *Gracilaria sp*. was 10% and Eucheuma cottonii was 12.5% compared to only 3-4% for CP (A4 office paper). Ultimate tensile strength of pulpsheets from *Gracilaria sp*. was 10 Kgf/cm2 and Eucheuma cottonii was 49 Kgf/cm2 compared to 18 Kgf/cm2 for CP (recycled A4). Further, energy absorption for *Gracilaria sp*. pulpsheets was 2 Kgf.cm and 5 Kgf.cm for Eucheuma cottonii sheets compared to only 1 Kgf.cm for CP (A4). The helliclular microfibrillar arrangement in *Chara sp*. has a low net angle of orientation which was correlated with comparatively increased values of longitudinal elastic stiffness, longitudinal elastic modulus, and standard tensile strength [110-112], but with diminished values of percentage stretch and tensile energy absorption [113,114]. Crystallinity indices of Chara pulp cellulose was 0.80 and Cladophora pulp was 0.92 as compared to 0.89 for CP (softwood pulp) [115].

(20 % of NaOH treated samples of *Rhizoclonium* and Pithophora had tensile strengths, burst strengths and tear strengths in the range of 150 %, 250 %, and 165 % greater than hand sheets made from the base pulp alone [116]. Tissue papers made from 10-30% algae fibers with CP have significant increased wet strength (specific absorption > 10 g/g) with a geometric mean tensile strength between 600 - 4500 grams (force) per 3 inches of sample width [117]. Mazur, 2015 [118], proposed fungal mycelia of Saprolegnia ferax would have an ultimate tensile strength of 41N (as compared to 528N for a standard copy paper, roughly 1/10th the tensile strength of standard weight (60g/m2) copy paper). Additionally pulpsheets from incorporation of fibers from *Ulva sp*. greatly enhanced tear resistance and elongation, but diminished tensile and burst properties [119].

Enhanced mechanical properties (flexural and tensile modulus of 70% and 86%) were found when 56% algae fiber was used for the compression-molded laminates composite but volume of porosity was 11% due to lack of compression in some of the fibers [120]. Although some properties may be decreased with algal pulp in some cases, it should be noted that they are still acceptable for many applications, and using algae fibers implies notorious savings in terms of costs of raw materials, energy, reagents, and equipment.

Conclusion

The use of algae as an alternative source of paper production will meet the needs of environment issues like deforestation and global warming. Indian handmade paper Industry primarily uses cotton rags, waste paper and waste Kraft as raw materials. Some steps have been initiated for the utilization of straws, jute, rice husk and grasses though further research for incorporating other raw materials like algae need to be undertaken. Although some work on the lab scale has been done in Japan and US, paper from algae has a long way to go in process and quality development for commercialization. The market value of hand-made paper has thrived well and found their way into the art crafts industry and furniture industry. Use of algae hand-made paper are making way into extraordinary fields of applications and more seems to come in future.

For example, the recent use of thin hand-made paper from Cladophora algae as conducting polymer coatings in batteries have been found to store 50-200 % more charge than other conducting polymer batteries that may give a tough competition to the commercial lithium batteries. Value added products from algae also hold much promise in generating alternative sources of livelihood generation from the economic point of view. Carbon dioxide sequestration, removal and productive utilization of fouling biomass from paddy fields and alternative income generation to the rural people are certain other aspects that may make additional input in bio-remediating environment by direct or indirect means.

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Conflict of Interest

The Authors declare that they have no conflict of interests.

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Overview on Polymer-Nano Clay Composite Paper Coating for Packaging Application

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This is a review of the existing studies on the Polymer/ clay nano composite used for improving water and moisture barrier in coating. Clays have been and continue to be one of the more important industrial minerals. Research and development activities by clay scientists in academia, government, and industry are continually resulting in new and innovative clay products; many of these new applications are the result of improved processing which provides clays of higher purity, more precise particle size and distribution, whiter and brighter colour, modified surface chemistry, and other physical and chemical modifications. Some new and improved clay products include tailored or engineered paper coating kaolins, nanocomposites for plastics etc. The use of mineral pigments in coating to provide improved barrier properties has recently gaining increased attention. This article describes the use of Polymer nano clay for improving the barrier properties of the coated paper studied by several researchers.

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Abstract

This is a review of the existing studies on the Polymer/ clay nano composite used for improving water and moisture barrier in coating. Clays have been and continue to be one of the more important industrial minerals. Research and development activities by clay scientists in academia, government, and industry are continually resulting in new and innovative clay products many of these new applications are the result of improved processing which provides clays of higher purity, more precise particle size and distribution, whiter and brighter color, modified surface chemistry, and other physical and chemical modifications. Some new and improved clay products include tailored or engineered paper coating kaolins, nanocomposites for plastics etc. The use of mineral pigments in coating to provide improved barrier properties has recently gaining increased attention. I described the use of Polymer nano clay for improving the barrier properties of the coated paper studied by several researchers.

Keywords: Paper coating; Polymer/clay nanocomposite; Moisture barriers

Introduction

The paper packaging industry is one of the growing industries due to an increasing demand for packaging products in the market. In addition, market competition often forces companies, especially in market of consumer products, to enhance the packaging in order to improve the image of their products and by this attract more consumers to buy them. Paper coating, which is one way to enhance the packaging, is a process where a coating film is applied onto paper to impart certain qualities to the paper, including weight, surface gloss, smoothness and protection. The coating materials widely used are thin laminated-plastic films or liquid polymeric coat. Without coatings, paper does not have the strength, gloss, printability or resistance to grease and moisture that is required in most of these growth areas [1].

The term "clay" refers to a naturally occurring material composed primarily of fine-grained minerals, which is generally appropriate water contents and will harden with dried or fired. Although clay usually contains phyllosilicates, it may contain other materials that impart plasticity and harden when dried or fired [2]. Associated phases in clay may include materials that do not impart plasticity and organic matter. Clays have been and continue to be one of the more important industrial minerals. Clays and clay minerals are widely utilized in many facets of our society. They are important in geology, agriculture, construction, engineering, process industries, and environmental applications. Traditional applications are many. Some of the more important include ceramics, paper, paint, plastics, drilling fluids, foundry bondants, chemical carriers, liquid barriers, decolorization, and catalysis Kaolin is one of the most widely used pigments in paper industry and exploited in a large range of coating applications [3]. Fine secondary kaolin's are used for good gloss because of their smaller particle size. In general, platy kaolin particles carry out good coating opacity and printability [4,5] Kaolin has a layered structure, which is composed so that (0 0 1) crystal plane is parallel to the surface of kaolin particle (Table 1).

Nanocomposite Properties

Polymer composites are mixtures of polymers with inorganic or organic additives having certain geometries (fibers, flakes, spheres, particulates). The use of nanoscale fillers is leading to the development of polymer nanocomposites and represents a radical alternative to these conventional polymer composites [6-8]. This new generation of composites exhibits significant improvements in modulus, dimensional stability and solvent or gas resistance with respect to the pristine polymer. Nanocomposites also offer extra benefits like low density, good flow, better surface properties and recyclability. It is worth recalling that all these improvements are obtained at very low filler contents (generally lower than 5%) [6].

The enhancement of many properties resides in the fundamental length scales dominating the morphology and properties of these

Kaolin	Smectite	Palygorskite
I:llayer	2:llayer	2:1 layer invetted
White or near white	Tan, olive green, gray. or white	Light tan or gray
Little substitution	Octahedral and tetrahedral substitutions	Octahedral substitution
Minimal layer charge	High layer charge	Moderate layer charge
Low base exchange capacity	High base exchange capacity	Moderate base exchange capacity
Pseudo-hexagonal flakes	Thin flakes and laths	Elongate
Low surface area	Vety high smface area	High surface area
Vety low absorption capacity	High absotption capacity	High absotptiou capacity
Low viscosity	Vety high viscosity	High viscosity

Table 1: Some important properties of clay minerals that relate to their applications.

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materials. The inorganic particles have at least one dimension in the nanometer (from 1 to 100 nm) range. It means that a uniform dispersion of these particles can lead to ultra-large interfacial area between the constituents. The very large organic/inorganic interface alters the molecular mobility, the relaxation behavior and the consequent thermal and mechanical properties of the resulting nanocomposite material.

Various inorganic nano-particles have been recognized as possible additives to enhance the polymer performance. Some examples of these particles are represented by the solid layered, the synthetic polymer nano-fibers, the cellulose nano-whiskers and the carbon nanotube. Among these, up to now only the layered inorganic solids like clay have attracted some attention by the packaging industry. This is not only due to their availability and low cost but also due to their significant enhancements and relative simple process ability. The first successful example of a polymer–clay hybrid, developed at Toyota Central Research Laboratories in 1986 was a nylon–clay hybrid (Figure 1) [9].

Packaging Application

Paper and paperboard are coated in order to improve their optical properties and printability. Paper coating formulations generally consist of inorganic pigments such as kaolin and calcium carbonate, binder, soluble co-binders, dispersants, water as carrier and other additives. Pigment is the abundant component in the coating and is naturally the most important factor affecting the properties of the coating materials [10]. The use of mineral pigments in dispersion coating to provide improved barrier properties has recently gaining increased attention [11-16]. Important physical or chemical properties of the pigments which affect the water vapor permeability are their aspect ratio, particle size distribution and hydrophilic/hydrophobic character found that a narrow particle size distribution and a large aspect ratio both had a positive effect on the barrier properties of talc-filled dispersion-coated paper substrates [11-13]. Talc pigments in the polymer coatings were also shown by to give slightly lower water vapor transmission rates (WVTR) than kaolin clays [17,18].

Improving Water and Moisture Barrier in Coating

Polymer–clay nanocomposites, with fully-exfoliated platelet structure of nanoclay dispersed within a polymer matrix, provide excellent mechanical and barrier performances due to the high surface-to-volume ratio of the nanofiller and the increased tortuosity of the diffusion path against the permeant [19-23]. The modification of the clay by intercalating cationic surfactants into its interlayer space allows the entry of hydrophobic monomer or polymer into the organophilic intergalleries. The *in situ* polymerization of monomer within the clay interspacing causes the expansion and exfoliation of the nanoclay platelets [24,25]. Although many polymer–nanoclay composites have been developed, it is generally accepted that a strong mechanical force, such as delamination and extrusion, is needed to help polymer molecules penetrating into the nanoclay basal interspacing.

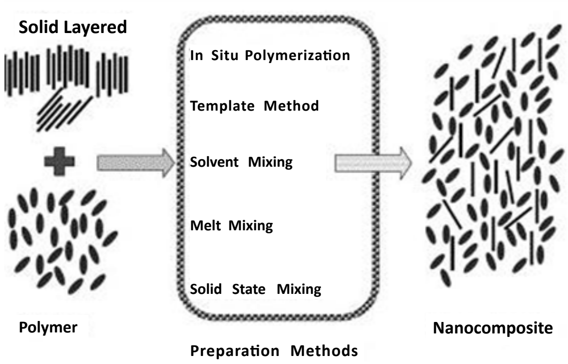

Figure 1: Preparation methods of polymer nanocomposites.

Barrier coating is one of the most important properties for paper packaging containers. The conventional barrier boards for water vapor, grease and oxygen-proofing applications have been developed based on the extrusion products of a range of polymers, such as polyethylene (PE), poly (ethyl terephthalate) (PET), or natural wax as well Recently, aqueous-based polymers have come into use in many on-machine or off-machine coatings, due to their environmentally friendly process and easy to use, in comparison with the conventional extruding machine coating processes. There are some challenges in improving barrier coating efficiency using water-based nanoclay composite suspensions. For example, the nanoclay particles must be colloidally stable in the suspension and the clay particles must be exfoliated in the final polymer matrix. The former requires a high hydrophilic surface of the clay so the clay can be well dispersed in water phase but the latter requires a high hydrophobicity so the polymer can diffuse into the intergalleries between clay plates. Furthermore, the nanoclay particles must possess strong affinity to polymer to avoid interior defects formation in hindering the diffusion of permeants through the coating layer. In conventional polymer composites, the micron-sized fillers, for example, kaolin with particle size up to a few microns, are immiscible with polymer matrix, leading to a coarsely blended composite with chemically distinct phases. The poor compatibility causes a poor physical attraction between the organic and inorganic components, resulting in agglomeration, and therefore, weaker mechanical properties, and thus low barrier resistance at the same process conditions [26].

Moisture barrier coatings containing clay

Moisture barriers are frequently applied to paper wrappers or paperboard to protect food products and to corrugated paperboard in order to withstand high humidity storage conditions. In the latter case, it is important to prolong the lifetime of the packaging box by resisting creep failure. Barriers can be applied to a substrate such as paperboard by extrusion coating, lamination or dispersion coating techniques. The latter has recently gained much interest as a low cost alternative with many benefits [27-33]. Moisture barrier dispersion coatings have a competitive advantage over wax based coatings, laminates or extruded products in recyclability and higher application speeds as well as fewer processing steps. Barrier dispersion coatings being more readily compostable and repulpable are far more environmentally friendly than extrusion coatings or laminated boards where recovery of the fibres and disposal of polymer film and/or wax represent a significant cost impost. In some food applications, the use of coatings that are free of fluorine containing compounds is also of interest. The two most attractive reasons for using barrier dispersion coatings are lower cost and the ability to use conventional coating techniques. The barrier dispersion coatings studied by *C. Kugge* based on styrene–butadiene latex and clay, with latex solid ratios of less than one; the coatings are transparent and clay acts as filler in a polymeric matrix. This situation compares with conventional paper coatings where the pigment to latex ratio is greater than one and the latex functions as a binder.

Citation: Gaikwad KK, Ko S (2015) Overview on in Polymer-Nano Clay Composite Paper Coating for Packaging Application. J Material Sci Eng 4: 151. doi:10.4172/2169-0022.1000151

Clay and Polymer Matrix Varieties on the Barrier Properties

The mechanism to increase the barrier properties of materials from nanoclay is based on the increase in the tortuous length of the diffusion path through a polymer matrix. Because nanoclay has much greater specific surface area than micron-sized clay particles, higher barrier resistance will be expected for nanoclay-polymer composite than micron-clay-polymer complex. This also suggests that the barrier properties of the polymer/claynanocomposite will strongly depend on the degree of the dispersion of the nanoclay in thepolymer matrix, or obviously on the exfoliation degree of nano-clay layers. Therefore, the change of the barrier properties of the composite reflects indirectly the dispersion state of the nanoclay in polymer matrix, if other conditions are maintained the same.

Filler Reinforcement

Fillers can be added to a barrier polymer to reduce the price of the coating, to enhance the opacity or for mechanical reinforcement. The addition of fillers to polymer matrices can either increase or decrease the permeability, depending on the compatibility and adhesive properties between the polymer and the filler and also on their relative concentrations. Dispersion polymers are readily compatible with conventional coating pigments such as clay. The barrier properties are improved by increasing the diffusion path length of the permeating species (Figure 2).

The critical pigment volume concentration CPVC is an important factor concerning filler addition. The CPVC concept refers to the point where the binder concentration is just large enough to fill in the interstitial voids between pigment particles for conventional paper coating, the addition of fillers is usually done at concentrations considerably higher than the CPVC. In barrier dispersions, on the other hand, pigments are added at a concentration well below the CPVC. The reason is that an increased number of filler particles will lead to an increase in voids, thus leading to an increase in permeability a higher binder concentration gives a more flexible coating, and the optimum pigment volume concentration becomes a compromise between barrier properties and flexibility. The CPVC of dispersions is affected by the immobilization volumes (i.e. the packing volume of the wet coating, which is dependent on particle shape, size, size distribution of pigment and binders, colloidal, chemical and rheological properties), the consolidation power of the binders, the type of substrate and the drying conditions. The most important factors concerning filler addition to barrier dispersions are the adhesion of the binder to the pigment particles, the particle shape and the chemical nature of the pigments. The CPVC value of a polymer/pigment system depends on

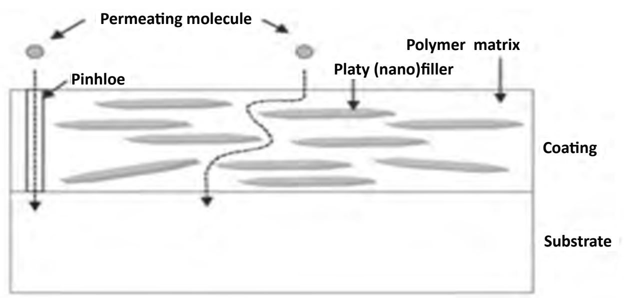

Figure 2: Mechanism of barrier improvement by fillers or nanocomposites.

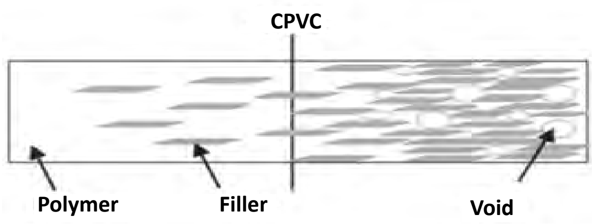

Figure 3: Critical pigment volume concentration (CPCV).

the latex particle size and its size distribution [34]. Increased particle size decreases the CPVC as does an increased value of the glass transition temperature. In contrast, in dispersions where strong deformation of the latex particles occurs, a higher CPVC is obtained due to the more dense packing of polymer (Figure 3).

Nanoparticulate Materials

Montmorillonite is a naturally abundant clay material with a layered aluminosilicate structure that is often used in nanocomposite technology due to its high surface area and large aspect ratio. Dispersion of layered silicates in a polymer matrix can result in a number of different states, leading to micro composites, intercalated or exfoliated nanocomposites. It is believed that complete and homogeneous dispersion in which the clay platelets are arranged in a non-parallel manner (exfoliation) will give the highest performance improvements in coatings. The aluminosilicates can be dispersed into individual layers only 10 Å thick. The distance between the platelets, the basal spacing, is defined as the distance from a certain plane in one layer to the corresponding plane in a parallel layer. Montmorillonite is hydrophilic but can be made organophilic by exchanging the naturally occurring Na^+ ions in the galleries of the clay with organic cations, e.g. alkyl ammonium surfactants, making them more compatible with organic polymers. The relationship between surface diameter and thickness of the nanoclay particles is defined as the aspect ratio. Typically, commercial nanoclays have aspect ratios between 50 and 1000, which is much larger than for typical clay pigments (10–30) used in paperboard coating. The large aspect ratio of nanoclays makes them effective for barrier improvement even at very low (≤5% by weight) concentrations [35-37]. Higher weight additions may be difficult from a processing perspective, because the viscosity of the dispersions increases significantly at increased loads of clay. The use of nanoparticles in paper and board coating is thus advantageous, particularly given that less material is required (thinner coating layers) to reach the desired barrier or mechanical properties. Less material use leads to reduced costs and reduced amounts of waste [38]. Southern Clay Products and Nanocor are among the biggest suppliers of montmorillonite clays for nanocomposite applications. The addition of a nano filler is made to reinforce the polymer, i.e. to increase the strength and toughness of the material [39]. Other issues are to enhance the optical, thermal or barrier properties. The mechanism of barrier improvement relies on increasing the path length that the molecules have to traverse while diffusing through the film, i.e. forcing them to take a tortuous path, which leads to significantly prolonged transmission rates The barrier properties of a nanocomposite material depend on the relative orientation of the silicate layers and on the state of aggregation and dispersion. The plate-like structure of clay increases the path for diffusing molecules, thus decreasing the permeability of molecules through the material [40]. Porous nanoparticles into which the diffusing molecules can penetrate are also efficient in this respect [41]. Improvement of barrier properties by up to four orders of magnitude upon incorporation of nanoclays in a polymer coating has been reported. The lack of a completely exfoliated structure has been used to explain why an efficient reduction in WVTR could not be observed when montmorillonite clays were dispersed in a barrier latex [42]. The incorporated clay particles can inhibit crystallization of the polymer matrix by restricted chain mobility through the association with the clay plates. This has led to an increase in the tensile strength of starch/polyester blends with increased montmorillonite content. Fischer et al. reported the blend of a thermoplastic starch with clay particles using a modifier (e.g. cat ionized starch) which is compatible with both the clay and the matrix. The results observed were a homogeneous incorporation of clay particles in the starch matrix, followed by an easier processing and a strong decrease in hydrophobicity. The stiffness, strength and toughness of the film could also be changed by changing the water content. Homogeneous dispersion of nanoparticles in nematic crystal matrices of liquid crystalline polymers has also been observed [40]. Nanoclays have been demonstrated to reduce both the water vapor and the OP of PLA and PLA–PCL films. The use of nanosized materials in food packaging should be approached so as to minimize the potential risks with inhalation or ingestion of small particles that can have unhealthy effects on the human body [41]. However, overall migration tests and analysis of specific metals (Fe, Mg and Si) have shown no change in the quantity of these species in food that has been in contact with a potato starch/clay nanocomposite film (Figure 4).

Characterization and Test Methods

The coated specimens should condition for 24 h at 23°C and 50% relative humidity before any measurements, this is as per ISO standards.

Scanning electron micrographs (SEM) SEM of the surfaces of the samples is obtain with a Digital Scanning Electron Microscope.

X-ray diffraction (XRD) is employ to estimate the degree of orientation of the clay particles in the polymer film. The measurements should perform in the cross-direction of the coating.

Electron spectroscopy for chemical analysis (ESCA) is use to assess the chemical composition of the surface of the coatings on paper.

Water vapor transmission rate, WVTR, is measure using gravimetric cups according to TAPPI method T 448 om-97. Silica gel, 35 ± 0.1 g in each cup, as the desiccant WVTR g/ (m^2 day^{-1}) is calculate by dividing the slope of total weight and number of days by the sample area. All samples need conditioning as per ISO conditions for at least 24 H prior to measurements.

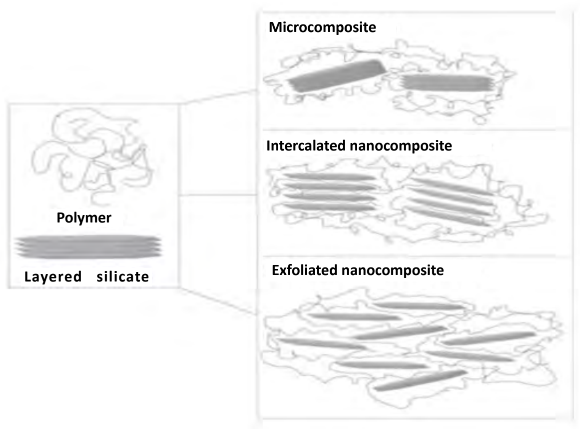

Figure 4: Dispersion of nanoclayina polymer matrix.

OTR: Oxygen transmission measurements is perform with Oxygen Permation Analyser The tests were carried out at 23°C and 0, 50, and 80% relative humidity as per ISO standards

Water contact angle: Water contact angles of the coated surface is measure in test conditions of 23°C and 50% relative humidity. Contact angle values is measure as a function of time.

Cobb test: This is important test to determine the water resistant properties of paper. This test can be done by Cobb tester.

Conclusions

Polymer-nano clay is good choice in the development of new functionality of paper by coating. While there is still further research needed to reach the requirements set on all types of functional properties as well as on material availability, process ability, suitability for product contact, etc., the remaining hindrance to be overcome is, in most cases, the cost. Although the price for materials and processing will increase with increased modification of polymers and clay. Reduction of the final price for each package should be achievable by increased volume of production. However, there exists no universal barrier chemical that covers all potential applications and still fulfil is all possible requirements. Future functional surface treatment of Paper will most likely involve multilayer coatings where each single layer makes its own specific, property-based contribution with its specific properties to the overall performance of the coated products. Replacing one or more barrier layers consisting of plastic film in demanding packaging especially with bio-based polymers.

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PAPERmaking!
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Fiberboard Created Using the Natural Adhesive Properties of Distillers Dried Grains with Solubles

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Distillers dried grains with solubles (DDGS) were employed as a bio-based resin/adhesive. DDGS were defatted with hexane, ball ground, and screened prior to use. DDGS flour was mixed dry with Paulownia wood (PW) to make composites. Moulded composites were evaluated for their flexural properties. DDGS-PW composite properties satisfied several European Committee Industry Standards for fiberboards in terms of flexural properties but were inferior in terms of thickness swelling properties.

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Fiberboard Created Using the Natural Adhesive Properties of Distillers Dried Grains with Solubles

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Distillers dried grains with solubles (DDGS) were employed as a bio-based resin/adhesive. DDGS were defatted with hexane, ball ground, and screened prior to use. DDGS flour was mixed dry with *Paulownia* wood (PW) to make composites using the following conditions: temperature of 150 to 195 °C, PW particle sizes of ≤ 75 to 1700 μm, pressure of 2.1 to 5.6 MPa, and using DDGS dosages of 10 to 100%. Molded composites were evaluated for their flexural properties. Composites were examined with Fourier transform infrared spectroscopy, differential scanning calorimetry, thermogravimetric analysis, and X-ray diffraction. The best flexural properties were obtained from composites containing 50% DDGS and 50% PW, using 180 to 250 μm PW particles, pressed at 5.6 MPa, and employing 185 °C. Flexural properties of DDGS-PW composites were similar to composites fabricated using soybean flour (Prolia) as the resin/adhesive. Dimensional stability properties (water absorbance and thickness swelling) of DDGS-PW and Prolia-PW composites were similar. DDGS-PW composite properties satisfied several European Committee Industry Standards for fiberboards in terms of flexural properties but were inferior in terms of thickness swelling properties.

Keywords: Medium density fiberboard; Particle board; Renewable resources; Paulownia; Flexural properties; Thermal properties; Dimensional stability

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INTRODUCTION

It is estimated that by 2030, global consumption of industrial and solid wood will increase by 60% over currently consumed levels, and in addition, there will be a substantial demand for more paper and paperboard products (Elias and Boucher 2014). To satisfy wood needs, engineered wood products are employed such as fiberboard (FB), which includes particleboard (PB), medium density fiberboard (MDF), hardboard (HB), and oriented strand board (OSB) (Hemmilä *et al*. 2017). These products are composed of various sized cellulosic particles bonded together with synthetic resins or adhesives using heat and pressure. Engineered wood products are expected to grow 25 to 33% by 2020 (Elling 2015). Structural panels made in North America will increase 21% by 2020 (*i.e.*, from 31.5 billion square feet to 38 billion), largely in response to increased housing.

Currently, engineered wood products use petroleum-based thermosetting resins such as urea formaldehyde, phenol formaldehyde, melamine fortified urea formaldehyde, or polymeric diphenylmethane diisocyanate (Hemmilä *et al*. 2017). Using these resins to create engineered wood products has adverse environmental and health consequences because of the emission of volatile organic compounds (VOCs) such as formaldehyde (Hemmilä *et al*. 2017). New engineered wood products often employ isocyanate resins since they do not contain formaldehyde and are considered non-volatile when cured. In addition, other additives are incorporated into the FB such as borate compounds (to prevent termites, wood boring beetles, molds, and fungi) and waxes (to increase hydrophobicity) (Hemmilä *et al*. 2017). Engineered wood products are a major source of formaldehyde off-gassing in US homes and present a serious health problem (CPSC 2013). Formaldehyde is classified as a carcinogen, and its exposure levels are regulated in the USA to avoid health problems (CEPA-ARB 1997; EPA 2010; CPSC 2013; ClassAction.org 2015; Hemmilä *et al*. 2017). However, wood composite flooring made in China and exported to the US have formaldehyde emission levels that exceed current US safety emission standards, in some cases by as much as 350% (ClassAction.org 2015).

Soy protein-based adhesives derived from soya bean meal (SBM) have been employed to some extent over the last 80 years (Zhong *et al*. 2001). Soybean proteins are an alternative to petroleum polymers because of their abundance, renewability, biodegradability, and feasibility (Mo *et al.* 2001, 2003; Mohanty *et al*. 2002; Lodha and Netravali 2005a, 2005b; Liu and Li 2007; Frihart *et al*. 2014; Nasir *et al.* 2014; Xu *et al.* 2014). Soybean meal is inexpensive, abundant, and easy to handle because it can be cold or hot pressed (Zhong *et al*. 2001; Amaral-Labat *et al*. 2008; Jeon *et al*. 2011; Reddy and Yang, 2011; Gu *et al*. 2013; Xu *et al.* 2014). However, SBM was essentially replaced in the 1960s by less-expensive synthetic adhesives. In recent years, interest in their use as adhesives was renewed because they are biodegradable and free of VOCs. For example, Uniboard (Laval, Quebec, Canada) markets a "Nu Green SOYA" particle board utilizing a soy based adhesive (Uniboard Canada Inc. 2016). Soya protein isolate (SPI) has high adhesion strength but costs more than PF and UF (Mo *et al*. 2001; Zhong *et al*. 2001; Kumar *et al*. 2002; Lodha and Netravali 2005a; 2005b; Liu and Li 2007; Vnučec *et al.* 2015). Commercial products such as SPI (Pro-Fam 970) (ADM, Decatur, IL) containing 90% protein (dry basis) and defatted SBM such as Prolia (PRO) (Cargill, Cedar Rapids, IA) containing ≥ 50% protein are available. SBM currently sells for ≈ \$0.45 to \$0.50/lb (\$0.99 to \$1.10/kg) (Alibaba.com 2016).

Other sources of bio-based adhesives have also been developed (Shukla and Cheryan 2001; Beg *et al*. 2005; Norström *et al.* 2014). Of particular interest is the employment of zein, which is derived from corn gluten meal and is highly effective as a resin/adhesive (Shukla and Cheryan 2001). Zein is a prominent storage protein (a prolamine protein) in corn and comprises ≈ 35 to 40% of the corn protein. It is extracted from corn gluten meal, which is obtained from the wet milling processing of corn seeds. Unfortunately, the cost of zein is prohibitive to most commercial enterprises such as bio-plastics and bio-composites. Zein sells for ≈ \$4.54 to \$18.20/lb (\$10 to \$40/kg) (Shukla and Cheryan, 2001). Corn gluten meal itself contains 55 to 70% protein and is considerably less expensive, selling for ≈ \$0.36 to \$0.45/lb (\$0.79 to \$0.90/kg) (Alibaba, 2016). Corn gluten meal has been employed in a myriad of products including livestock feed, plastic fillers, coatings, and bio-plastics (Beg *et al.* 2005; Samarasinghe *et al.* 2007).

Nevertheless, there is still a great need to develop even less expensive, abundant bio-based adhesives to be employed in the manufacture of engineered wood products.

The major feedstock used in ethanol production in North America is corn, with over 90% of the 226 operational ethanol plants utilizing corn exclusively (Liu 2011; Ethanolproducer.com 2017). Approximately 30% of the U.S. harvested corn acreage, representing 5,200 million bushels of corn, is used for ethanol production (Wisner 2015). Over 80% of the ethanol produced is derived from the dry-milling process (Kim *et al.* 2008). Distillers dried grains with solubles (DDGS) are the cereal by-product of the dry-milling process (Shukla and Cheryan 2001). Approximately 38 to 42 million metric tons of DDGSs are produced annually in North America (Clarizio and Tatara 2013). DDGS are a relatively low value by-product, are mainly used as an animal feed, and sell for about \$0.03 to \$0.05/lb (\$0.06 to \$0.10/kg) (Irwin 2017). Recently, DDGSs have been employed as a bio-filler blended with thermoplastic resin matrix (*e.g.* poly(lactic acid) (PLA)), high density polyethylene (HDPE), or thermoplastic starch to fabricate biocomposites (Tatara *et al.* 2009; Tisserat *et al*. 2013a; Clarizio and Tatara 2013; Lu *et al*. 2014a; 2014b; Madbouly *et al*. 2014; Ju *et al*. 2016). However, our interest was to utilize the DDGS, not as a filler/reinforcement material, but as the matrix itself in the fabrication of biocomposites. Both zein ($\approx$ 96% protein) and corn gluten ($\approx$ 65% protein) have been employed as matrix resin material to fabricate biocomposites (Shukla and Cheryan 2001; Beg *et al.* 2005; Samarasinghe *et al.* 2007). DDGS contains $\approx$ 25 to 35% protein, which suggests it could be employed as adhesive/resin to construct engineered wood products as a substitute for zein or corn gluten meal. This study investigated the possibility of developing a DDGS-wood biocomposite product. The filler material chosen in this study was *Paulownia* wood (PW) derived from trees of *Paulownia elongata* S.Y. Hu, (Paulowniaceae) grown at the Paulownia Demonstration Plot, Fort Valley State University. This tree is an extremely fast-growing coppicing hardwood that is native to China and cultivated in plantations in China and Japan. PW is highly valued in the construction and furniture industries (Chinese Academy of Forestry Staff 1986; Joshee 2012). *Paulownia* trees can be established on marginal lands and have deep tap roots, which make them drought tolerant (Joshee 2012). PW is light-weight, insect resistant, pale colored, and heat resistant (Chinese Academy of Forestry Staff 1986; Ashori and Nourbakhsh 2009; Joshee 2012). *Paulownia* trees offer an inexpensive source of woody biomass for both energy and lumber, and their wood wastes could be employed in the fabrication of engineered wood products (Ashori and Nourbakhsh 2009; Joshee 2012). Juvenile *Paulownia* trees could be a likely source of woody biomass needed in the future. Hence, this study utilized PW derived from juvenile tree biomass (*i.e.* 36-month-old).

The influence of processing temperatures, pressures, wood filler particle sizes, and DDGS-filler dosage ratios on the flexural properties of DDGS/PW biocomposites were assessed. The flexural properties of DDGS/PW biocomposites were compared to industry standards for commercial composites (*i.e.* PB, MDF, and HDF) to assess their potential commercial application. In addition, since SBM flour is commonly employed as a bio-adhesive in engineered wood products, the flexural properties of DDGS-PW composites to PRO-PW composites using various resin and wood dosages were also compared. As part of this study, Fourier transform infrared spectroscopy (FTIR), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), and X-ray diffraction (XRD) were also employed to assess the bonding nature associated with DDGS and wood particles.

EXPERIMENTAL

Materials

DDGS were obtained as the commercial animal corn feed pellet product (Archers Daniel Midland Co., Decatur, IL, USA). Prolia™ (200/90) (PRO) containing 54% protein and 5% moisture was provided by Cargill Inc., Cedar Rapids, IA, USA and used as provided. *Paulownia elongata* wood material was obtained from 36-month-old trees grown in Fort Valley, GA. PW shavings were milled successively through 4-, 2-, and then 1-mm screens with a Thomas-Wiley mill grinder (Model 4, Thomas Scientific, Swedesboro, NJ, USA). Particles were then sized through a Ro-Tap™ Shaker (Model RX-29, Tyler, Mentor OH, USA) that employed 203 mm diameter stainless steel screen/sieves. The sieve/screens employed were #12, #30, #40, #80, #140, and #200 US Standards (Newark Wire Cloth Company, Clifton, NJ, USA). The shaker was operated for 60 min intervals at 278 rpm to obtain particle separation. Two PW mixtures composed of 50% ≤ 600 µm particle selection, obtained from particles passing through the #30 mesh sieve, and a 600 to 1700 µm particle selection, obtained from particles passing through the #12 mesh sieve and collected on the #30 mesh sieve, were used throughout this study. PW contained 6% moisture. DDGS were ground in a Wiley mill as described. DDGS were defatted with hexane as the solvent using a Soxhlet extractor to obtain a DDGS containing 30% crude protein and 5% moisture. DDGS were ball ground into a flour (< 425 µm particles) using a laboratory bench top ball mill (Model 801CVM, U.S. Stoneware, East Palestine, OH, USA) to obtain fine powder. DDGS was ground in Alumina mill jars containing Burundum cylindrical grinding media pellets (13 mm diam, ≈ 7.3 g wt.) (U.S. Stoneware) at a speed of 50 rpm for 60 h. DDGS flour was sieved through a #80 mesh to be obtained as ≤ 250 µm particles.

Preparations

To test the influence of mold temperature on DDGS-PW composites, a composite composed of 80 g of DDGS was mixed with 40 g of < 600 µm PW particles and 40 g of 600 to 1700 µm PW particles. DDGS and PW were mixed in a zip-lock bag and given 15 min of circular agitation using a 0.074 m^3 compact dryer (Model MCSDRY1S, Magic Chef, Chicago, IL, USA). An aluminum mold (outer dimensions: 15.2 cm width × 30.5 cm length × 5 cm depth and mold cavity: 12.7 cm width × 28 cm length × 5 cm depth) was employed. The mold interior was sprayed thoroughly with mold release (Paintable Dry Spray with Teflon, No. T212-A, IMS, Chagrin Falls, OH, USA). Pressings were conducted using manual hydraulic presses (Model 4126, Carver Press Inc., Wabash, IN, USA). The mold was then transferred to a preheated Carver press at 150, 170, 180, 185, or 190 °C. Initially, molds were given 2.8 MPa pressure for 4 min, and then pressure was released in order to remove internal air build-up within the composite. Then, molds were pressed to 4.2 MPa for 4 min and pressure was released again. Finally, molds were pressed to 5.6 MPa for an additional 4 min. Total heating/compression time was ~12 min. Mold composites were then held at 5.6 MPa pressure while the heating was terminated, and cooling process of the press platens commenced (*via* cold water). The mold was removed from the Carver press when the mold surface reached 27 °C.

The influence of PW particle size on the mechanical properties of DDGS-PW composites was determined by testing particles obtained from sieve/screens as previously described. Composites composed of 80 g of DDGS were mixed with 80 g of < 1700, <

600, 425 to 600, 180 to 250, 106 to 180, < 74, or 600 to 1700 μm PW. DDGS-PW composites were subjected to 185 °C under 5.6 MPa pressure for 12 min. The influence of mold pressure on DDGS-PW composites was tested on composites composed of 80 g DDGS and 40 g of PW consisting of < 600 μm particles and 40 g of PW consisting of 600 to 1700 um particles. DDGS-PW composites were fabricated at a temperature of 185°C for 12 min using a pressure of 2.1, 2.8, 4.2, or 5.6 MPa. To compare DDGS to PRO, 15, 25, 50, 75, and 100%, mixtures of DDGS or PRO were mixed with the balance of PW consisting of equal amounts of 74 to 600 μm particles and 600 to 1700 um particles. DDGS-PW and PRO-PW composites were subjected to 185 °C temperature under 5.6 MPa pressure for 12 min.

FTIR

FTIR spectra were measured on an ABB Arid Zone FT-IR spectrometer (ABB, Houston, TX, USA) equipped with a DTGS detector. Test samples were transparent discs that consisted of 1.00 mg solids homogenized with 300 mg of dry spectronic grade KBr, placed in a KBr die, and compressed at 24,000 psi using a Carver press. Absorbance spectra were acquired at 4 cm^{-1} resolution and signal-averaged over 32 scans. Interferograms were Fourier transformed using cosine apodization for optimum linear response. Spectra were baseline corrected and adjusted for mass differences and normalized to the methylene peak at 2927 cm^{-1}.

DSC and TGA

DSC experiments were performed in duplicate on a TA Instruments DSC, Model Q2000 with refrigerated cooling system (New Castle, DE). Calibration was done without a pan for baseline and with indium for temperature. Samples (9 to 10 mg) were added in Tzero aluminum pans and press sealed (non-hermetic). The DSC was purged with dry nitrogen at 50 mL/min. The sample was equilibrated at -60 °C, then heated to 190 °C at 10 ºC·min^{-1}, and this heating cycle was repeated twice. TGA experiments were conducted in duplicate with a Model Q50 TGA (TA instruments, New Castle, DE, USA) under nitrogen with 60 mL/min flow rate. An approximately 10 mg sample was placed on a platinum sample pan, and the pan was loaded with the autosampler. The sample was heated at 10 °C/min from 25 °C to 800 °C. TA Universal Analysis software was used to analyze the results.

XRD

XRD analysis was employed to assess the morphological properties of ingredients and composites. X-ray diffraction spectra analyses were performed using a Bruker D2 Phaser (Bruker AXS Inc., Billerica, MA, USA) X-ray diffractometer. The X-ray source was Cu-Kα radiation at a current of 10 mA and 30 kV, set up using θ/θ geometry. Samples were scanned at 10 to 90°, 2θ, step size 0.01°, 0.2 s/step, and stage rotation of 10 rpm. Initial divergence slit size was 0.6 mm and a 1 mm air scatter screen was used above the sample. A Lynxeye™ detector was used with a 2.5° Soller slit and a Ni-Kβ filter.

SEM

Scanning Electron Microscopy (SEM) was conducted at Fort Valley State University, Fort Valley, GA, USA. Samples were mounted on Hitachi aluminum specimen mounts M4, ø15 x 6 mm, (Ted Pella, Inc., Redding, CA, USA) using double sided carbon tape. The samples were then dried at a room temperature (~26 °C) for 48 h to remove excess trapped moisture. After 48 h, the specimens were sputter coated with gold using Denton Vacuum Sputter Coater Desk V (Denton Vacuum, NJ, USA). The vacuum pressure was set at 0.05 tort for 60 sec of sputter coating with 50 Å thickness. A variable pressure SEM (Hitachi 3400 NII, Hitachi Technologies America, Inc., Pleasanton, CA, USA) was used to take pictures at various magnifications. Sample surfaces and edges were examined.

Flexural and Physical Tests

Following pressings, composite panel boards were conditioned at 25 °C and 50% relative humidity (RH) for 72 h. A table saw was employed to cut specimen boards in order to conduct three-point bending tests (EN 310:1993). Specimen board thickness was measured according to the EN 310:1993 test. Specimen board dimensions were 127 mm long, 50 mm wide, and ≈ 3.5 to 5.5 mm thick, depending on the treatment. The specimen thickness dictated the free span length. Tests were performed on a universal testing machine [Instron Model 1122 (Instron Corp., Norwood, MA, USA)] using a crosshead speed of 5 mm/min. Densities of the composites were determined using the EN 323:1993 standard. Water absorbance (WA) and thickness swelling (TS) were conducted on 50 x 50 mm squares immersed in water for 24 h according to EN 317:1993 standards utilizing composite formulations of the various DDGS-PW dosages (EN 317:1993).

Statistical Analysis

Five specimens of each formulation were tested. The average values and standard errors were reported. The experimental data obtained were analyzed statistically by analysis of variance for statistical significance, and multiple comparisons of means were accomplished with Duncan's Multiple Range Test ($p \leq 0.05$) (Statistix 9, Analytical Software, Tallahassee, FL, USA).

RESULTS AND DISCUSSION

FTIR Analysis

Figure 1 a-d shows the FTIR spectra of ingredients DDGS and PW and composite panels 100DDGS (100% DDGS wt.) and 50DDGS-PW (50% DDGS:50% PW wt.). There was no difference in the absorption bands between the original DDGS and 100DDGS composite panel except for a peak region occurring at 625 cm^{-1} in the 100DDGS, which was absent in the DDGS ingredient spectra. The 600 to 700 cm^{-1} region is characteristic of P-S and P=S stretching (Pretsch *et al.* 2000). That the region shows up in the 100DDGS suggests unfolding of the protein component so that a buried vibration could be observed.

All spectra (Fig. 1a-d) showed characteristic H-bonding and -OH stretching absorption around 3300 to 3500 cm^{-1} and C-H asymmetric and symmetric stretching of methylene groups around 2800 to 3000 cm^{-1} (Pretsch *et al*. 2000; Nagieb *et al*. 2011; Hemsri *et al*. 2012; Deka *et al*. 2015; Li *et al*. 2016). This region's band was centered at 3384 cm^{-1} and is identified as -OH of carbohydrate overlapping the protein -NHs (Pretsch *et al*. 2000; Deka *et al*. 2015). A broad alkyl band occurs at 2921 cm^{-1}, which was resolved in the 2nd derivative spectrum into four bands: strong 2958 cm^{-1} ($-CH_3$ asymmetrical stretching), very strong 2927 cm^{-1} ($-CH_2$ asymmetrical stretching), 2876 cm^{-1} ($-CH_3$ symmetrical stretching), and very strong 2858 cm^{-1} ($-CH_2$ symmetrical stretching) (Pretsch *et al*. 2000; Deka *et al*. 2015). A residual ester or lignocellulosic carbonyl and protein bands occur at 1738 cm^{-1} (-C=O, medium carbonyl band either from lignin or uronic esters), and 1656 cm^{-1} (N-C=O, amide I). The 1543 and 1517 cm^{-1} (H-N-CO) bands are the protein amide IIs (Pretsch *et al*. 2000; Deka *et al*. 2015). Bands 1470 cm^{-1} and 1372 cm^{-1} are identified as CH_2 and CH_3 deformations, respectively, and are commonly known as the alkyl deformation region of the spectrum (Pretsch *et al*. 2000). Other prominent bands are located at 1117 cm^{-1} (O-C=O), 1081 cm^{-1} (-CHO-), 1050 cm^{-1} ($-CH_2O-$), and 994 cm^{-1} (unknown).

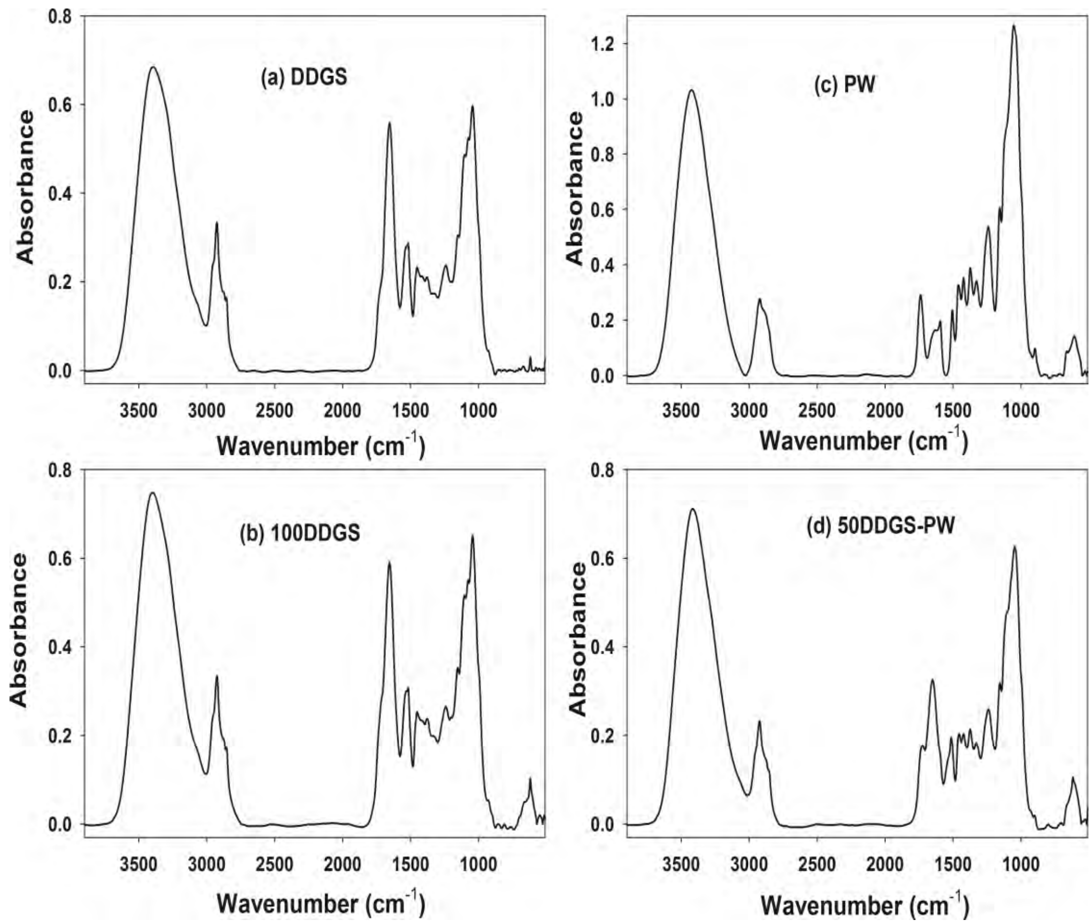

Fig. 1. FTIR spectra of ingredients (a) DDGS and (c) PW and bio-composites (b) 100DDGS and (d) 50DDGS-PW

Figure 1b 100DDGS spectrum is similar to Fig. 1a of the DDGS ingredient. As previously noted, a strong band occurs at 625 cm^{-1} representing P-S and P=S stretching of protein. This band was inconspicuous in the spectrum of the folded DDGS protein (Fig. 1a) but now obvious in the unfolded matrix (Fig. 1b).

Figure 1c is the spectrum of PW. Like in many carbohydrates a broad and strong symmetric absorption band is observed at 3420 cm^{-1} for the (H bonding and -OH stretching) with a moderate intensity alkyl band occurring at 2925 cm^{-1} (Pretsch *et al*. 2000; Li *et al*. 2016). The broad band at 2925 cm^{-1} is resolved into a sharp 2969 cm^{-1} (-

CH_3 asymmetrical stretching), 2924 cm^{-1} (-CH_2- asymmetrical stretching), 2876 cm^{-1} (-CH_3 symmetrical vibrations) and 2852 cm^{-1} (-CH_2 symmetrical vibrations). The alkyl groups occurring between 2925 cm^{-1} and 620 cm^{-1} of the spectrum are easier to identify from its 2nd derivative spectrum because these bands are better defined. A medium carbonyl band either from lignin or uronic esters is also evident at 1739 cm^{-1} followed by moderate protein absorbances at 1642 to 1505 cm^{-1} (Pretsch *et al*. 2000; Li *et al*. 2016). Alkyl chain deformation bands (-CH_2- and -CH_3) trending toward the low frequency region ending at 620 cm^{-1} (see previous paragraphs). The 620 cm^{-1} band is analogous to that in processed 100DDGS. There is a single carbonyl band at 1738 cm^{-1} assignable either to a uronic ester in the wood component or a lignin carbonyl moiety (Pretsch *et al*. 2000; Li *et al*. 2016). Next there is a low protein carbonyl absorption at 1656 cm^{-1}, amide I and very intense peaks at 1597 and 1508 cm^{-1} presumably represent the amide II mode. The -CH_2- and -CH_3 deformation bands are shown at 1470 and 1372 cm^{-1}, respectively. There is a sizable O-C=O band at 1246 cm^{-1} followed by very intense –CHO-, and -CH_2O- bands located at 1159, 1128, 1037, and 991 cm^{-1}. Finally an anomalous P-S and P=S band is observed at 670 cm^{-1} (Fig. 1c).

The 50DDGS-PW composite spectra (Fig. 1d) is characterized by a strong 3410 cm^{-1} band representing the overlapping -OHs of DDGS and PW together with the -NH stretching bands of the intrinsic protein content. A broad band at 2913 cm^{-1} is resolved in the 2nd derivative of its FTIR spectrum into four discrete bands: 2959 cm^{-1} (-CH_3 asymmetrical), 2923 cm^{-1} (-CH_2 asymmetrical stretch), 2875 cm^{-1} (-CH_3 symmetrical stretching) and 2854 cm^{-1} (-CH_2 symmetrical stretching) absorption. The next absorption series of the spectrum comprise an ester carbonyl band at 1743 cm^{-1} resulting from the PW, a single amide I absorbance at 1656 cm^{-1} (probably the α-helix of the DDGS), and prominent amide II peaks at 1596, 1546 and 1517 cm^{-1}. These are followed by the deformation bands, 1470 and 1378 cm^{-1} of the –CH_2- and -CH_3 alkyl moieties, respectively. The latter bands are followed by the -O-C=O stretching of the ester at 1246 cm^{-1} and the –COH- and -CH_2O- at 1167, 1130, 1077, 1039 and 992 cm^{-1} and finally by the P-S and P=S vibration at 621 cm^{-1}.

DSC and TGA Evaluations

Ganesan and Rosentrater (2007) observed glass transition temperatures (T_g) at 20 to 50 °C with unmodified DDGS, defatted DDGS, or de-waxed DDGS using DSC. The defatted DDGS used in this study showed a somewhat higher T_g (54.0 °C) during the first heating cycle, which was shown as a small shoulder in the large water evaporation curve (Fig. 2a). The difference, presumably, resulted from slightly different compositions produced by different processes to obtain the DDGS. The second heating cycle, conducted after the first heating cycle, showed no water evaporation peak and a higher T_g (117.8 °C). The reason for this weak signal was that the DDGS is a mixture of many ingredients and some of them exhibit a “thermoplastic property”. The presence of water lowers the T_g and acts as a plasticizer in a material having glass transition, and thus removing the water increases the T_g (Frascareli *et al*. 2012). The DSC of PW did not show an obvious T_g during the first or the second heating cycles, indicating that the PW did not have ingredients undergoing glass transition (Fig. 2c). The DSC of 100DDGS showed a slightly lower T_g than that of DDGS in both the first and the second heating cycles, indicating that the materials showing glass transition underwent little change during the process of making this composite (Fig. 2b). In contrast, 50DDGS-PW showed no T_g (Fig. 2d). In the presence of wood, DDGS binds more completely to produce a thermoset composite. This result indicated that in addition to the fact that 50DDGS-PW contained only 50% DDGS, there may have been physical changes in DDGS during the composite-making process.

The physical change such as the interface of DDGS molecules with PW particles may have been one of the possible reasons for the increased strength of 50DDGS-PW over 100DDGS (which will be discussed later), since there were no substantial chemical reactions evident between DDGS and PW as observed in FT-IR spectra.

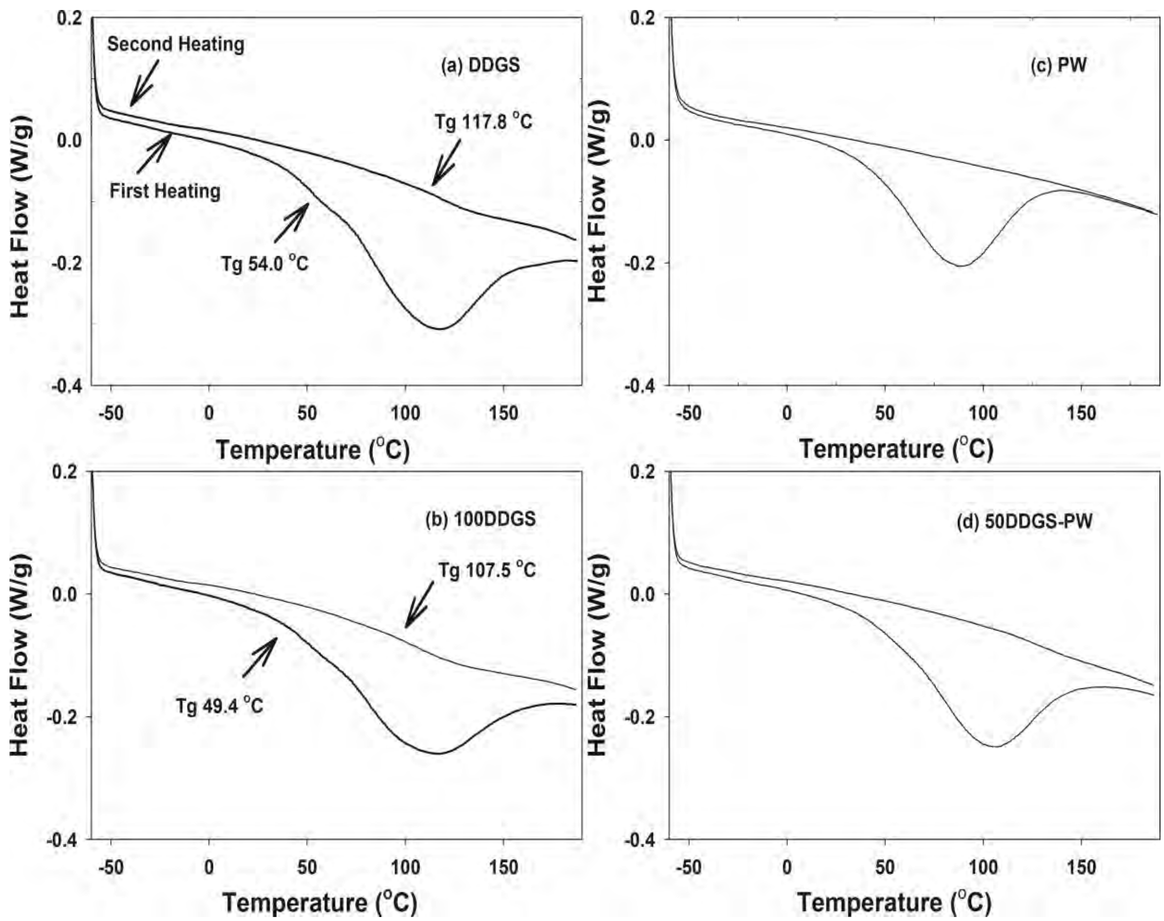

Fig. 2. DSC of ingredients (a) DDGS and (c) PW and bio-composites (b) 100DDGS and (d) 50DDGS-PW

The TGA analysis confirmed water evaporation from both ingredients and composites was initiated around 100 °C (Fig. 3). DDGS further lost weight starting around 140 °C, while PW did not begin substantial weight loss until the temperature reached 210 °C. Beyond 210 °C, all four samples exhibited remarkable weight loss due to decomposition. This indicated that such process temperatures should have been avoided because of detrimental damage to the composites. However, there should be a certain temperature and enough incubation time for the physical changes required for interfacing of the DDGS molecules with PW particles to occur in order to obtain optimized strength of the composite. Process temperatures that are too high or process times that are too long could cause excessive thermal decomposition of the composite resulting in lower strength. This will be discussed further in a later section.

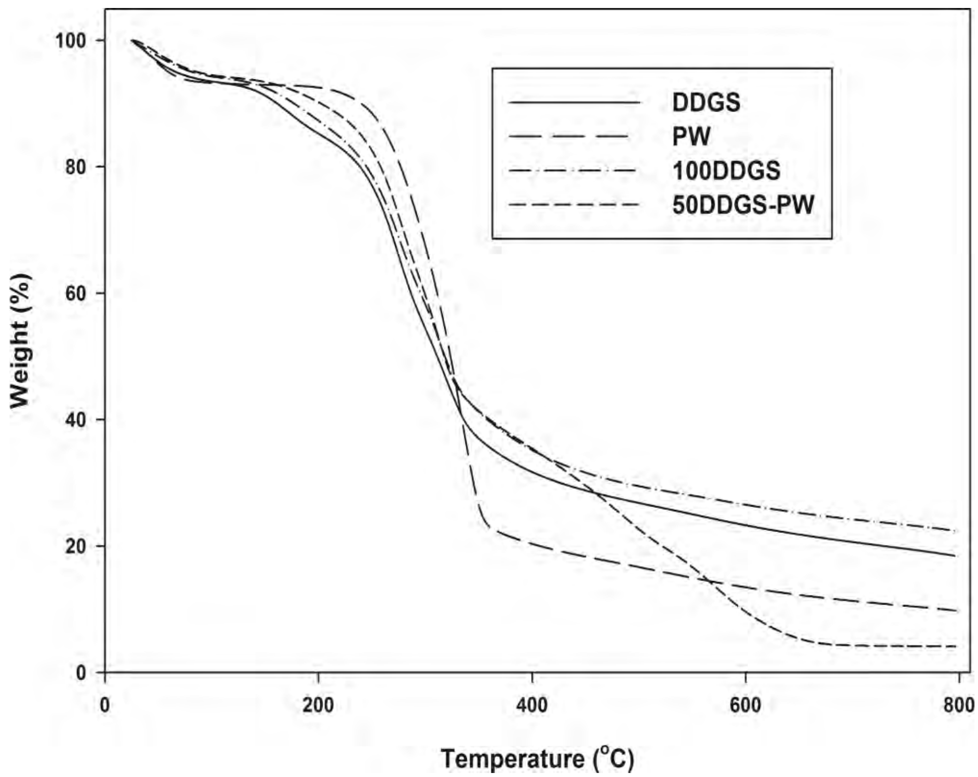

Fig. 3. TGAs of DDGS, PW, 50DDGS-PW, and 100 DDGS

XRD Analysis

Figure 4 represents the X-Ray diffractograms of the native DDGS and PW versus the resulting bio-composites (100 DDGS and 50DDGS-PW). Both ingredients (DDGS and PW) are biological, amorphous solids that soften and semi-melt over a temperature range conducted in this study. In addition, it was noted that breaking of the 50DDGS-PW and 100DDGS panels results in curved or irregular faces, which are characteristic of amorphous solids.

The DDGS samples (DDGS, 100DDGS, and 50DDGS-PW) had a doublet peak occurring around 30 degree 2-theta. The occurrence of this doublet has been previously reported (Xu *et al.* 2008). The PW ingredient had a broad peak occurring around 22 degree 2-theta which is characteristic of amorphous materials such as wood (Devi and Maji 2013). In addition, PW diffractogram showed shoulder peaks occurring before and after the main peak at 22 degree 2-theta.

The 50DDGS-PW diffractogram represented a combination of the DDGS and PW ingredients without any new peaks occurring. The PW peaks of the 50DDGS-PW composite were somewhat masked by the broader DDGS peak. Overall, the composites did not show any additional peaks at higher degree 2-theta values, which would have indicated the occurrence of crystallization (Xu *et al*. 2008). It was concluded that little or no crystallization occurred in the preparation of the composites from the ingredients employed. This suggested that the interaction between the DDGS and PW is disordered and amorphous in nature.

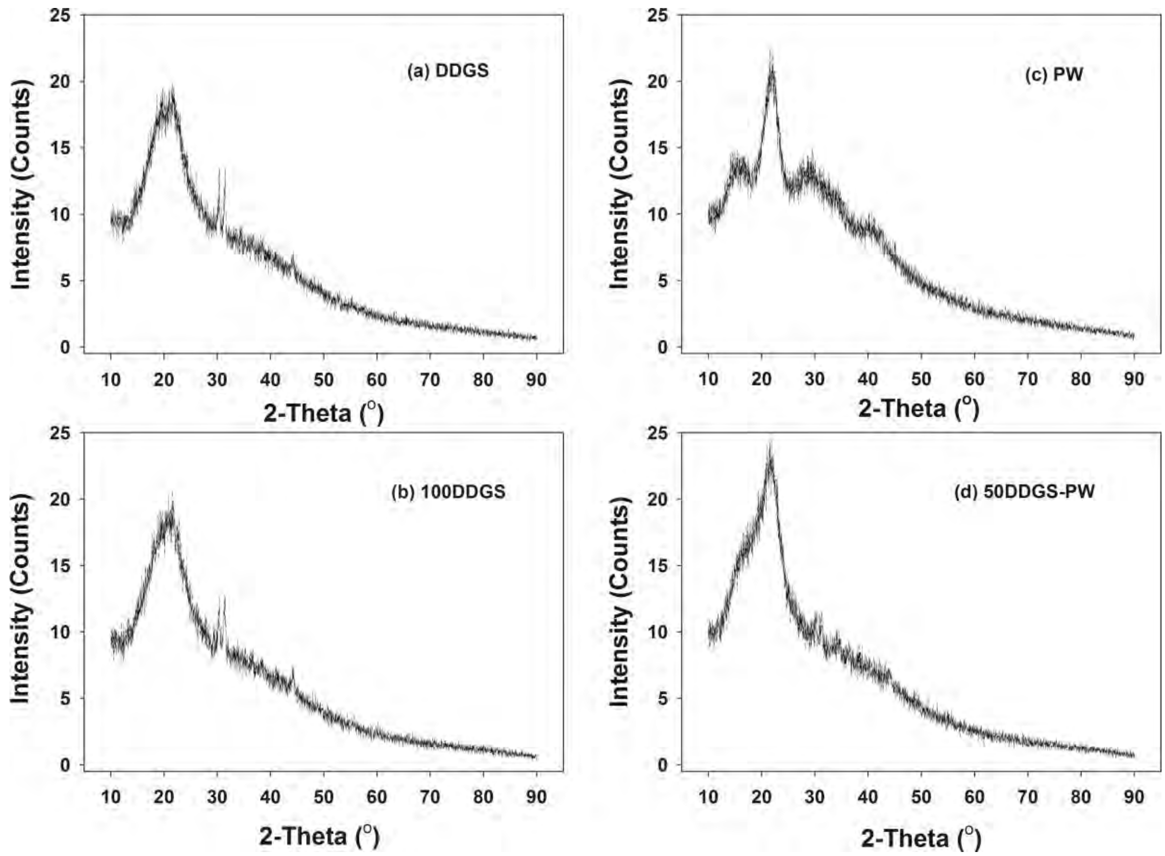

Fig. 4. X-Ray diffractograms of ingredients (a) DDGS and (c) PW and bio-composites (b) 100DDGS and (d) 50DDGS-PW

Effect of Temperature on Flexural Properties

It should be noted that all composites were found to have smooth tactile feel on their surface, resembling a commercial MDF or even thermoplastic or thermoset resin-wood composite. The temperature employed to hot-press composites was found to have remarkable influence on the flexural properties of the composites. The F_m obtained from specimens using 150, 170, and 180 °C as the hot-press temperatures were similar (*Fig.* 5). The DDGS-PW composites hot-pressed at 185 °C showed a remarkable increase in bending strength (F_m), while the 190 °C hot-pressed specimens showed a decline. Likewise, the modulus of elasticity (E_m) values followed the same pattern (Fig. 5).

Clearly, the mechanical properties of DDGS-PW composites hot-pressed at 185 °C were superior to other hot-press temperatures. This was attributed to the optimum plasticization of the DDGS matrix having occurred at this temperature. Below this temperature (185 °C) some plasticization of DDGS occurred, while above this temperature (190 °C) both plasticization and thermal degradation of the DDGS occurred. DDGS-PW composites hot-pressed at 185 °C had F_m and E_m values of 41.4 ± 0.7 and 6073 ± 123 MPa, respectively, while DDGS-PW composites hot-pressed at 150 °C had *Fm* and E_m values of 22.8 ± 2.0 and 3548 ± 157 MPa, respectively. This translated into DDGS-PW composites hot-pressed at 150 °C with F_m and E_m values being -45 and -42% less, respectively, than composites hot-pressed at 185 °C.

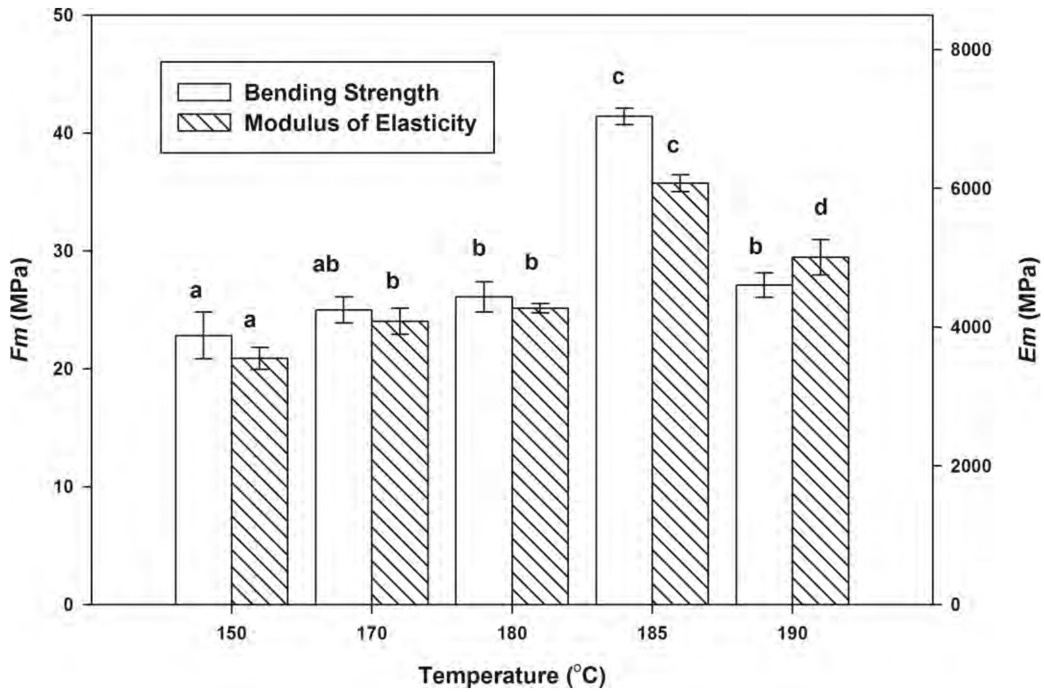

Fig. 5. Effect of press temperatures on the flexural properties of biocomposites

Effect of Particle Size on Flexural Properties

The size of wood particles plays an important role in the fabrication and overall characteristics of engineered wood (Korosten MDF manufacture 2013; Lias *et al*. 2014). Particleboard usually consists of large wood particles obtained from inexpensive wood sources, which are hot-pressed with a petroleum based binding agent (*i.e.,* formaldehyde resins) (Korosten MDF manufacture 2013). MDF in contrast is made of finer wood particles and typically are much denser and thinner than particleboard. MDF may be glued together with lignin and wax (paraffin), and these are therefore more eco-friendly than particleboard (Korosten MDF manufacture 2013; Lias *et al*. 2014). In this study a variety of wood particles were employed in the DDGS-PW composites (*Fig.* 6). It was found that the bending strength (F_m) and modulus of elasticity (E_m) values of DDGS-PW composites were influenced by the particle size of the wood employed. For example, composites composed of the largest wood particles (600 to 1700 μm) had the lowest flexural values when compared to the other composites tested, F_m and E_m values were 34.2 ± 1.4 and 5151 ± 244, respectively. The composite that contained 425 to 600 μm particles selection also exhibited lower flexural properties. Composites containing 180 to 250 um particles had the highest F_m and E_m values that were 45.4 ± 2.3 and 7409 ± 276, respectively. This suggested that this particle size was optimum for producing high quality composites. Composites that contained a mixture of wood particles composed of < 1700 μm or < 600 μm exhibited higher flexural properties that rivaled the 180 to 250 μm composite. Interestingly, composites containing the smallest particle (< 74 μm) exhibited lower F_m values but had E_m values in par with the other composites. Other researchers have noted the importance of wood particle size on the mechanical properties using thermoplastic resin-wood blends (Stark and Berger 1997; Tisserat *et al*. 2013b).

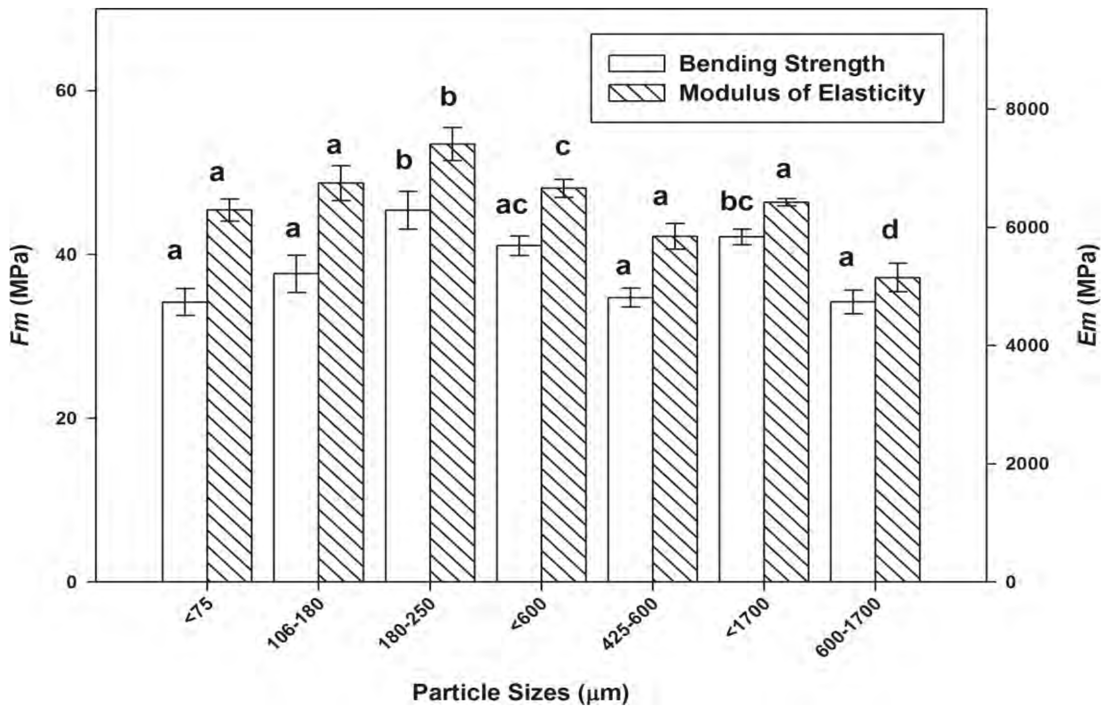

Fig. 6. Effect of the Paulownia wood (PW) particle size on the flexural properties of DDGS-PW composites

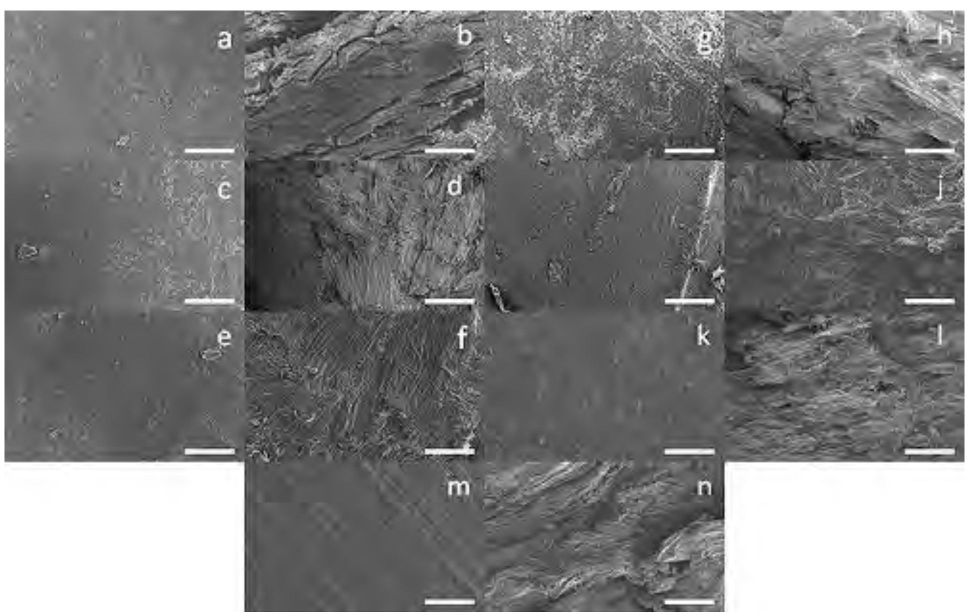

Fig. 7. SEM micrographs of DDGS-PW composites composed of various particles sizes: (a) < 74 to 1700 μm particles-surface, (b) < 74 to 1700 μm particles-edge, (c) < 74 to 600 μm particles-surface, (d) < 74 to 600 μm particles-edge, (e) 425 to 600 μm particles-surface, (f) 425 to 600 μm particles-edge, (g) 180 to 250 μm particles-surface, (h) 180 to 250 μm particles-edge, (i) 106 to 180 μm particles-surface, (j) 106 to 180 μm particles-edge, (k) < 75 μm particles-surface, (l) < 75 μm particles-edge, (m) 600 to 1700 μm particles-surface, (n) 600 to 1700 μm particles-edge; scale bar = 200 μm

SEM examination of the various composites showed little differences in their surface topography (Fig. 7). However, the cut edges showed the outlines of the particles sizes employed in the composition of the panels (Fig. 7). DDGS coating of the particles often obscured the wood particles (Fig. 7). Deeper fissures occurred in the micrographs of the DDGS-PW composites containing the larger particles sizes compared to that found in the other composites (Fig. 7 b and n). These fissures were often associated with poor interfacial adhesion between ingredients and resulted in lower flexural properties (Fig 6).

The interaction between the DDGS and wood particle size was responsible for flexural properties of the composite. The DDGS matrix somewhat resembled a thermoset matrix, which mimics SBM74 matrix/adhesives. The mode of bio-based adhesion is unclear and complex (Frihart *et al*. 2010; Frihart 2011; Frihart and Birkeland 2014; Frihart *et al*. 2014). The adhesive nature of SBM is believed to be attributable to the protein composition (Frihart *et al*. 2010; Frihart 2011; Frihart and Birkeland 2014; Frihart *et al*. 2014). Soya seed proteins represent 30 to 50% of the seed mass with storage proteins accounting for 65 to 80% of the total proteins. The main storage proteins in SBM are quaternary globulins, glycinin, and conglycinin (Frihart and Birkeland 2014; Wolf 1970). DDGS is chemically dissimilar from SBM. In addition, yeast contributes 5.3% of the protein content of DDGS (Lim and Yildirim-Aksoy 2008). Corn meal proteins consist of 14% albumin/globulin, 35 to 40% zein (a prolamine protein), and 30% glutelin. It is conjectured that soy protein adhesive properties occur through the denaturation of the quaternary globulins into tertiary structures and crystalline secondary structures, α-helices, and β-sheets (Frihart 2010; Frihart and Birkeland 2014; Frihart *et al.* 2014). These crystalline secondary protein structures are suspected to provide the optimum adhesive properties that bind protein to wood (Frihart 2010; Frihart and Birkeland 2014). No crystalline structures in the XRD studies with DDGS were observed which suggested a different method of protein adhesion may occur.

Denaturation of proteins can be achieved through a variety of methods such as heat, alkali, or chemical modification (Frihart and Birkeland 2014; Frihart *et al*. 2014). DDGS powder contained 30% protein and was originally a solid and through the application of heat and pressure undergoes a "phase change or transition" and becomes a "liquid-gel" that binds with wood. These events are recognized as typical in the adhesive process (Adhesives.org 2017). Apparently, the DDGS proteins are denatured under pressure and heat to a state that can then bind to wood. Upon cooling, DDGSs transitions back into a solid, which cannot be melted again.

It should be noted that employing a high moisture DDGS-PW formulation results in explosive stream generation and ultimately an unacceptable composite exhibiting excessive blistering. Therefore, a relatively dry DDGS-PW formulation was employed which was prepared by mixing the ingredients dry and not pre-stirring DDGS in any liquids as commonly reported in the fabrication of SBM biocomposites (Zhong *et al*. 2001; Amaral-Labat *et al*. 2008; Jeon *et al*. 2011; Reddy and Yang, 2011; Gu *et al*. 2013). In addition, in the preparation method steam was allowed to escape during the molding process by short releases of the molding pressure. Further, it was found that rapid cooling resulted in blistering and internal cracking of the DDGS-PW composites, while slow cooling the composite produced a non-blistered composite (Fig. 8). Blistering is a common problem in thermoset materials (Plenco 2015). Thermoset materials cure as a result of a chemical reaction and are affected by temperature and pressure (Plenco 2015). Blistering is often due to areas of gas trapped beneath the surface. One of the methods commonly employed to address this problem in injection molding is to decrease mold temperature by cooling after molding (Plenco 2015; IDI Composites International 2017). Reddy and Yang (2011) employed prolonged slow cooling to molds to obtain soy-wood composites. Likewise, this problem was recognized and was addressed similarly.

Composites that contained predominately large wood particles formed an interfacial complex with the "melted" DDGS, which formed a biocomposite that was weaker than the DDGS composite matrix that interacted with smaller wood particles. It was speculated that smaller wood particles interacted better with the DDGS matrix because of the ability of the DDGS to obtain a more fluid molten state that could penetrate the wood of smaller particles. Composites consisting of various particle sizes exhibited different flexural properties, suggesting that two types of interactions were occurring: (1) the wood particles were providing a support role based on their size, which contributed to the composite strength, and (2) the DDGS was interacting differently with the wood particles depending on their size. The < 1700 μm blend produced a composite that exhibited high flexural properties and was the simplest to prepare when compared to the other composites. This PW composite blend was adopted in all further studies (Fig. 8).

Fig. 8. Comparison of composite panels. Top panel consists of 50:50 mixture of DDGS: PW subjected to fast cooling. Note blistering and internal cracking. Middle panel consists of 50:50 mixtures of DDGS:PW subjected to slow cooling. Note absence of disruptive blemishes. Bottom panel is commercial PB locally purchased

Effect of Pressure on Flexural Properties

The effect of pressure applications on the flexural properties of composites is presented in Fig. 9. Best flexural properties were obtained using the highest pressure tested. The equipment used did not permit higher pressures to be administered. Composites subjected to 5.6 MPa had F_m and E_m values of 41.4 ± 0.7 and 6073 ± 123, respectively. Composites subjected to 2.1 MPa had F_m and E_m values of 12.6 ± 1.0 and 2354 ± 286, respectively. F_m and E_m values of composites subjected to 5.6 MPa were 228% and 158% greater than F_m and E_m values of composites subjected to 2.1 MPa, respectively. Similar results have been reported by other investigators (Li *et al*. 2011). Applied pressure had a profound influence on the flexural properties and affected their physical properties, thickness and density. This phenomenon was attributed to the increased densification of the DDGS-PW composite, which resulted in an enhancement in the interfacial binding between particles and thus improving the flexural properties of the composites. Density of composites treated with 2.1, 2.8, 4.2, or 5.6 MPa were 929, 1,052, 1,212, or 1,275 kg·m^3, respectively. Conversely, thickness of the composites decreased when treated with 2.1, 2.8, 4.2, or 5.6 MPa to 0.470, 0.430, 0.361, or 0.358 mm, respectively.

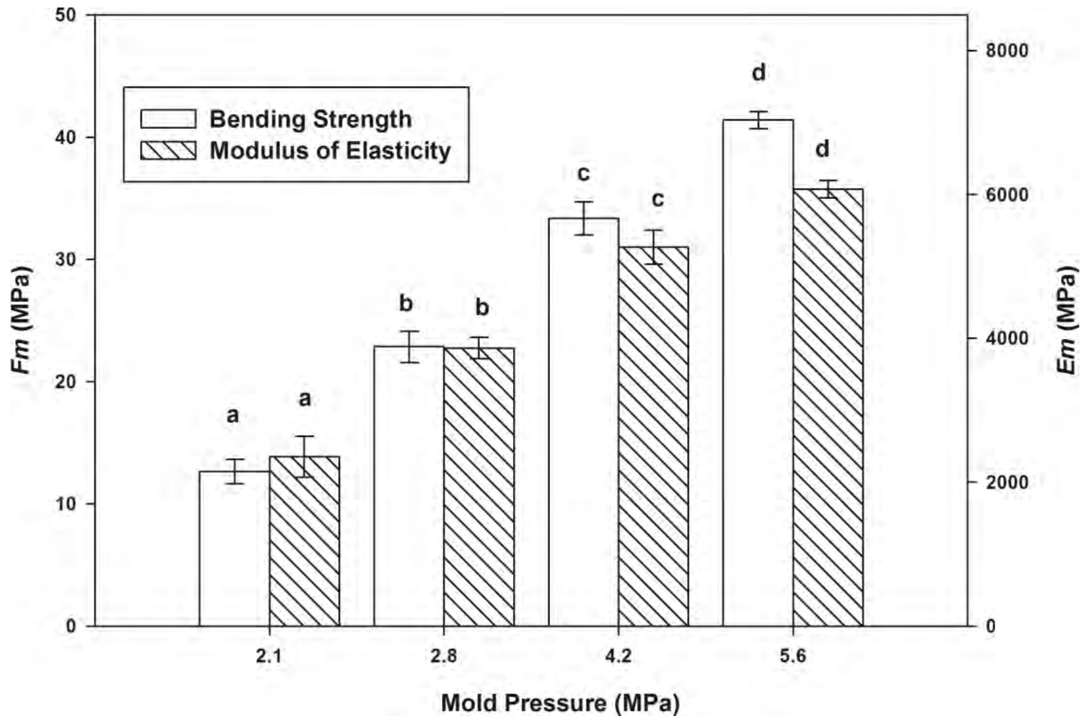

Fig. 9. Effect of various mold pressures on the flexural properties of composites

Influence of PW dosage on the Flexural Properties of Composites

The influence of DDGS-PW and PRO-PW dosages on the flexural properties of composites is presented in Table 1. Neat DDGS (100%) produced a panel that had the highest density and lowest thickness of all DDGS-PW composites tested but exhibited the lowest flexural values of all the DDGS-PW composites tested (Table 1). Increasing PW content increased the flexural values of all the DDGS-PW composites compared to neat DDGS. The highest flexural properties were obtained from composites containing 50:50 DDGS-PW (% wt.). Increasing the concentration of PW in the 10:90, 15:85, and 25:75 DDGS-PW (% wt.) composites resulted in a reduction of flexural properties compared to other DDGS-PW composites (*i.e.* 50:50 and 75:25 % wt.). DDGS-PW composites had flexural properties comparable to PRO-PW composites for the 50:50 formulations (Table 1). However, the flexural properties of PRO-PW composites to DDGS-PW composites differed depending on the concentrations tested. For example, neat 100% PRO produced a panel that cracked and shattered within 24 h after removal from the mold and therefore could not be tested. Composite formulations of 10PRO-PW, 15PRO-PW, and 25PRO-PW had superior flexural properties compared to 10DDGS-PW, 15DDGS-PW, and 25DDGS-PW. Soy flours (*e.g*. SBM, Prolia, Prosante, and SPI) have been employed in numerous studies to fabricate fiberboards (Zhong *et al*. 2001; Mo *et al*. 2001; Amaral-Labat *et al*. 2008; Frihart *et al*. 2010; 2014; United (USB) Soybean 2010; Jeon *et al*. 2011; Gu *et al*. 2013; Vnučec *et al*. 2015). SBM and DDGS have different protein compositions and concentrations. Nevertheless, the adhesive properties of DDGSs were similar to PRO. That observation suggested that DDGS may have merit as a potential substitute for soybean flour as a bio-based adhesive.

Table 1. Comparison of the Flexural Properties of Biocomposites Using Soybean and DDGS Flours*

	Thickness	Density	F_m	E_m	WA	TS
Composition	(mm)	(kg·m³)	(MPa)	(MPa)	(%)	(%)
10DDGS-PW	3.8 ± 0.05a	1065 ± 24a	20.8 ± 2.7a	3640 ± 276a	133 ± 7a	141±18a
15DDGS-PW	3.7 ± 0.03a	1092 ± 24a	28.3 ± 3.1ac	4169 ± 248a	101 ± 7b	116 ± 6b
25DDGS-PW	4.1 ± 0.12b	1069 ± 46a	25.4 ± 1.2a	4027 ± 142a	78 ± 7c	104 ± 3c
50DDGS-PW	3.4 ± 0.24c	1288 ± 39b	41.4 ± 0.7b	6073 ± 123b	38 ± 7de	49 ± 9e
75DDGS-PW	3.1 ± 0.04c	1408 ± 14c	31.5 ± 1.0c	5309 ± 90c	37 ± 4d	40 ± 1e
100DDGS	2.6 ± 0.1d	1401 ± 6c	21.5 ± 1.0a	2840 ± 73d	29 ± 1e	44 ± 5e
10PRO-PW	3.8 ± 0.05a	1065 ± 25a	30.5 ± 1.7c	4665 ± 423a	94 ± 14b	84 ± 5f
15PRO-PW	3.8 ± 0.04a	1059 ± 22a	34.3 ± 2.7c	4511 ± 334a	75 ± 6c	78 ± 6g
25PRO-PW	3.8 ± 0.04a	1098 ± 51a	36.6 ± 5.6cf	5179 ± 731c	51 ± 3f	54 ± 5e
50PRO-PW	3.3 ± 0.04c	1262 ± 12b	41.8 ± 0.8bf	7575 ± 589e	49 ± 5f	51 ± 2e
75PRO-PW	3.2 ± 0.05c	1304 ± 14e	26.8 ± 0.6c	5699 ± 155c	54 ± 0f	62 ± 1h
100PRO	--	--	--	--	--	--

*Treatment values with different letters in the same column were significant ($P \leq 0.05$); means and standard errors derived from five different replicates are presented.

Water Absorption and Thickness Swelling of Composites

Water absorption and thickness swelling of DDGS-PW composites were compared to PRO-PW composites (Table 1). Regardless of the adhesive matrix employed, as the concentration of wood flour increased, the amount of water absorbed by the composite increased proportionally. This situation occurred because of the decreasing cohesion that occurs within the composites between the wood and the adhesive (Pan *et al*. 2006). Higher adhesive contents within the 50DDGS-PW and 75DDGS-PW composites exhibited substantially less water absorption and thickness swelling. TS and WA properties vary with the type of raw materials (*i.e.* bonding agents, additives, and fillers/reinforcements) employed during manufacturing (Mendes *et al*. 2012; Melo *et al*. 2014). Bio-based adhesives have a hygroscopic nature compared to synthetic adhesives derived from petroleum sources which are more hydrophobic. WA and TS for the two different types of adhesive composites were somewhat comparable (Table 1).

Comparison of DDGS-PW Composites Properties with European Committee for Standards

As shown in Table 1, the DDGS-PW composites produced in this study compared well with the nominal flexural requirements for PB, MDF, and HDF established by the European Committee for Standards presented in Table 2 (EN 662-2:1997; EN 622-5:2006; EN 312:2003). However, the non-conventional DDGS-PW composites prepared in this work were often inferior in terms of TS compared to that adopted by the European Committee for Standards (EN 662-2:1997; EN 622-5:2006; EN 312:2003). Clearly, additional research is necessary to improve water resistance properties.

Table 2. European Standards for the Nominal Properties for Particleboard, Medium Density Fiberboard, and Hard Density Fiberboard

Specifications (Description, thickness)	F_m (MPa)	E_m (MPa)	TS (%)
Particleboard (PB):[1]			
General Purpose boards/dry conditions (P1), 3 to 6 mm	14	--	--
Boards for interior fitments (including furniture)/dry conditions (P2), 3 to 4 mm	13	1800	--
Boards for interior fitments (including furniture)/dry conditions (P2),>4 to 6 mm	14	1950	--
Non-load-bearing boards/humid conditions (P3), 3 to 4 mm	13	1800	17
Non-load-bearing boards/humid conditions (P3), >4 to 6 mm	14	1950	16
Non-load-bearing boards/humid conditions, 3 to 4 mm	--	--	15
Non-load-bearing boards/humid conditions, >4 to 6 mm	--	--	14
Load-bearing boards/dry conditions (P4), 3 to 4 mm	15	1950	23
Load-bearing boards/dry conditions (P4), >4 to 6 mm	16	2200	19
Load-bearing boards/humid conditions (P5), 3 to 4 mm	20	2550	13
Load-bearing boards/humid conditions (P5), >4 to 6 mm	19	2550	12
Medium Density Fiberboards (MDF):[2]			
General Purpose boards/dry conditions (MDF), >2.5 to 4 mm	23	--	35
General Purpose boards/dry conditions (MDF), >4 to 6 mm	23	2700	30
General Purpose boards/humid conditions (MDF.H), >2.5 to 4 mm	27	2700	30
General Purpose boards/humid conditions (MDF.H), >4 to 6 mm	27	2700	18
Load-bearing boards/dry conditions (MDF.LA), >2.5 to 4 mm	29	3000	35
Load-bearing boards/dry conditions (MDF.LA), >4 to 6 mm	29	3000	30
Load-bearing boards/humid conditions (MDF.HLS), >2.5 to 4 mm	34	3000	30
Load-bearing boards/humid conditions (MDF.HLS), >4 to 6 mm	34	3000	18
Hardboard Fiberboard (HB):[3]			
General Purpose boards/dry conditions, ≤3.5 mm	30	--	35
General Purpose boards/dry conditions, >3.5 to 5.5 mm	30	--	30
General Purpose boards/humid conditions, ≤3.5 mm	35	--	25
General Purpose boards/humid conditions, >3.5 to 5.5 mm	32	--	20
General Purpose boards/exterior (HB.E), ≤3.5	40	3600	12
General Purpose boards/exterior (HB.E), >3.5 to 5.5 mm	35	3200	10
Load-bearing boards/dry conditions (HB.LA), ≤3.5	33	2700	35
Load-bearing boards/dry conditions (HB.LA), >3.5 to 5.5	32	2500	30
Load-bearing boards/humid conditions (HB.HLA1), ≤3.5 to 5.5	38	3800	15
Load-bearing boards/humid conditions (HB.HLA1), >3.5 to 5.5	36	3600	13
Heavy-duty load-bearing boards/humid conditions (HB.HLA2), ≤3.5 to 5.5	44	4500	15

[1]EN 312:2003, [2]EN 622-5:2006, [3]EN 622-2:1997.

CONCLUSIONS

1. Novel DDGS-PW composites were fabricated containing 25 to 75% distillers dried grains with solubles (DDGS): 75 to 25% paulownia wood (PW) through a phase-change process whereby the DDGS flour powder reacts with PW particles under high pressure and temperature to become a "liquid-gel" matrix to interfacially bond to the PW. Upon slow cooling, the DDGS liquid-gel transforms back into a solid to create panel boards exhibiting relatively high flexural properties.
2. FTIR analysis failed to show esterification; similarly, thermal analysis using DSC and TGA suggested that plasticization of DDGS occurs around 117 °C. XRD analysis failed to show evidence of crystallization, suggesting the DDGS and PW interaction is associated with the generation of a composite in which the binding material is amorphous in nature.
3. Pressure, temperature, PW particle size, and DDGS dosages were found to be important factors in the fabrication of DDSG-PW composite panels in terms of its flexural properties.
4. DDGS-PW composite panels were found to have similar flexural properties when compared to PRO-PW panels.
5. DDGS-PW composite panels exhibited similar water resistance properties as PRO-PW panels.
6. DDGS-PW composite panels were found to be comparable or superior to flexural properties required by Industry Standards (EN 312:2003). However, DDGS-PW composite panels were often found to be inferior in terms of water resistance (*i.e.* thickness swelling) compared to Industry Standards.

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Approach to Reducing Production Lead Time to 1/20 in Small-scale Corrugated Cardboard Factory

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In response to population decline in Japan, the production demand has shifted from mass production to quick production of multiple products in small lot since 2005.In this paper, we delineate the method that conducts production in one-twentieth (1/20) of usual lead time (hereinafter referred to as L/T), which is revolutionary short, is able to respond to the needs of the users concerning delivery, among QCD (quality, cost and delivery). This proposed method is energy efficient, and it is designed for the companies that strive to be the top company in the region. It aims for development of corrugated cardboard makers and optimum efficiency of management.

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Abstract

In response to population decline in Japan, the production demand has shifted from mass production to quick production of multiple products in small lot since 2005.In this paper, we delineate the method that conducts production in one-twentieth (1/20) of usual lead time (hereinafter referred to as L/T), which is revolutionary short, is able to respond to the needs of the users concerning delivery, among QCD (quality, cost and delivery). This proposed method is energy efficient, and it is designed for the companies that strive to be the top company in the region. It aims for development of corrugated cardboard makers and optimum efficiency of management.

Peer-review under responsibility of the organizing committee of the 12th EMSES 2015

Keywords: Corrugated Cardboard; Innovation in Production; Outstandingly Fast Delivery; Reduction of Stock

1. Background of JPACKS production system – maximum reduction of l/t

As of 2015, it is said that there are approximately 3,000 corrugated cardboard companies in Japan, meaning there is extremely tough competition, and small and medium size companies with small capital are especially always in straggle. However, there are ways compete with large businesses through innovation and repositioning within limited resources.

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When examining the three most important elements of business, namely Quality, Cost and Delivery, it is apparent that, though quality and cost are equivalent with those of the large companies, small companies can be in a highly advantageous position when it comes to delivery [1-5]. In this paper, we will delineate the "Jpacks Production System" which is able to reduce delivery time without excessive pressure on the production, centered around "Production method of preferentially proceed of purchase order with multiple processes", "Production Method with Every Processes Conducted in Parallel" and "Single Unit Flowing Production" developed by JPacks.

2. Production method of preferentially proceed of purchase order with multiple processes

It is a method where arranging purchase orders in the descending order of processes and starting the production from the order with the most steps, which is why it is named "Production method of preferentially proceed of purchase order with multiple processes". Normally, in the first process of corrugated cardboard production which is printing, it is common to produce the board with the same color all at once in a large quantity in order to reduce ink loss when changing color. However, the cost of ink loss is very small and negligible in relation to the entire operational cost of the factory. In fact, in the production method of preferentially proceed of purchase order with multiple processes, waiting time of the workers during the 2nd to the last steps is significantly reduced, hence a major improvement can be expected. The delay in the production process cannot be theoretically regained, and moreover influence all the way to the last process. Therefore, how to reduce the delay in processes is extremely important for L/T shortening.

2.1. Simulation

We simulated the common production method (Table 1) and production method of preferentially proceed of purchase order with multiple processes (Table 2) under these conditions.

• 15 lots are produced per day.
• 3 types of lots (1st process, 2nd process, 3rd process) are mixed, each of 5 kinds with different colors.

Table 1 **Common Production Method**

Lot	**The 1st Process**	**The 2nd Process**	**The 3rd Process**	**Set Change**	**Operation Time**
①	○			5	10
②	○	○		7	20
③	○	○	○	12	30
④	△			5	10
⑤	△	△		7	20
⑥	△	△	△	12	30
⑦	□			5	10
⑧	□	□		7	20
⑨	□	□	□	12	30
⑩	×			5	10
⑪	×	×		7	20
⑫	×	×	×	12	30
⑬	◎			5	10
⑭	◎	◎		7	20
⑮	◎	◎	◎	12	30

Measurement Change	15 Times				
Color Change	5 Times				
Waiting Time		50	100	120	
Operation Time					300
Working Time					**570**

Unit is minute
The gray color in the table is the waiting time

Table 2 **Production method of preferentially proceed of purchase order with multiple processes**

Lot	**The 1st Process**	**The 2nd Process**	**The 3rd Process**	**Set Change**	**Operation Time**
①	○	○	○	15	30
②	△	△	△	15	30
③	□	□	□	15	30
④	×	×	×	15	30
⑤	◎	◎	◎	15	30
⑥	○	○		10	20
⑦	△	△		10	20
⑧	□	□		10	20
⑨	×	×		10	20
⑩	◎	◎		10	20
⑪	○			5	10
⑫	△			5	10
⑬	□			5	10
⑭	×			5	10
⑮	◎			5	10

Measurement Change	15 Times				
Color Change	15 Times				
Waiting Time		0	0	150	
Operation Time					300
Working Time					**450**

Unit is minute
The gray color in the table is the waiting time

• Each process should produces 100 sheets per minute with the same speed.
• The set time for each process is 5 minutes. However, when there is no color change in 1st process, the set time will be 2 minutes.

• Compare the paused time between the method of batch production with common colors and the production method of preferentially proceed of purchase order with multiple processes.

3. Results

There was 30 minutes increase in the color changing time in the 1st Process. However, there was 150 minutes reduction in the waiting time for the 2nd and the 3rd Processes,which means that the production time for a working day was reduced for 120 minutes, in other words reduced for 21%. (Table 3) ***Units and Measurements***

Table 3	Common Production Method			Production Method of Jpacks			
	Minute	Step number	Total	Minute	Step number	Total	Difference
Color change in the 1st Process	3	5	15	3	15	45	30
Set change in the 1st Process	2	15	30	2	15	30	0
Set change in the 2nd Process	5	10	50	5	10	50	0
Set change in the 3rd Process	5	5	25	5	5	25	0
Waiting time in the 2nd Process	10	5	50	0	0	0	-50
Waiting time in the 3rd Process	10	10	100	0	0	0	-100
Total Operation Time	10	30	300	10	30	300	0
Production Time of a Working Day			570			450	-120

3.1. Creation of All-Round Worker and Holding Process with Many Steps

When the production method of preferentially proceed of purchase order with multiple processes is realized, the idle times that are normally dispersed throughout the production process are gathered together toward the end of each process (gray cells). Therefore, the workers are abled to engage with the steps for other processes. At this time, it will be possible to allocate more workers to the process that is normally a bottleneck, and can reduce the burden of the works and adjust the discrepancy in workload among the workers.

4. Production method with every process conducted in parallel

Production method with every processes conducted in parallel is the method where all the processes are operated at the same time, and the production is completed in one go from the beginning to the end. In the common method, there are moments where the work-in-progress piles up. But this proposed method conducts production straight from the beginning to the end. Therefore, it was named production method with every processes conducted in parallel.

For instance, in the production of 12,000 sheets for corrugated cardboard boxes requiring three processes, if 100 sheets can be produced in every minute, each process requires 120 minutes. In the common production method (Fig. 1 (b)), the work-in-process is stopped between each process, and its average production L/T is approximately 3 days.

On the other hand, the proposed production method with every processes conducted in parallel (Fig. 1), the time lag between each process is only for 1 pallet, if 1 pallet holds 500 sheets, the 2nd Process can be started only after approximately 5 minutes. Moreover, even if it takes extra 5 minutes for transportation and preparation, the 2nd Process can be started after 10 minutes in total, and the 3rd Process can be started approximately 10 minutes after that. Therefore, the production L/T is 150 minutes (Preparation process: 120min + 10min × 3 times).

In the common method, 1 process takes 1 day. Hence the whole production requires 50 hours and 10 minutes (3,010min). When the cycle time of a single sheet is compared, Production Method with Every Processes Conducted in Parallel is 150min ×60sec ÷ 12,000 sheets ＝ 0.75sec/sheet, while the common method is 3,010min×60sec ÷ 12,000 sheets ＝ 15.05 sec/sheet. This means our production method can reduce the production time to approximately 1/20 of the common method.

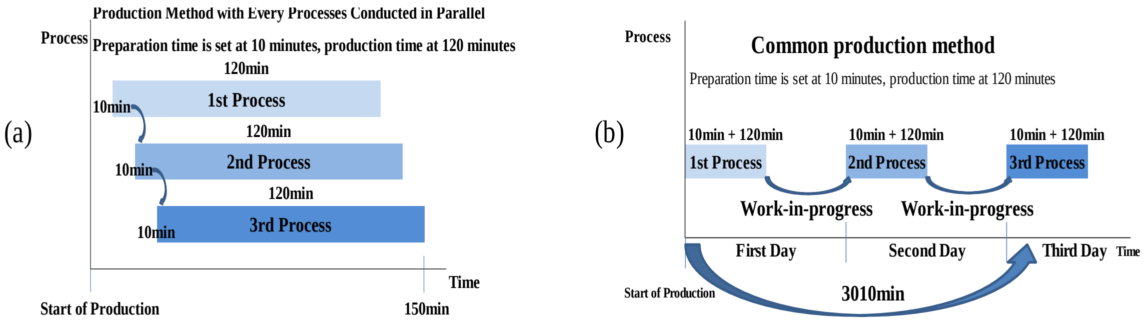

Fig. 1. (a) Production method of every process; (b) Common production method.

5. Batch production and single unit flowing production (Fig. 2)

Commonly, it is called batch production (method producing multiple lots in a batch), it is expected to reduce production cost with its stable and efficient process for mass production. However, there is little chance for small and medium size factories to compete with the large companies using the same production method, it is considered that they should strengthen their ability to produce diverse types of product in small lots.

In batch production, if for instance there is an assignment to deliver a case containing 500 sheets every day for five days, it is common to produce 2500 sheets on the first day, deliver the first 500 and store the remaining 2,000, shipping 500 sheets for the rest of the days from the storage. However, in this method, there is a need for in total 8 storing and shipping operation, and it also requires storage space and management of the stock. Moreover, it is inflexible in responding to the change in order (specification or quantity), and there are possibilities for demerits such as damage caused during storage. Especially, when producing products to be stored, it delays the starting of next lot and its completion, making it difficult to shorten L/T.

On the other hand, Single Piece Flowing Production is literally the method to produce with a single unit. For instance, in the case discussed above, this method will produce 500 sheets to be delivered each day, it will eliminate the production time for each lot’s production to be stored, making the starting time of the following lot to move up and quickens the start and completion of every process.

Furthermore, not only there will be no necessity for going back and forth for 8 times inside the factory for transport, it will also lead to reduction of transportation vehicles such as forklifts. In fact, at Jpacks, we managed to reduce forklifts from 5 to 2 without affecting the productivity. Commonly, lease fee for a forklift is around 30,000JPY per month, meaning it lead to 90,000JPY per month or 1,080,000JPY per year reduction of operational cost. In addition, this method eliminates the necessity for storage space, allowing us to utilize the storage space for expanding production capacity, leading to the increase in productivity as well as using the time for stock management for other tasks.

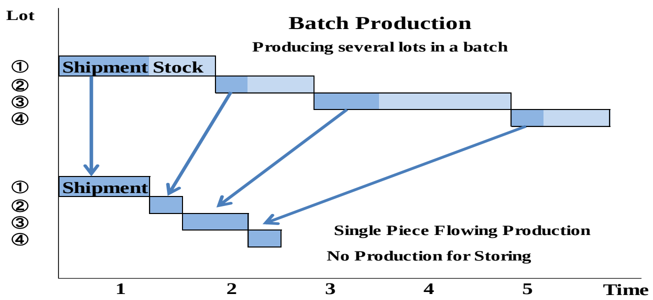

Fig. 2.Batch production.

6. Summary (Realizing Zero Storage of Complete Product)

At Jpacks, we normally receive orders from a single sheet to several tens of thousands sheets. By combining “Production method of preferentially proceed of purchase order with multiple processes”, “Production method with every processes conducted in parallel” and “Single Unit Flowing Production”, we managed radical reduction of L/T of every lots, and achieved zero storage of complete product.

Commonly, a corrugated cardboard factory is considered to be good when the sales-stock ratio is less than 10% at end of month inventory count. However, when there is no stocked product, it means funds equal to 10% of total sales is raised, leading to a considerable improvement of management.

Below is the formula for L/T under production methods of Jpacks.

$$T_{\mathrm{L/T}} = t_{\mathrm{s}} + \left\{\sum_{i=1}^{n} t_i + t_{\mathrm{p}}(n-1)\right\} \quad (1)$$

$T_{\mathrm{L/T}}$: Lead time, t_{s}: Time required for arrange purchase orders in the descending order of processes, t_{i}: Time required for each process, t_{p}: Time required for preparation between processes, n: Number of process.

In this paper, it is assumed that the time required for preparation between processes is the same. However, it is necessary to generalize following each production pattern in the future.

7. Conclusions

Win the Competition by Optimizing Management Efficiency-

Small businesses including Jpacks have limited management resource, and they often find themselves in a difficult situation. However, by delivering products much faster than other companies by using Jpacks Production System, which is a strength that must be fully utilized, it is possible to win the trust of users and survive the competition.

By employing the proposed methods, not only it will improve the sales, but it will also create extra time and space, producing additional value to the products that will serve the customers better. In the future, we aim to popularize this Jpacks Production System and benefit many companies.

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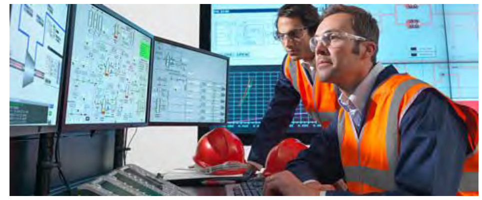
Improve paper quality, reduce raw material, energy, services and maintenance costs, and increase production efficiency with a package of solutions that provides the lowest total lifecycle cost available – Experion MX.

Crepe Structure Measurement



Experion MX Platform

Experion MX is a fully integrated quality control and process knowledge system that provides superior visibility into the papermaking process while it simplifies your operational efforts and is easy and cost effective to maintain and service. Crepe Structure Measurement is a completely new, unique sensor for Experion MX to optimize creping in real-time for improved production quality and efficiency. Improve paper quality, reduce raw material, energy, services and maintenance costs, and increase production efficiency with a package of solutions that provides the lowest total lifecycle cost available – Experion MX.

Crepe Structure Measurement - Model Q4224-50

Honeywell's Crepe Structure measurement analyzes tissue quality by capturing high resolution images of a moving sheet to identify important variables on creping process. These allow optimization of creping blade life while maintaining consistent quality. Longer blade running time means less blade changes and more quality production without process upsets. The sensor allows mill personnel to monitor tissue structure characteristics online throughout the entire production process, facilitating immediate corrective action if the quality deviates from targeted. Crepe Structure Measurement provides an excellent tool for tissue process optimization, troubleshooting and test runs for selecting optimal chemicals and process operating points in real-time.

The image control unit inside the sensor controls both the camera and the illumination unit for optimal image quality with varying machine speeds. Single-sided construction houses camera and illumination on same side of the sheet. The captured image is analyzed with proprietary algorithms, producing numeric indicators characterizing tissue crepe structure. Imaging and analysis computation are done by sensor processor unit in real-time. Numeric values of the measurements are then transferred to the system server for display, profiling and trending. Captured images are periodically transferred to the Experion MX system server for display.

Features & Benefits

- The sensor measures the following crepe structure characteristics:
  - Folds/length
  - Macro Crepe
  - Micro Crepe
  - Impurity
  - Caliper[1*]
- Sensor module camera and illumination automatically adapts to different machine speeds for the optimal image quality

- Standard sensor modular design allows installation in any slot inside the measuring head
- There are no moving parts in the sensor module, which minimizes maintenance needs and ensures a long lifetime
- Up to four images per scan are available in Experion MX from operator-defined cross direction locations for visual analysis and trouble-shooting
- An "Image Gallery" display shows 8 images each representing reel average crepe structure characteristics. These are displayed around grade dependent reference image for comparison
- In single point operation, images are transferred periodically at a fixed rate for operator observation

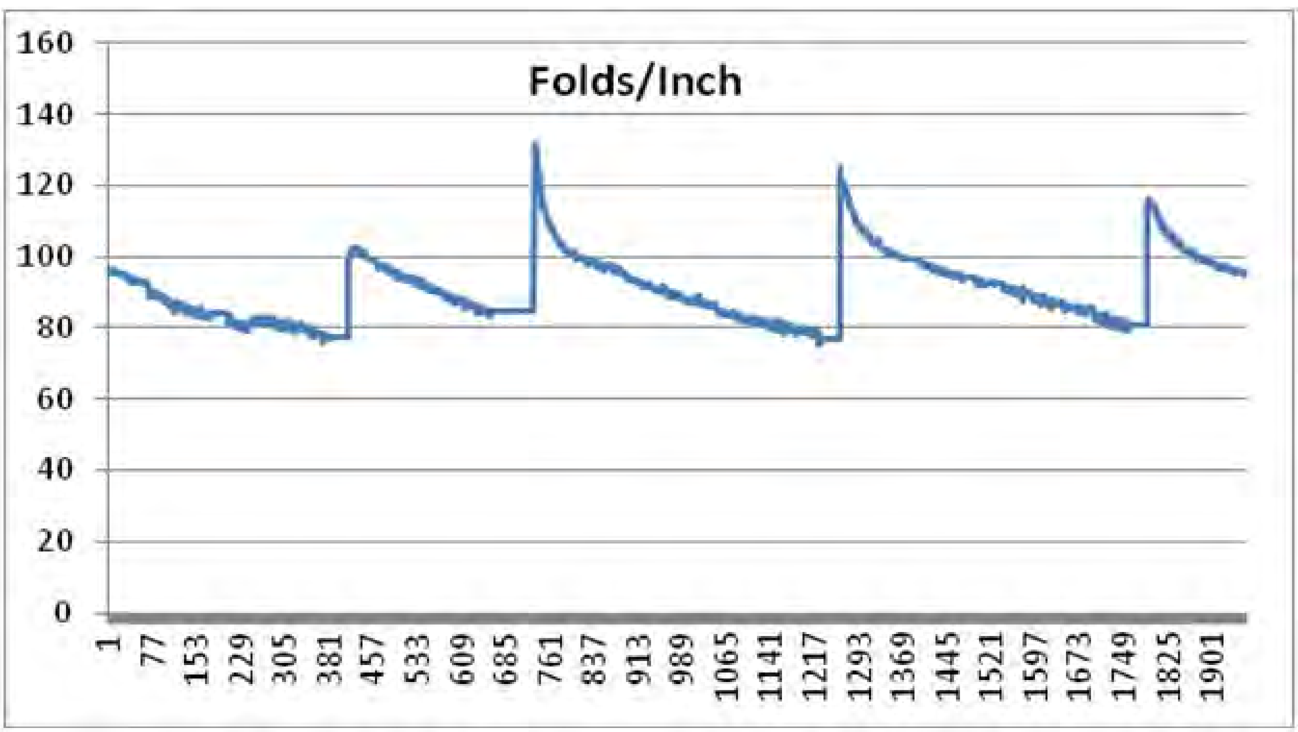
Description

The measurement is designed for online use in the challenging tissue machine environment. Fast image capture allows reel speeds up to 2600 m/min (8530 ft/min) without reduction of image quality. The measurement automatically adjusts illumination and imaging parameters for varying speeds. An intelligent operating algorithm mitigates the effect of uneven illumination, ambient light, and dirt/dust buildup. Images are captured and analyzed at the rate of 10 Hz.

Folds/length reports crepe folding per length unit (typically inches or centimeters). This correlates with creping blade wear: new blade produces high folds/length and worn blade low values. Macro and Micro Crepe indicate folding types categorized as in long and short wavelengths. Caliper indicates crepe dominant sheet thickness. With new blade macro and caliper are typically low and micro high. As the blade wears, macro and caliper will increase and micro decreases.

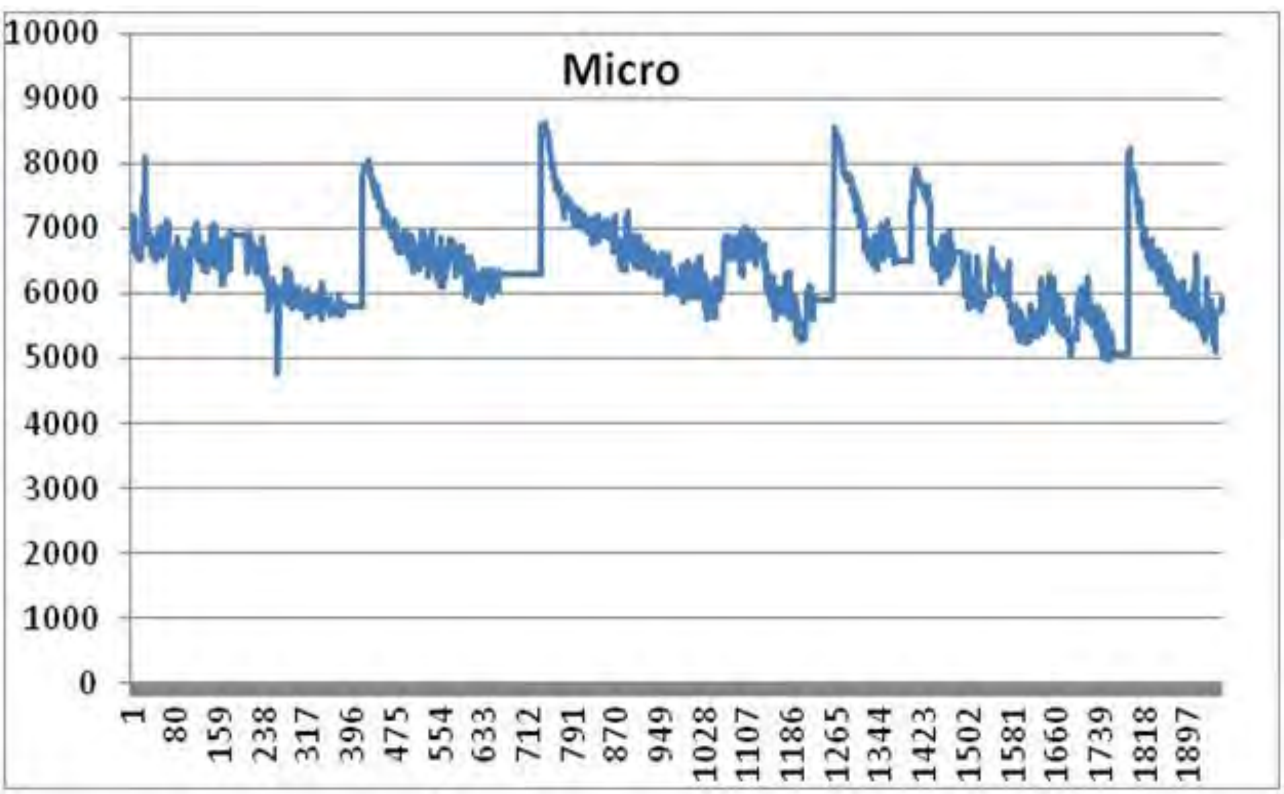
The system displays the latest captured surface image to operator for visual analysis.

1 Application dependent additional measurement*



Folds per inch. Upward peaks occur after creping blade change

Macro Crepe. Reading drops after creping blade change



Micro Crepe. Reading jumps up after creping blade change

Specifications, Model Q4224-50

Category	Specification
Measurement range	Folds/Lenght Range 0 - 2000 Macro Crepe Range 0 - 50000 Micro Crepe Range 0 – 50000 Impurity Range -100 - 100
	15 x 15 millimetres
Measurement speed	10 hz
Maximum ambient temperature	See scanner and measuring head enclosure specifications
Machine speed range	0 – 2600 m/min

For More Information
For more information on Crepe Structure Measurement, visit www.honeywell.com/ps or contact your Honeywell account manager.

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Paper Burning and Associated Pollution Problems in Higher Educational Institutions of Ethiopia; The Need and Potential for Recycling

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Higher educational institutions use large amount of paper for students' assessments each year. As recycling is one of the best options for efficient material utilization and waste management, the potential in higher education institutions was assessed taking Kotebe Metropolitan University (KMU) and Ethiopian Civil Service University (ECSU) as sampling site.

The aim was to evaluate the human health and environmental consequences of storing and burning assessment papers there by turning the cause of the damage to sustainable utilization through proposing recycling. Accordingly, the potential criteria air pollutant emissions while burning assessment papers, heavy metal concentrations in the ash of the burned paper and macro-nutrients were determined.

About 35,000 reams of paper is burnt in each of the institutions per year, and 69% of the respondents (instructors) were volunteered and were ready, to provide assessment paper for recycling which shows that there exists considerable potential for paper recycling in HEIs. Therefore, the researchers need to recommend that paper recycling should be taken as an integrated system of the activities in HEIs.

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Paper Burning and Associated Pollution Problems in Higher Educational Institutions of Ethiopia; The Need and Potential for Recycling

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Abstract

Higher educational institutions use large amount of paper for students' assessment each year. As recycling is one of the best options for efficient material utilization and waste management, the potential in higher education institutions was assessed taking Kotebe Metropolitan University (KMU) and Ethiopian Civil Service University (ECSU) as sampling site. The aim was to evaluate the human health and environmental consequences of storing and burning assessment paper there by turning the cause of the damage to sustainable utilization through proposing recycling. Accordingly, the potential criteria air pollutant emissions while burning assessment papers, heavy metal concentrations in the ash of the burned paper and macro-nutrients were determined using Aero-Qual series 300 in open burning at KMU, and Atomic Absorption Spectrophotometer at JIJE Analytical Testing Service Laboratory, respectively. It was found that the average emissions for CO (119.67 ppm), CO_2 (1700 ppm), SO_2 (038 ppm), VOCs (3749 ppm) and NOx (0.10 ppm) were recorded. The concentration of CO, SO_2 and NOx were significantly higher than the guidelines recommended by WHO and other international organizations. The paired sample t-test between white paper and the printed one showed significant difference ($p<0.05$) on the parameters CO_2 and NOx. Similarly, the heavy metal analysis result indicated that Cd (0.47 mg/kg), and Pb (0.48 mg/l) were detected from the ash of printed paper. Moreover, the average pH and macro-nutrients (NPK values) of the printed paper were 9.07, 0.83%, 40.88 ppm and 83.68 ppm respectively. About 35, 000 ream of paper is burnt in each of the institutions per year, and 69% of the respondents (instructors) were volunteered and were ready, to provide assessment paper for recycling which shows that there exist considerable potential for paper recycling in HEIs. Therefore, the researchers need to recommend that paper recycling should be taken as an integrated system of the activities in HEIs.

Keywords: Attitude; Paper recycling; Heavy metals; Air pollutants; Higher learning institutions

Introduction

Solid waste management is one of the basic essential services provided by municipal authorities to keep urban centers tidy. "The adverse impacts of waste management are best addressed by establishing integrated programs where all types of waste and all facets of the waste management process are considered together. The long-term goal should be to develop an integrated waste management system and build the technical, financial, and administrative capacity to manage and sustain it" [1].

Waste reduction is a fundamental tenet of sustainability, and recycling is an integral part of any solid waste management plan. It's one of the four Rs we are all familiar with: reduce, reuse and recycle, practiced in that order of importance [2].

Paper and cardboard are reported as the second largest component of domestic waste next to organic waste which contributes about 13% of the total domestic solid waste [2]. Similarly, waste composition data in different Universities show that paper alone constitutes more than 11% [3,4] which is still the second in volume compared to other solid waste components.

Developed countries have already started recycling papers efficiently. For example, the Sydney plant ark environmental foundation [5] reported that manufacturing paper and cardboard products from recycled material not only conserve trees, it also uses consumed up to 50% less energy and 90% less water than making them from raw materials. This report also stated that for every 100 reams of recycled office paper that is printed doubled sided, the savings are estimated at two trees, more than one tone of greenhouse gases and almost a cubic meter of landfill space, compared with using 100 reams of non-recycled paper or printing single-sided. Moreover, recycling practices in USA shows that recycling rate for office type paper is 74.2% in 2009 [1].

On the contrary, paper recycling practices are low in developing countries; rather they utilize recycled products imported from developed countries [6]. In addition, the waste collection method is reported as informal and in unorganized manner [7]. In the case of Ethiopia, there are no well-established waste paper recycling system, strategies and studies.

Higher educational institutions (HEIs) purchase considerable amount of paper each year which could require significant amount of budgeting. Assessment paper takes the largest share for the utilization of the paper that is openly burned after utilization which is not environmentally benign activity. Moreover, there could be ecological, social and economical advantage both for the recycling company, as it utilizes waste to establish a sustainable business and to generate income, and higher education institutions if the paper gets recycled and purchased back with a minimum cost.

Lack of such scientific knowledge and technology may let

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destruction of ecology /environment and economical/social benefits continue unnoticed. The current alarming expansions of universities in number and increasing consumption rate in Addis Ababa city and the entire country has initiated this study.

Therefore, integrated sourcing of used papers and purchasing of recycled papers among recycle companies and educational institutions should be made for the sustainable use of waste materials as a raw material for production, considering the environmental impacts of manufacturing including those associated with processing scrap paper and deinking.

Materials and Methods

General approach

This study was conducted in two governmental Universities in Addis Ababa: Kotebe Metropolitan University and Ethiopian Civil Service University. In addition to Universities, paper manufacturing companies and small scale paper recycling enterprises were also communicated to collect the data.

The data was collected from departments, property offices, president office, different departments, and finance and disbursement office of the two Universities by using pre prepared semi-structured questionnaire. In order to address the paper consumption pattern (the amount of paper purchased per year and allocated for assessment and other office activities per year for each university), a total of about 422 interviewed informants were selected after preliminary survey out of which 100 key informants (lecturers and above ranked instructors) were randomly selected from purposely selected colleges and faculties and assessed the awareness level, willingness to provide assessment paper for university delegated companies and reused the recycled paper for assessment and other office activities.

Determination of pollutants

The concentrations of the selected pollutants (CO, CO2, SO_2, NOx and VOCs) were measured using Aero-Qual series 300. Lead (Pb) and cadmium (Cd) were measured as they could be components included during ink manufacturing (Better paper project, 2015). Concentration of Pb, and Cd were determined in the sludge using furnace atomic absorption spectrometry and flame atomic absorption spectrometry. The PG-990 Atomic Absorption Spectrophotometer equipped with a graphite furnace and ASC- 990 auto-sampler for GFAAS and ASC-900 auto-sampler for flame was used for determinations [8] at JIJE Analytical Testing Service Laboratory.

Determination of pH and macro-nutrients on the sludge: Nitrogen, Phosphorus and Potassium (NPK) and pH values of the sludge were determined following the APHA [9] procedures at JIJE Analytical Testing Service Laboratory.

Data analysis

The collected data were analyzed and summarized using descriptive statistics using excel and significant differences at 0.05 levels was analyzed in paired samples t-test using SPSS version 20. Finally the results were reported in mean ± SD.

Results and Discussion

Quantity of paper purchased and used for assessment

From the sampled public Universities, KMU and ECSU, the amount of paper utilized per year for assessment and associated activities is presented in Figure 1. As it's indicated in Figure 1, the consumption rate as well as the burning rate of assessment paper is increasing annually which highly associated with the universities expansion and the increase in yearly intake of students. This is one indication of the amount of burned paper and associated risks (Table 1), and waste paper potential for recycling purpose.

Environmental emissions during burning paper

The 34% of the instructors responded that they manage waste papers by burning the assessment paper each year. Burning paper is not environmentally sound because during burning particulates and gaseous air pollutants are emitted to the atmosphere. Besides, recycling the paper provides double benefits. The first one is keeping environmental quality and the other one is that it can be used as a raw material to produce other paper based products rather than using trees. The potential gases that could be emitted during burning are measured and the report is presented in Table 1.

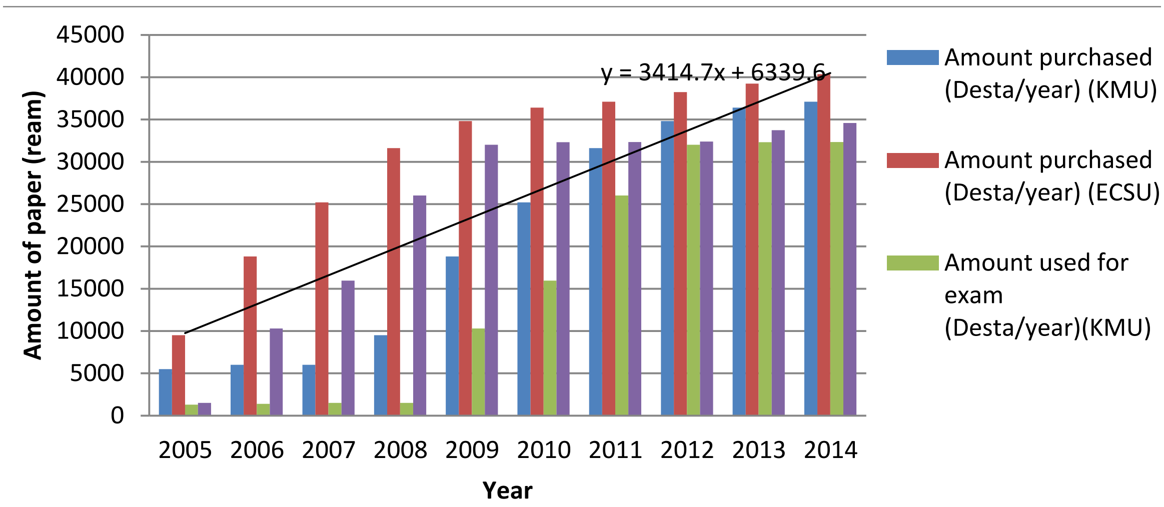

Figure 1: Amount of paper purchased versus used for assessment.

Pollutants	Concentration (ppm)		Paired sample t-test result		Guide line concentration (ppm)	Exposure duration
	White paper	Printed paper	t-value	p-value		
CO	84.67 ± 10.21	119.67 ± 26.31	2.917	0.100	9	8 hours
					35	1 hour
CO_2	384.33 ± 35.02	1700 ± 157.16	14.66	0.005		
SO_2	0.37 ± 0.16	0.38 ± 0.14	0.111	0.922	0.20	1 hour
					0.08	24hours
					0.02	1 year
VOCs	3047 ± 104.93	3749.33 ± 229.01	3.647	0.068		
NO_x	BDL	0.19 ± 0.03	1.110	0.383		

Table 1: Pollutants measured during paper burning.

Emission of CO, CO_2, SO_2, Volatile organic compounds (VOCs) and nitrogen oxides (NOx) were determined. These gases are selected as they are considered to be the criteria air pollutants (commonly emitted and detrimental to health) except CO_2. CO_2 is considered as it is the common greenhouse gas that has been given attention by the scientific community. As it can be seen from Table 1, the concentration of the air pollutants in this study is higher than the values in the guideline. If one is obliged to burn a paper, it is better to keep far away to minimizing the duration of exposure once it is ignited. Generally, the concentrations of each of the gaseous pollutants in burnt assessment papers are high enough to pose health risks. Therefore, it is better to recycle such papers than burning.

In addition, the concentration of each of the air pollutants emitted while burning the printed paper is larger than the non-printed one. This might be due to the additional pollutant produced by the printing ink. However, the difference is statistically significant ($p<0.05$) only for CO_2 and NOx (Table 1). This indicates that much of the ingredients in the printing ink are converted to CO_2 and oxides of nitrogen (NOx).

Total projected emission

The amount of gaseous pollutants released to the atmosphere annually is estimated by considering the total amount of assessment papers, and their potential concentration for the consecutive six years and the result is presented in Figure 2.

Estimated total emission of heavy metals per year

Not only air pollutants but also heavy metals on ash of burned assessment papers that could be mixed to soil were determined and results are shown in Table 2. It was found that the concentration of Pb and Cd in printed paper is significantly higher ($p<0.05$) than their corresponding concentration on white paper. The source for the additional concentration on printed paper could be the ink. Pb and Cd are among toxic heavy metals that results in detrimental health effects. Pb has a number of toxic effects, including inhibition of the synthesis of hemoglobin and adversely affects the central and peripheral nervous systems and the kidneys. Cd adversely affects several important enzymes; it can also cause painful osteomalacia (bone disease) and kidney damage. Inhalation of cadmium oxide dusts and fumes results in cadmium pneumonitis characterized by edema and pulmonary epithelium necrosis (death of tissue lining lungs) [10]. This shows that assessment papers had better be recycled than be burnt to prevent toxic metal exposure and the associated risks.

pH and macro-nutrients

The result showed that the pH of white paper is slightly alkaline (7.98) and that of the printed paper sample is quite alkaline with an average pH of 9.07 (Table 3). The pH, total nitrogen (TN), total

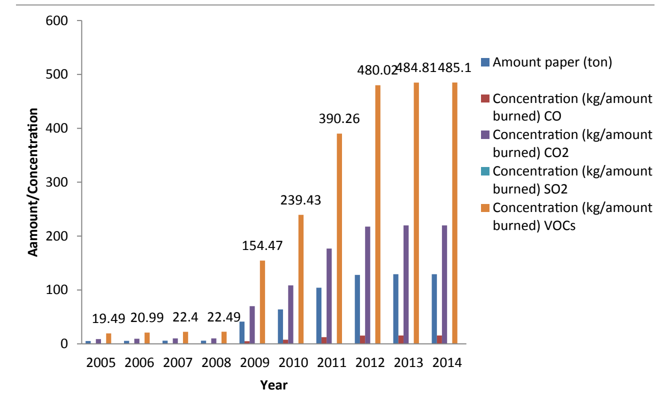

Figure 2: Annual projected gaseous pollutant emissions.

Heavy Metal	Concentration (ppm)		Paired sample t-test test result	
	White paper	Printed paper	t-value	p-value
Pb	0.39 ± 0.13	0.84 ± 0.16	4.041	0.046
Cd	0.33 ± 0.25	0.47 ± 0.24	15.11	0.004

Table 2: Heavy metal concentration on paper ash.

Heavy Metal	Value		Paired sample t-test test result	
	White paper	Printed paper	t-value	p-value
pH	7.98 ± 0.32	9.07 ± 0.24	2.092	0.172
Moisture content (%)	3.39 ± 0.15	2.89 ± 0.04	-	
TN (%)	0.17 ± 0.09	0.83 ± 0.06	15.684	0.004
TP (ppm)	23.49 ± 0.69	40.88 ± 1.38	36.039	0.001
K (ppm)	70.54 ± 1.83	83.68 ± 1.93	118.850	0.000

Table 3: pH and macronutrient level of white paper and printed paper.

phosphorus (TP) and potassium (K) content of the printed paper are higher than the one on the white paper. The paired sample t-test result indicated that the difference on the values of macro-nutrients on printed and white paper is significantly ($p<0.05$). This indicates that printed paper could be composted and used to fertilize acidic soils that contain sulfur which utilize Pb and Cd to precipitate in the form of PbS and CdS, respectively.

Instructors' perception and willingness on assessment paper handling

A total of 100 lecturers (46 and 54 work at KMU and ECSU, respectively) were participated in this assessment. Their perception on the use of assessment papers is presented in Figure 3. As it is indicated in Figure 3, only12 (12%) of the respondents were experienced in

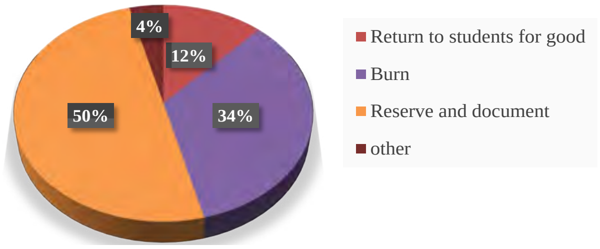

Figure 3: Instructors experiences on assessment paper.

returning the assessment paper for the students after correction to use it for future reference. Although, 50% of the respondents preferred to reserve and document the assessment papers in their offices after correction, they pointed out that they suffer from shortage of storage space and unpleasant odor results in decrease aesthetic value of the offices and health problems like asthma. Those who burned the assessment papers put the prevention of student dependency on the assessment papers in case they obtain, to get enough space for storage, to minimize unpleasant odor that cause health problems and to maintain the aesthetic value of the office as the main reasons. Moreover, 74.07% and 63.05% of the respondents of ECSU and KMU respectively, indicated that they are volunteer and ready to provide used paper to delegated company for recycling as indicated in Figure 4.

Conclusion

Based on the findings, it is possible to conclude that there is huge potential of waste paper for recycling in higher education institutions. The paper recycling projects could minimize the amount of criteria air pollutants (CO, SO2, NOx, VOCs) which are detrimental to health, and the greenhouse gas CO_2 as well as toxic heavy metals (Pb and Cd). On the other hand, printed paper contains significant amount of macronutrients which could be used for fertilizer for acidic soils after composting if recycling of paper is found to be difficult. Instructors' perception on the side effects of burning and storing assessment papers and their willingness to provide for recycling along with the huge amount of paper purchased and used for assessment is indication of availability of huge potential for paper recycling in HEIs [11-13].

Recommendation

- Recycling assessment papers can be an additional business development area in higher educational institutions. Therefore, to be economically efficient and environmentally sound higher learning institutions had better establish paper recycling enterprises independently or in co-operation. If establishment of recycling company is difficult, the waste paper could be composted for nutrient recovery and soil fertilization.
- Environmental science and related departments should raise awareness among instructors to submit assessment papers to working on recycling of papers enterprises.
- The established enterprise should agree to keep assessment papers save or cut in to small pieces till processing.

Acknowledgment

This work is based on the annual financial support of Kotebe Metropolitan University for research projects. The authors greatly acknowledge this institution. Key informants of the scientific community who willingly shared their valuable perceptions and scientific knowledge and provided information about the assessment paper status of their university are also duly acknowledged.

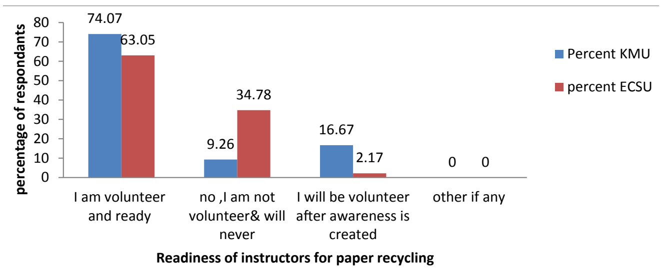

Figure 4: Volunteer and readiness to provided assessment paper for recycling company.

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Condensate Recovery: the unsung hero of boilerhouse efficiency

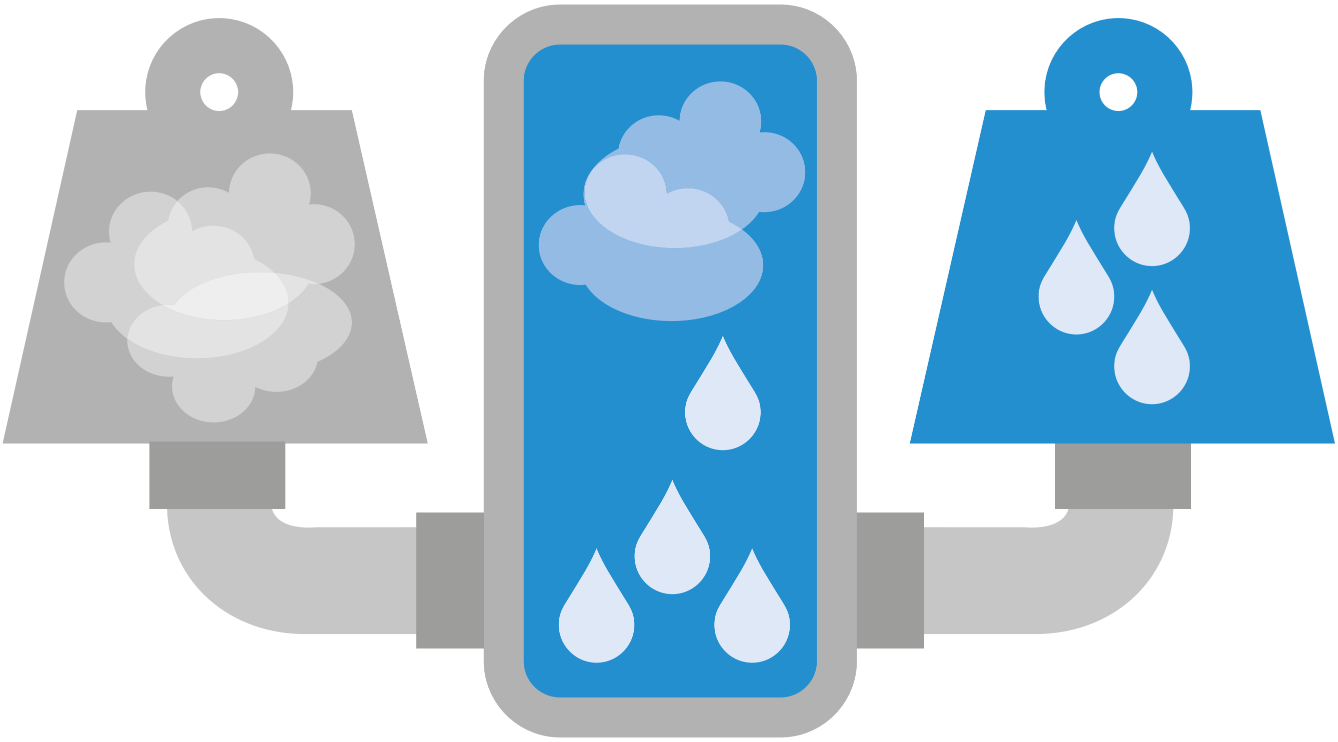
Striking the right balance between energy supply deals and productivity levels can make that crucial, tangible contribution to your company's revenue flow. However, at a time of economic uncertainty, many are maintaining use of ageing inefficient equipment rather than investing in new, more efficient machinery.

Wouldn't it be helpful therefore, to find a way to extend the life cycle of equipment, while simultaneously making our businesses more productive, driving down costs, complying with regulatory targets and improving our companies' environmental and public profile?

The good news is that truly efficient condensate recovery can help us to achieve all of these things, and at a far lower cost than we would imagine. In this white paper, we will find out how and why good condensate management can make a real difference to your steam system operations, and to your company's financial and managerial results.

Chris Coleman
Boilerhoue National Specialist
Spirax Sarco

spiraxsarco.com/uk



White Paper

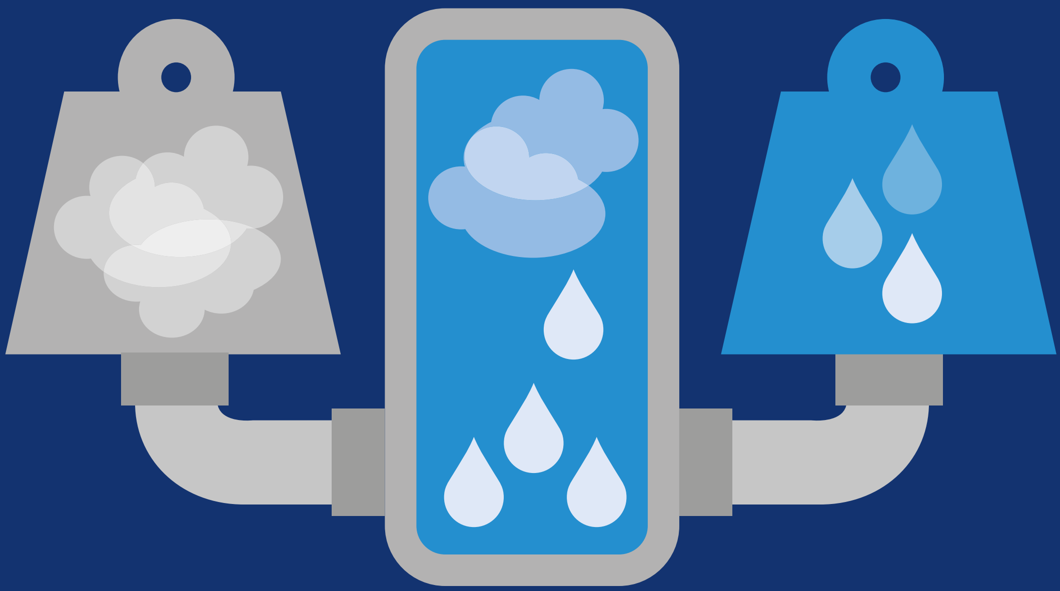
The unsung hero of boilerhouse efficiency

How condensate recovery can be a real game-changer in energy and facilities management

First for Steam Solutions

EXPERTISE | SOLUTIONS | SUSTAINABILITY

spirax sarco



First for Steam Solutions

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Introduction: What's this guide all about?

It's no longer enough to strike a good deal on energy supplies, or achieve high levels of productivity: now we are expected to do both, and at the same time comply with a complex web of regulation. Striking the right balance between these, of course, can make that crucial, tangible contribution to your company's revenue flow. Industry is changing, technologies are shifting, and with it the way that many sectors and organisations function. In an increasingly complicated economic and industrial landscape, those of us working in energy and facilities management are facing new and ever-increasing challenges. Given that many of us are dealing with ageing equipment, at a time when economic uncertainties can make it difficult to justify investment in anything new, these challenges are very significant and can be tough for us to deal with.

Wouldn't it be helpful therefore, to find a way to extend the life cycle of equipment, while simultaneously making our businesses more productive, driving down costs, complying with regulatory targets and improving our companies' environmental and public profile?

The good news is that truly efficient condensate recovery can help us to achieve all of these things, and at a far lower cost than we would imagine. In this white paper, we will find out how and why good condensate management can make a real difference to your steam system operations, and to your company's financial and managerial results. Ready?

Chris Coleman
Boilerhouse National Specialist

"LET'S GET STARTED!"

Summary of reasons for condensate recovery:

- Water charges are reduced
- Effluent charges and possible cooling costs are reduced
- Fuel costs are reduced
- More steam can be produced from the boiler
- Boiler blowdown is reduced and less energy is lost from the boiler
- Chemical treatment of raw make-up water is reduced.

> "TO PUT IT REALLY SIMPLY, CONDENSATE IS THE HOT WATER THAT FORMS WHEN STEAM PASSES FROM THE VAPOUR TO A LIQUID STATE."

What is condensate and why does it need to be managed?

When water first enters the boiler and is transformed into steam, this transformation is achieved by the action of the latent heat. The latent heat is the form of energy that changes the water from a liquid state to a gaseous state. The feedwater absorbs the latent heat, which turns it into steam. In many industrial steam applications, the steam moves through the system, where it transfers a proportion of its latent heat into whatever it is heating. In releasing that latent heat it then turns back into a liquid – or as we know it, condensate.

As we all know, condensate is hot, making it a valuable resource in terms of energy. Any loss of the latent heat within the steam system does not cause a temperature drop. So, when the steam turns back to the liquid state (or condensate) we will not see a temperature drop, because the sensible heat remains.

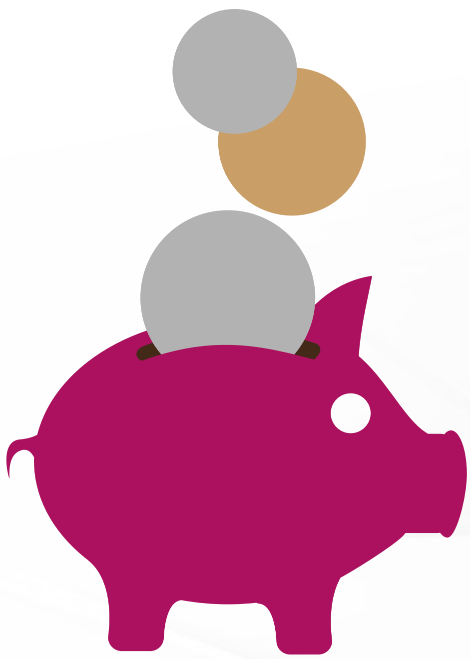
The condensate generated by the steam heating system will normally have about 25% of the energy that the steam had, and contains virtually no dissolved solids. Recovering and re-using as much of the condensate as possible can have huge advantages for you in terms of financial savings.

Where does condensate go?

> "IF THE CONDENSATE IS MERELY DISCHARGED FROM THE SYSTEM AND DISPOSED OF, THAT VALUABLE ENERGY RESOURCE IS THROWN AWAY WITH IT AND THAT IS AN ENTIRELY, EASILY AVOIDABLE WASTE THAT FEW OF US CAN AFFORD."

If condensate is drained away rather than reused, it can trigger water and effluent management costs which can be significant for many of us. Draining condensate can make it harder for us to comply with the regulatory standards around environmental effluent. In many countries, including the UK, condensate often has to be cooled before it can be drained which again may cost us extra. Put simply, we're throwing money away.

Since water and energy, both alone and in combination, are valuable resources, it simply doesn't make financial or managerial sense to tip them down the drain. So, how else can we put that energy and water to good use? This is what you do…



The uses of condensate

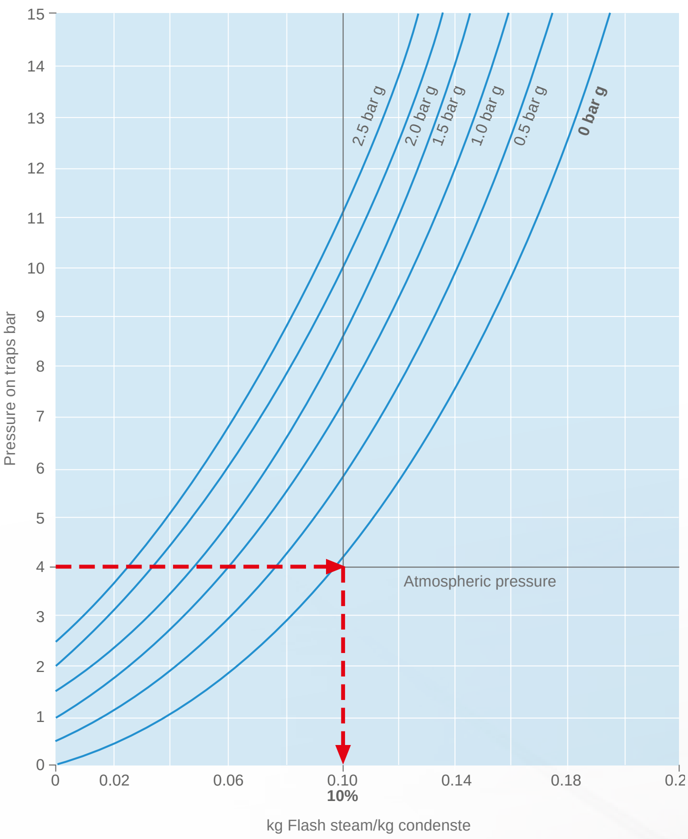
" BETTER STILL, GOOD CONDENSATE MANAGEMENT IS COST-EFFECTIVE AND GENERALLY STRAIGHT-FORWARD TO ACHIEVE, AS WE SHALL SEE. "

Boiler feedwater

If condensate is not used as feedwater, the boiler must be continually topped up with cold water, which is costly in terms of both water and energy. Cold feedwater must be heated. In contrast, condensate is already hot, so not only does it reduce the need for (and cost of) fresh water and treatment chemicals, it also requires much less energy than cold make-up water does to be ready for use. Indeed, re-using condensate in this way can reduce boiler fuel costs by 10–20%.

Or, to look at things differently, every 6°C boost in the temperature of the feedwater knocks 1% off a typical boiler's energy usage. Reducing boiler fuel demand has other benefits, too. It can bring down emissions of carbon dioxide, nitrogen oxides and sulphur oxides, which makes the entire process more environmentally friendly.

> ON TOP OF THE COST SAVINGS, YOU CAN PACK QUITE A PUNCH IN ENVIRONMENTAL BENEFITS TOO.

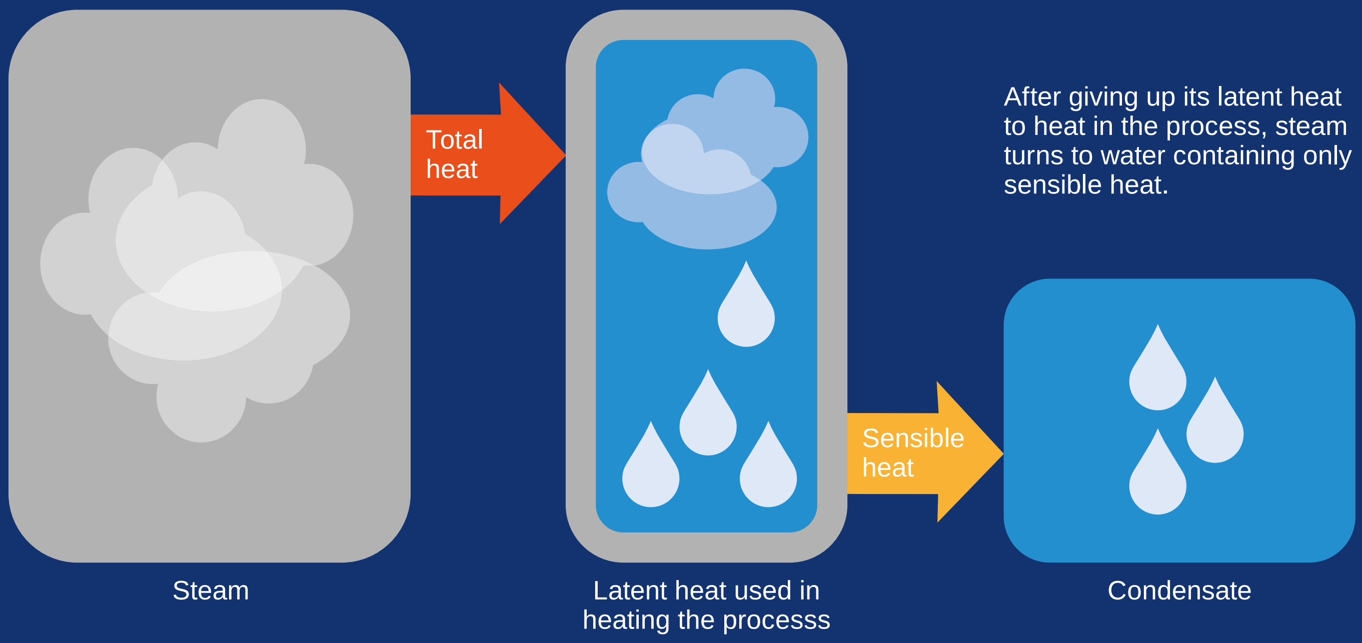


Flash steam recovery

Flash steam can be harvested and re-used. This is formed when high pressure condensate is exposed to a large pressure drop, often created during the blowdown process. A flash vessel is just one method that can be used to recover energy by separating flash steam from condensate. As condensate enters the flash vessel, flash steam is produced and can be piped from the top of the vessel to the feedtank through the deaerator.

We can fit float traps to the outlet of the flash vessel where residual blowdown water will be drained. The water will still be hot at this point and is allowed to pass into the plated heat exchanger where it gives up its heat to the circulating cold make-up water. In other words, if we use the hot water from the flash vessel, heat energy is recovered.

The use of both a flash vessel and plated heat exchanger pack will allow you to recover up to 80% of the energy from the rejected Total Dissolved Solids (TDS) water, which can also result in fuel savings, a reduction in carbon dioxide emissions, and the elimination of unsightly plumes of steam. So, on top of the cost savings, you can pack quite a punch in environmental benefits too.



The costs and benefits of recovering condensate

The higher the temperature of recovered condensate, the more it can contribute to the efficiency of your operation, so it's important to remove condensate promptly (before it can lose much sensible heat) and in as great a volume as possible. A good, efficient system should generate a recovery rate of around 80% - a good rate of return, in anybody's terms.

Of course, your situation is unique, and only a technical and financial assessment can determine the payback profile of your particular condensate recovery system.

"RECOVER UP TO 80% OF THE ENERGY REJECTED FROM TDS WATER."

- Fuel savings
- Reduced CO^2
- Eliminate unsightly plumes of steam

spirax sarco

Worked example:

The following worked example shows the potential savings of condensate recovery at a real UK site:

Steam supply: Two 454 kg/h boilers delivering up to 908 kg/h of steam
Condensate recovery potential: 400 kg/h (a conservative estimate)

Fuel savings:

The rate of energy saved by re-using condensate at

95°C, replacing cold feedwater at 10°C (based on a specific heat capacity of water of 4.186 kJ/kg) =
(400 x 4.186 x (95-10))/3600(seconds) = 39.53 kW

Assuming 75% boiler efficiency, generating 39.53 kW

would require gas equivalent to 52.71 kW.

Hours of operation = 24 hours x 5.5 days/week x 50

weeks = 6,600 hours

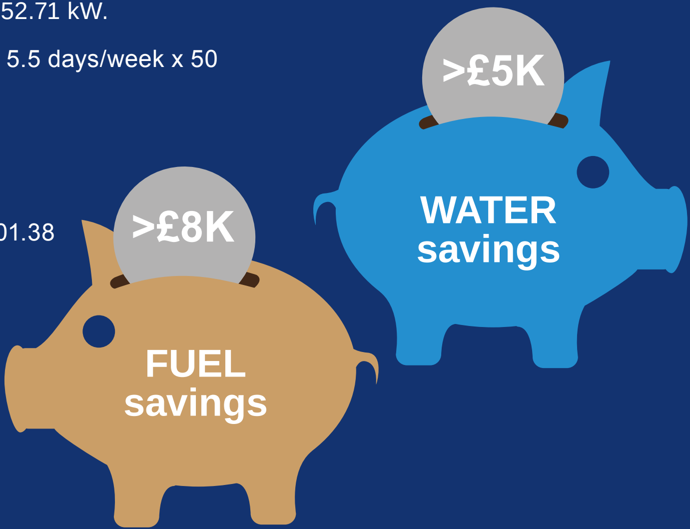
Gas price = 2.3 p/kWh

Cost of gas saved per year =
(52.71 x 6600 x 2.3)/100 = £8,001.38

Water savings:

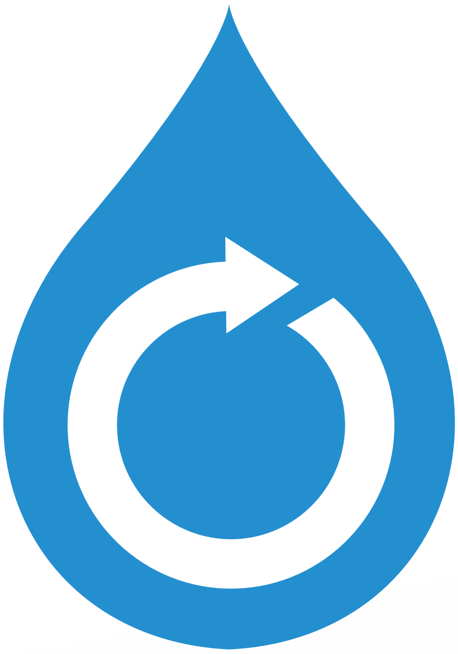
Water and effluent costs = £2.00 per m3

Annual water cost savings =
(400 x 6600)/1000 = 2640 kg x £2.00 =
£5,280.00



TOTAL COST SAVINGS: **£13,281.38** PER YEAR
(Not including boiler blowdown and additional savings in water treatment chemicals.)

What about contamination?



If we reuse condensate, how many of us worry about putting contaminates directly into the boiler? This is a genuine concern. Condensate can pick up contaminates, and contaminated feedwater can cause problems such as corrosion and carryover.

There are two very effective ways you can overcome this challenge.

1. The first is to fit conductivity or turbidity meters to an existing condensate return system to detect contamination. Whenever it is detected, the contaminated condensate is automatically dumped before it reaches the boiler. This solution can be fine-tuned according to the nature of the operation.

2. Another approach is to recycle only the heat energy from contaminated condensate. This is done using heat exchangers, which ensure the heat is captured before the contaminated liquid is disposed of.

"IF WE REUSE CONDENSATE, HOW MANY OF US WORRY ABOUT PUTTING CONTAMINATES DIRECTLY INTO THE BOILER?"

How is condensate recovered?

So, we've talked about the benefits of condensate, but how is it recovered? Here's a simple step-by-step process.

Step 1

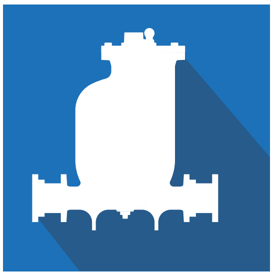
Steam traps are used to remove condensate from the steam system

Steam traps are perhaps the most important part of this process. Their job is to remove condensate and incondensable gases from the system at the appropriate time while leaving in place the steam that is central to the heating activity. Condensate and incondensable gases must be removed efficiently, since they can cause corrosion, poor heat transfer and other problems if they are left in the system. A good first step in any condensation recovery plan is a steam trap survey which will identify areas for improvement/upgrade, and estimate potential financial gains.

Steam trap surveys

A steam trap survey will help to keep a system running smoothly and will almost certainly reveal impressive savings through reduced fuel consumption, fuel emissions, water, and effluent charges. For example, an analysis of 50 Spirax Sarco steam trap surveys revealed potential annual energy savings of £28,400 per survey on average. The average payback time on each survey, including the cost of replacement products and their installation, is around two months when all upgrade work is completed.

Step 2



Pumps return condensate to the boiler feedtank

Ideally, condensate will run away from steam traps via gravity but where this is impossible the condensate must be lifted to a higher level. Sometimes, pumps are needed to achieve this. Depending on your unique operating environment, there are several types used, often in combination. These include: electrical condensate pumps, mechanical condensate pumps, and automatic pump traps.

Step 3

Feedtank heating and deaeration

In the feedtank, condensate is mixed with other feedwater to heat it. The most efficient way to heat and deaerate is using a deaerator head, which mixes returned condensate, flash steam and cold makeup water as they are fed into the feedwater tank.

While this outlines the basic process, there are other points to bear in mind.

Step 4

Flash steam can also be recovered

Flash steam is released from hot condensate when the pressure of that condensate drops, for example when it is being discharged from the main steam system. Using a flash steam system is one of the most energy efficient ways of extracting heat from condensate before it goes back into the feedwater tank.

Step 5

Pressurised low-loss condensate recovery can boost benefits

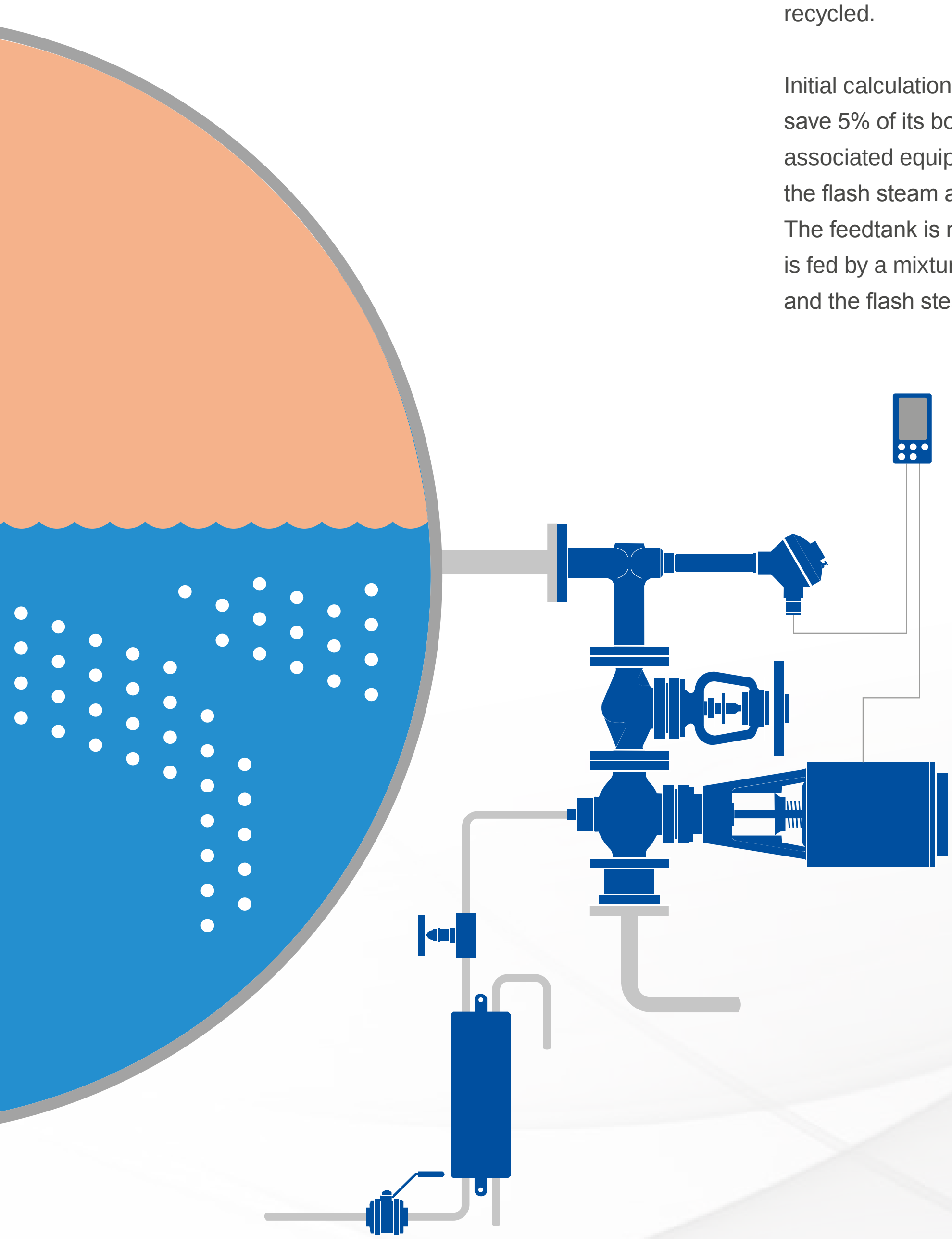
I know from extensive experience in the field that huge savings in annual fuel and water costs, ranging from £17,000 for a small system, to £160,000 for larger systems, are possible, along with significant savings in carbon dioxide emissions. Payback times for such systems have been very short, sometimes less than a year.

Case Study

Food production

A British bakery has knocked almost 6.5% off the combined cost of energy and water to its boiler, thanks to the installation of a flash steam recovery system. The system, commissioned by Spirax Sarco, recovers the flash steam generated by TDS blowdown from the main boiler at the company's site in Bicester. Previously, this flash steam was being discharged, rather than recycled.

Initial calculations predicted that the British bakery would save 5% of its boiler costs by installing a new flash vessel and associated equipment that would enable the company to recover the flash steam and return it to the boiler feedtank.
The feedtank is maintained at 85°C by injecting live steam, and is fed by a mixture of returning condensate, cold make-up water and the flash steam recovered from the TDS blowdown water.



Conclusion: Unlock the next level of steam efficiency

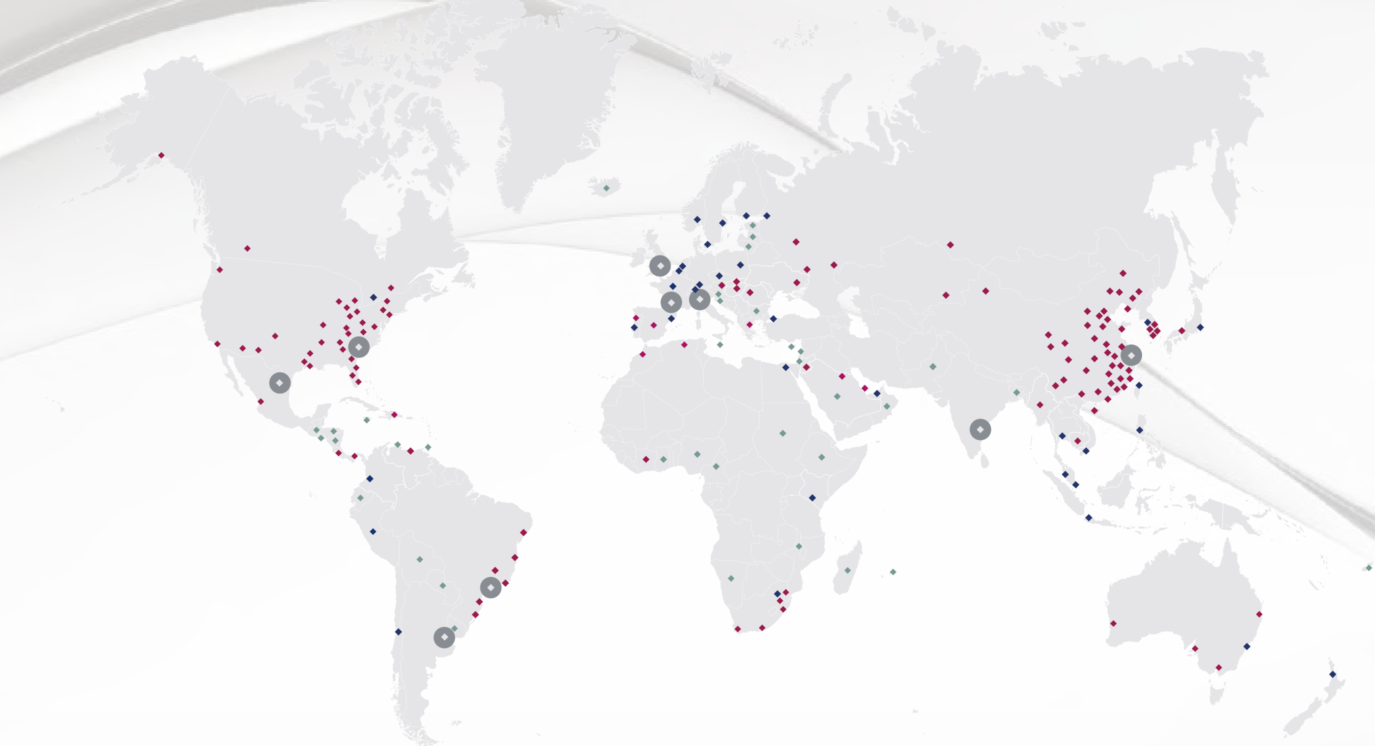
All of us, whether you're an energy manager, plant supervisor or maintenance manager at any level, are now facing more challenges than ever. Chief among these are the needs to manage costs, maximise productivity, extend equipment lifecycles without unacceptable loss of equipment performance, and generally contribute to the revenue flow. On top of this, technologies are shifting and there's an ever-increasing body of regulation to comply with, covering areas from health and safety to environmental protection.

These challenges aren't going to go away anytime soon. So, it makes sense for all of us to take every possible step to save money and make sure your plant or energy centre is adding real value to your business. It's only by doing this that businesses can become cleaner, more efficient, and more profitable. Condensate recovery is one process that absolutely lends itself to this approach, and will generate substantial savings and operational advantages to all of us who use steam systems.

Of course, there has to be a degree of strategy and logic involved, but that's why we've built up the expertise to help you determine what your specific system, set up and performance will be. It's a creative exercise, so keep that in mind if you get bogged down in technicalities. This might seem like a huge undertaking, especially when resources are limited, but as we've outlined, there are plenty of economical ways to not only get started with condensate recovery, but to continue the momentum in the years to come.

Chris Coleman
National Boilerhouse Specialist

spiraxsarco.com



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Noise and the Ear

Robert MacKinnon

National Institute for Health Research Nottingham Hearing Biomedical Research Unit

We only have one pair of ears, and they have to last us a lifetime. They are remarkable organs that allow us to hear, and we must take care that the sounds that we expose ourselves to will not cause them harm.

This article will discuss sounds that could potentially damage our hearing as loud noise. Such noise can be unwanted (for example, noise from loud machinery at work) or it could be desired (like listening to music with the volume turned up). You can be exposed to noise at work, or with leisure pursuits (eg loud music, motorcycling, DIY, pubs/clubs). It is important to identify which noise can be damaging to hearing, and how to go about reducing the risk of damage.

www.tinnitus.org.uk

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BTA BRITISH TINNITUS ASSOCIATION
A WORLD LEADER IN SUPPORT AND ADVICE

Noise & the ear

Robert MacKinnon
National Institute for Health Research Nottingham Hearing Biomedical Research Unit

This leaflet has been written to help you understand more about the effect of noise on your ears and the connection with tinnitus.

Introduction

We only have one pair of ears, and they have to last us a lifetime. They are remarkable organs that allow us to hear, and we must take care that the sounds that we expose ourselves to will not cause them harm.

This leaflet will discuss sounds that could potentially damage our hearing as loud noise. Such noise can be unwanted (for example, noise from loud machinery at work) or it could be desired (like listening to music with the volume turned up). You can be exposed to noise at work, or with leisure pursuits (eg loud music, motorcycling, DIY, pubs/clubs). It is important to identify which noise can be damaging to hearing, and how to go about reducing the risk of damage.

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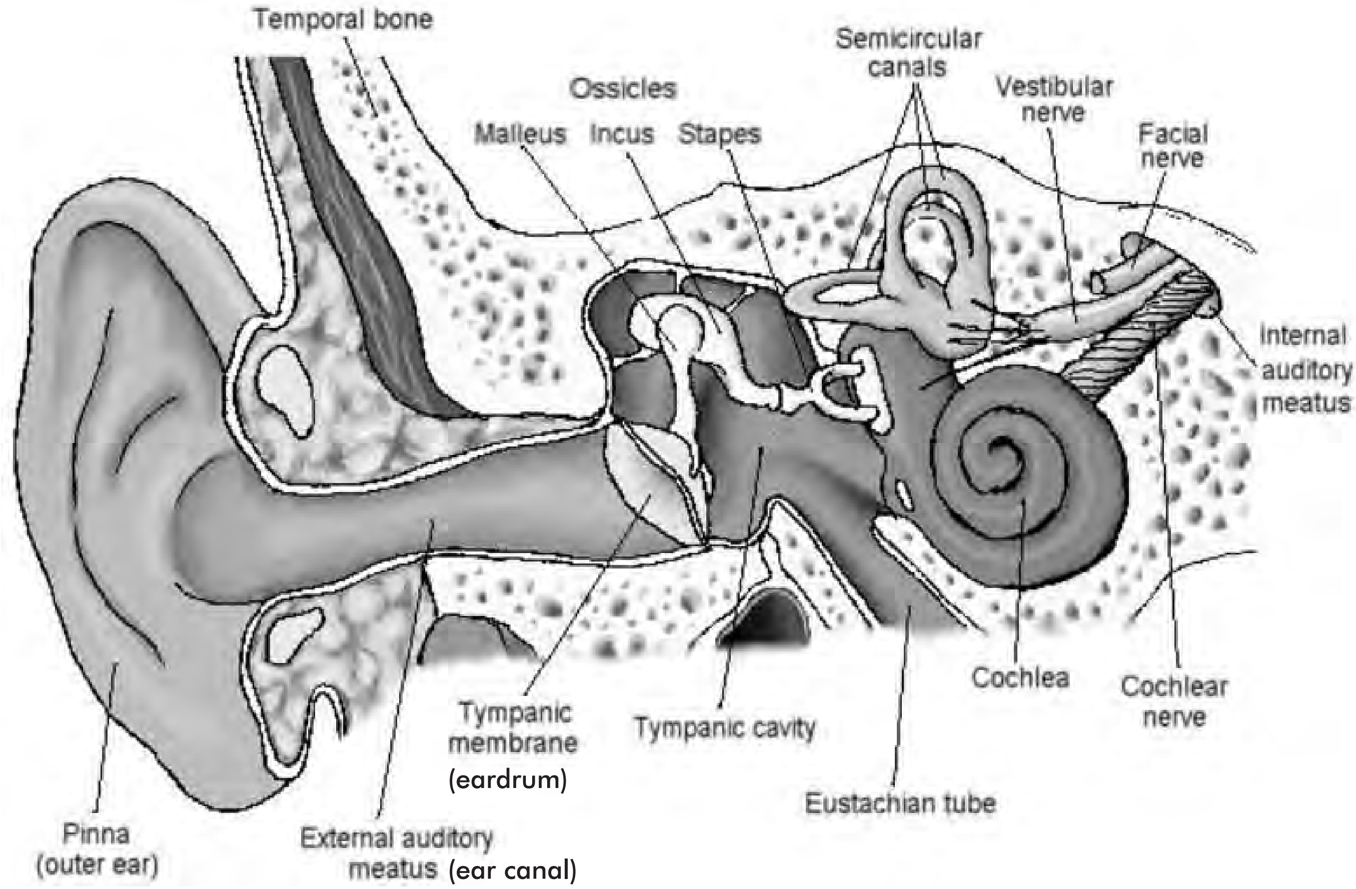
Your ears



The ear consists of three parts:

1. **The outer ear.** This is the visible part of the ear on the side of the head (called the *pinna*) and the external ear canal that goes inside the head, ending at the eardrum. This part of the ear channels the sound vibrations into the ear and onto the eardrum.

2. **The middle ear.** This is composed of the eardrum and the three smallest bones in the human body (called the hammer or *malleus*, the anvil or *incus* and the stirrup or *stapes*), which are held in an air filled space in the head. The middle ear helps to boost the vibrations at the eardrum into stronger vibrations that can be better detected by the inner ear. The *stapedial reflex* causes one of the ligaments in the middle ear to tense which helps reduce the intensity of very loud sound.

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3. **The inner ear.** The hearing part of the inner ear is called the *cochlea*. This is a fluid filled spiral structure that is pushed on by the stirrup or *stapes* of the middle ear. The vibrations that are delivered to it are turned into electrical signals by specialised cells called *hair cells*. These electrical signals are then sent along the cochlear nerve to the brain. One of the functions of the hair cells is to amplify quiet sounds. They also try to moderate the signal generated by loud sounds. However, if sounds are very loud, these hair cells can be overwhelmed and may end up permanently damaged. This can be by a single loud sound or by repeated exposure to loud sound.

These three parts enable the ear to hear a wide range of pitch of sound and a very wide range of 'loudness' of sound, from the gentle rustling of a leaf to the roaring jet engine of an aeroplane. However, as sounds get louder, there is a risk of these sounds damaging our ears. The risk of damage is associated with the 'dosage' of sound or noise received.

Noise dosage

The 'dosage' of noise exposure is dependent on two main things:

1. the 'volume' or intensity of the noise
2. the time or duration of the exposure to that noise.

The intensity of a noise can be measured by comparing its sound pressure (the change in air pressure caused by the sound) to that of the quietest sound that can be heard. The intensity of sound is measured in *decibels* (dB). Decibels are what's called a logarithmic unit, and this means that an increase of 3dB in a sound means that the sound intensity is doubled. So a sound of 88dB is twice as intense as a sound of 85dB.

Noise exposures are a combination of the intensity and the duration of the noise exposure. Most international regulations for noise exposure at work state that the loudest noise someone should be exposed to for an 8-hour working day is 85dB - roughly equivalent to a blender, or a milling machine. Now, as we saw before, a 88dB sound is twice as intense as a 85dB sound, so it follows that the maximum exposure duration should be half as much, so 4 hours. This rule of halving the maximum exposure duration for every 3dB increase (so doubling) in sound intensity is true for noises up to around 110-120dB. Above this, even a very short exposure time can be damaging.

A table of maximum exposure time for a range of noise intensities before damage may occur

Noise intensity (dB)	Maximum unprotected exposure*	Typical example
85	8 hours	blender, milling machine
88	4 hours	forklift truck
91	2 hours	Tube train
94	1 hour	lawnmower
97	30 minutes	industrial fire alarm
100	15 minutes	bulldozer, handheld drill
103	7½ minutes	mp3 player at full volume
106	3¾ minutes	motorbike
109	112 seconds	crying baby, jackhammer
112	66 seconds	live rock band
115	33 seconds	emergency vehicle siren

* before damage may occur

Measuring the duration of exposure is quite easy. However, it is hard to measure noise intensity without specialist equipment, so how do you recognise whether noise is loud enough to be damaging?

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Identifying loud noise

There is no definitive method to identify whether a noise is loud enough to be damaging without taking a proper measurement, but below are a few ‘rules of thumb’ to help you identify what is too loud:

1. If you have to shout to be heard by somebody around a metre away, the background noise is loud enough to be potentially damaging. If you can only hear or be heard above the noise when shouting right next to the ear, the intensity is very loud indeed and is even more likely to be damaging your hearing.
2. If you find your hearing is dulled after exposing yourself to noise, then your hearing has been damaged. This may be temporary, but if you expose yourself repeatedly to these situations, the damage may become permanent. You should speak to your GP if concerned (and your human resources if the noise is work related) as you may need a hearing test. If this noise exposure will be repeated, ear protection should be used.
3. If you find a ringing or buzzing in your ears (*tinnitus*) after exposing yourself to noise, then the noise is likely to have been damagingly loud. Avoiding further exposure is strongly advised, as is speaking to your GP if you are concerned.
4. Use common sense! If a sound is painfully or uncomfortably loud, stop exposure immediately. If you find you are getting a headache, feel uncomfortable, or are at all concerned about the intensity of the noise, remove yourself from the situation and the noise exposure.

Consequences

Exposure to loud noise can have consequences for your ears, the most obvious of which is hearing loss. If noise is the suspected cause, this is termed *noise-induced hearing loss*. Exposure to loud noise can damage the hair cells in your cochlea, resulting in a hearing loss at certain frequencies.

The hearing loss can be temporary, and recover within a day or two, or permanent, and not recover at all. Even if the hearing loss is temporary, it should be taken as a warning that permanent damage is likely if this exposure is repeated. Such hearing loss makes it harder to hear the quieter sounds encountered in daily life, and can make it harder to understand speech, particularly in background noise. There is also evidence that noise exposure can damage the nerve fibres that go from the cochlea to the brain, and that this damage doesn't necessarily show up in hearing tests such as an audiogram.

In addition to hearing loss, there are other risks from loud noise exposure. Loud noise exposure can sometimes cause a ringing or buzzing in the ears called *tinnitus*. Sometimes tinnitus goes away after a few minutes or hours after a loud noise exposure. However, sometimes it can persist for weeks, years, or even indefinitely, especially if you have a noise-induced hearing loss.

To avoid such damage, simple steps can be taken to reduce the risk posed by loud noise exposure.

Prevention

There are several practical steps you can take to minimise your risk of damage to your ears caused by loud noise exposure.

1. If possible, remove yourself from the noise, reducing the time of exposure. Stopping your exposure to a noise that you think may be damaging is the best way to avoid problems.
2. If removing yourself from the source of noise isn't possible or

practical, make sure you take frequent breaks from the loud noise. This gives your ears a chance to recuperate, and reduces the effect of the loud noise a little.

3. If you are going to be in a noisy environment (eg clubbing) wear hearing protection to reduce the intensity of the noise. Even if you are going to be exposed to a loud noise once (eg a concert), strongly consider wearing hearing protection because you will be exposed for a damaging amount of time. Buy ear plugs or ear defenders that are made for the task from a reputable seller. Cotton wool won't do anything to help! You must use proper hearing protection. For those who enjoy loud music, go clubbing or who are musicians, you can buy specially moulded earplugs that do not affect the balance of the sound. Sometimes audiology departments can arrange for these to be made for a reasonable price.

4. If you are going out, for example to a noisy pub or club, try to limit alcohol consumption and remain well hydrated. Both alcohol and dehydration can make your hair cells in the cochlea more vulnerable to damage.

5. Limit the time and volume when listening to music through earbuds or headphones. As earbuds are placed directly into the ear this can boost the audio signal by as many as 9dB. Larger earmuff-style headphones are to be preferred. Another protective measure is to adhere to the 60/60 rule, which simply put means never turn your volume up past 60%, and only listen to music with earbuds for a maximum of sixty minutes per day. You can also get noise-cancelling headphones which will allow you to listen to music for a longer extension of time, at a much lower decibel level.

6. If you are at work, your employer has a responsibility to protect your hearing and make sure you are not exposed to excessively loud noise. You should be issued with hearing protection if the noises you are exposed to are loud enough to be damaging. You must wear

this hearing protection if it is issued.

7. If you are concerned in any way about the effect of noise exposure on your hearing, or about tinnitus, get medical advice. Normally this means speaking to your GP in the first instance. They should be able to help investigate any problems you may be experiencing. Cease loud noise exposure in the meantime if possible.

Summary

This has been only a brief explanation of what loud noise is, its effects on your ears, and how to minimise the risk posed by loud noise exposure. Prevention is much better than treatment. By mitigating the risks fewer people will experience noise-induced hearing loss and tinnitus.

You've only got one pair of ears – look after them!

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Whilst the BTA makes every attempt to ensure the accuracy and reliability of this information, it is not a substitute for medical advice. You should always see your GP/medical professional.

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Alternative formats

This publication is available in standard print and audio formats on request.

For further information

Our helpline staff can answer your questions on any tinnitus related topics on 0800 018 0527 or info@tinnitus.org.uk

The Health and Safety Executive have lots of information about noise and hearing protection, including advice for employers and employees. Their website is http://www.hse.gov.uk/NOISE/index.htm

BTA publications

Our information leaflets are written by leading tinnitus professionals and provide accurate, reliable and authoritative information which is updated regularly.

Please contact us if you would like to receive a copy of any of our information leaflets listed below, or they can be downloaded from our website. Leaflets are available in standard print or large print.

- All about tinnitus
- Balance and tinnitus
- Complementary therapy for tinnitus: an opinion

Whilst the BTA makes every attempt to ensure the accuracy and reliability of this information, it is not a substitute for medical advice. You should always see your GP/medical professional.

- Drugs and tinnitus
- Ear wax removal and tinnitus
- Flying and the ear
- Food, drink and tinnitus
- Hearing aids and tinnitus
- Hyperacusis
- Information for musicians
- Musical hallucination (musical tinnitus)
- Noise and the ear
- Other sources of support
- Otosclerosis
- Pulsatile tinnitus
- Relaxation
- Self help for tinnitus
- Sound therapy (enrichment)
- Sources of mutual support for tinnitus
- Supporting someone with tinnitus
- Taming tinnitus
- Tinnitus and disorders of the temporo-mandibular joint (TMJ) and neck
- Tinnitus and sleep disturbance
- Tinnitus and stress
- Tinnitus services

Leaflets for children:

- Ellie, Leila and Jack have tinnitus (for under 8s)
- Tinnitus (for 8-11 year olds)
- Tinnitus (for 11-16 year olds)

We are a registered charity and currently receive no government funds to support our work. The production and distribution of this leaflet is subsidised by kind donations from our supporters. If you would like to help us to support others with tinnitus please consider making a donation online at **www.justgiving.com/bta** or by sending a cheque/postal order to the address at the foot of this leaflet. Thank you on behalf of the UK tinnitus community.

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HEATWAVE ALERT - BRITISH DRIVERS RISK SUN BURN ... EVEN IF THE WINDOWS ARE CLOSED!

Dangerous UV rays can still pass through glass windscreen and windows and cause skin damage, so drivers who spend hours in their cars during summer months are advised to take precautions, such as applying sun cream before long journeys.

www.edriving.com

SUMMER DRIVING PUTS UK MOTORISTS AT INCREASED RISK OF SKIN DAMAGE ON RIGHT SIDE OF THE BODY

- TEST REVEALS HOW LONG TERM EXPOSURE TO THE SUN WHILE DRIVING CAN LEAD TO WRINKLES, LEATHERING, SAGGING, BROWN “AGE” SPOTS AND EVEN SKIN CANCERS ON THE RIGHT SIDE OF THE BODY … EVEN WHEN WINDOWS ARE CLOSED

- MORE THAN A QUARTER OF MOTORISTS (26%) ADMIT SUFFERING SUNBURN IN THE CAR WITH ALMOST ONE IN SEVEN (13%) ADMITTING TO ROLLING DOWN THE WINDOWS TO CATCH A TAN [1]

- OVER HALF (53%) OF MOTORISTS ARE UNAWARE THAT THEIR SKIN CAN GET SUN DAMAGED WHILE INSIDE THE CAR - EVEN WITH THE WINDOWS CLOSED

Motor savings experts **confused.com** and leading skin cancer charity Melanoma UK have teamed up to raise awareness of skin damage to the right side of the body while driving in the sunshine – even if you aren’t lucky enough to own a convertible!

The message to cover up could not be more critical this summer as new research reveals over a quarter (26%) of UK motorists have suffered from sunburn while on the road, with 13% saying they have deliberately rolled down the car window to catch a tan. [1] One in seven (14%) drivers has even stuck their arm (or another body part) out of the car window in order to achieve a better tan, with almost a third (29%) of those sun worshippers having had an accident or near miss as a result.

Worryingly, a whopping four in five (81%) UK drivers say they have never been concerned about skin damage whilst travelling in a car on a sunny day, whilst over half (53%) are entirely unaware that this can occur even when the car windows are closed.

According to leading dermatologist Dr Christian Aldridge, a representative from Melanoma UK, glass – like clouds - does not protect you from UV radiation. These damaging sun rays can still pass through windows putting motorists at risk of asymmetrical sun damage as a result. Glass effectively blocks UVB, and windshields are specially treated to block UVA as well, but a car’s side and rear windows allow UVA to penetrate. [2]

For years, dermatologists have observed that patients in the US often have more sun damage on the left side of their faces than on the right, which can lead to wrinkles, leathering, sagging, brown age spots and even skin cancers. [3] One study showed the side of the body next to the window received up to six times the dose of UV radiation compared to the shaded side. [4]

While we aren’t as fortunate as our American cousins when it comes to our yearly supply of sunshine, British drivers do need to be aware of the dangers of sunburn when driving in the height of summer or during a heatwave. One in seven drivers (14%) don’t apply sun cream whether inside or outside of the car even if the weather is nice.

Therefore, Confused.com turned to Melanoma UK to test the skin of British drivers – comparing the right side of their face, shoulders and arms to the left which is shaded when driving.

Dr Christian Aldridge carried out an in-depth skin examination on individuals using UV photo technology to pick up on areas of sun damage not visible to the naked eye. Worryingly, results taken from a van driver from South Wales detected pre-cancerous cells on his right forearm - the arms most typically exposed to the sun - which was consequently treated. The research also highlighted the protective benefits of sunscreen when driving. Amanda Stretton, a former racing driver and Motoring Editor at Confused.com who regularly uses cosmetics containing SPF had little to no sun damage in comparison when tested.

Melanoma UK facts:

- In 2015, around 2,400 deaths due to melanoma
- Over 14,500 new cases were diagnosed last year
- Around 6 in 10 of all people who die of the disease are under 75 years old.
- In the UK, death rates from melanoma in people aged 75 and over have more than quadrupled in the last 40 years
- Melanoma is now the 5th most common cancer in the UK. When the parliamentary task force on melanoma met for the first time in 2010, it was envisaged that we would reach this point by 2020 - here we are, four years ahead of time.
- More than 6 in 10 non-melanoma skin cancer deaths are in men.
- One bad burn in early years can lead to melanoma in later life.

References

[1] One Poll carried out research of 2000 UK motorists with driving licenses between 07.07.16 and 11.07.16 on behalf of Confused.com

[2] The relatively long-wavelength UVA accounts for approximately 95 per cent of the UV radiation reaching the Earth's surface. It can penetrate into the deeper layers of the skin and is responsible for the immediate tanning effect. Furthermore, it also contributes to skin ageing and wrinkling. For a long time it was thought that UVA could not cause any lasting damage. Recent studies strongly suggest that it may also enhance the development of skin cancers. Source **http://www.who.int/uv/faq/whatisuv/en/index2.html**

[3] **http://www.skincancer.org/prevention/are-you-at-risk/sun-hazards-in-your-car**

[4] Moehrle M, Soballa M, Korn M. UV exposure in cars. *Photodermatol Photoimmunol Photomed* 2003;19:175-181.

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Leadership Resiliency: Handling Stress, Uncertainty, and Setbacks

In this uncertain world, problems and setbacks are never far away. How do you respond when things don't go according to plan? This short piece has some tips and suggestions for how to build resilience and be better prepared for the uncertainties life throws at us all.

www.ccl.org

"We live in very uncertain times," says CCL's Lisa Sinclair. "The question isn't how can you avoid difficulty and stress — that's nearly impossible to do. The question is, 'How do you face it?'"

Change is ongoing, plans unravel regularly, and your expectations don't always get met.

"The work priorities shift, the players change," Sinclair says. "You could be transferred, reassigned, or — who knows — will there even be a job?"

And of course, personal setbacks and crises don't go away just because work is already difficult. We often get an unwanted double dose, with setbacks facing us at home and work.

"All of us can benefit from becoming more resilient — better able to face our struggles, recover, and adapt," Sinclair continues.

Resiliency is also a business issue. People who can't handle a fast pace or uncertainty won't perform at their best in many modern organizations. They may be more likely to call in sick and perhaps feel unmotivated when they're working. Stress lowers productivity and increases health problems (and healthcare costs). And when people in leadership positions are angry, reactive, or anxious — in other words, not resilient — it sets the tone for how others interact, react, and get work done. It influences our ability to make decisions, affects our interpersonal interactions, and impacts our ability to see the big picture.

It's contagious.

Our ability to cope with stress, difficulties, roadblocks, criticism, rejection, or change is improved when we take better care of ourselves. One way to do this is to focus on overall well-being and building energy across multiple dimensions: physical, mental, emotional, and social. Here's the framework that participants in our Leadership Development Program use to come up with ideas for building their resilience and helping others to do the same:

1. **Sleep.** What can you do to conserve energy overall? Get between 7.5 and 8.5 hours of sleep each night. Set a regular sleep schedule, even on weekends. Disconnect — park those devices far from the bed. Create a relaxing environment that's dark, cool, and quiet.

2. **Physical**. What can you do to build your physical energy? During the workday, get up and move every 90 to 120 minutes. Suggest a walking meeting. Climb stairs instead of taking the elevator.

3. **Mental.** What can you do to overcome mental fatigue and exhaustion? Learn anything new. Solve a challenging puzzle. Find positive distractions such as hobbies or time with friends. Try meditation.

4. **Emotional.** What can you do to become more conscious of your emotional triggers? Figure out who and what pushes your buttons. Step away, slow down, or enlist an ally to help you control your reactions and choose your response. Create a gratitude journal. Cultivate kindness — do something nice for someone else.

5. **Social.** What can you do to create more meaningful and productive relationships? Ask a colleague for advice, give positive feedback, or share something you learned about yourself recently.

Still unsure of what to do to become more resilient? Sinclair suggests taking another page from the Leadership Development Program participants' workbook as a starting point:

Recall a time in your personal or professional life when you were able to overcome, prevail, bounce back, or rise above a difficult situation. Then ask yourself:

- What happened?
- What was I thinking and feeling at the time?
- How did I get through it?
- What did I do that helped me get through that situation?
- What did I learn from the experience that made me a more resilient person today?

"You have the resources within you to become more resilient," Sinclair says. "But it does take some effort to learn or remind yourself what will work best for you and it requires you making time for yourself."

3 Best Resiliency Practices When 'Bad Stuff' Happens

Our team members have had many opportunities to put this approach to resiliency to the test.

Back in 2006, one future CCL leader endured the unexpected loss of her father, declined an ideal promotion, left a wonderful organization, and moved across the country to help her mother. She found herself jobless while dealing with a crumbling marriage that eventually ended in divorce. Several years later, she became a CCL senior faculty member, a passionate speaker on the value of resilience. Like her, we advocate for these 3 best resiliency practices:

1. **Personal energy management.** Manage your own resistance. "Show up," give your best, and relinquish attachment to the outcome. Stay in the present. Exercise compassion for yourself and others.

2. **Shifting your lenses.** Take charge of how you think about adversity. Understand your beliefs about the situation and choose your response.

3. **Sense of purpose.** Develop a "personal why" that gives your life meaning. This helps you better face setbacks and challenges. Also, look for ways that crisis and adversity may connect to your larger life purpose.

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Products & Services

Dynasonics TFX-500w Ultrasonic Flow Meter

Bell Flow Systems is now offering the New Dynasonics TFX-500w Ultrasonic Clamp-on Flow Meter

Launched by US manufacturer Badger Meter, the new Dynasonics line product is a versatile, cost-effective solution for measuring water flow in industrial applications.

Providing an economical solution for measuring water flow bi-directionally in a variety of applications, this new model is remarkably easy to install - thanks to its clamp-on design. As a result, there is no requirement to tap or cut the pipe. Simply attach the meters sensors to the outer structure of the pipework to complete the installation. This makes the TFX-500w ideal for existing projects, as retrofitting to existing systems is simple and quickly completed, removing the requirement for any system shut down time. Furthermore, there is no loss of pressure as a result of the non-invasive design of this ultrasonic flow meter. The TFX-500w is capable of measuring flow rate, velocity and water flow with precision and accuracy. Finally, a large and user friendly display screen completes the design.

The TFX-500w is available in sizes 1/2 inch to 10 inch, and can function in a temperature range of -40 to 70 °C. It is capable of measuring flow from 0.38 to 37,000 L/min. Data communications options include Modbus RTU and BACnet MS/TP. It also supports full integration with the Badger Meter BEACON® and AquaCUE® Advanced Metering Analytics (AMA) cloud-based software suites. The front panel buttons control the programming of the TFX-500w, or alternative by programming it via USB cable using SoloCUE® configuration software.

Thanks to its flexible range of sizing and temperature handling abilities, the TFX-500w is an extremely versatile flow meter. The Dynasonics TFX-500w is well suited to a range of applications. Typical examples include water systems, wastewater effluent, agricultural irrigation and industrial discharge.

Further information on the Dynasonics TFX-500w

Contact us at Bell Flow Systems or visit our website for more information on the Dynasonics TFX-500w Ultrasonic Clamp-On Flow Meter.

LQ800 Multi Channel Water Analyser Controller - New From ECD

Introducing the new Model LQ800 Multi Channel Controller from ECD. The LQ800 provides a complete analytical fluid measurement and process solution, designed to operate with up to eight digital analytical and process sensors. The measurement parameter options include above 50 unique separate liquid measurement sensors including: pH, ORP, conductivity, resistivity, dissolved oxygen, selective ion, turbidity, flow, and also level, alongside many other fluid analytical measurements. Complete with varying configurations for each given application, as can be seen in full on the LQ800 data sheet.

The LQ800 Controller digitally communicates with any ECD Intelligent Sensor. Configuration for the correct parameter is then possible via the menu and display screens. This smart technology makes using the device hassle-free, and simple to operate.

Features of the LQ800 Multi Channel Controller

- Multiple Analytical & Process Measurements. Complete measuring & control system featuring up to 8 smart digital analytical & process sensors.
- Touch Screen Colour Display. Featuring easy and intuitive menu navigation.
- Built-in Analytical Calculations. Easy selection of mathematical functions. Simply convert dissociation, cross-sensitivity, and concentration.
- Multiple, Field Programmable Outputs: Digital communication, multiple relays, discrete digital outputs, with 4-20 mA outputs, and also data logging.
- Expandable. Easily create larger control systems with the ability to inter-connect to other LQ800 Systems and ECD on-line analysers.
- Web Enabled. Access via web with remote monitoring and interface with personal handheld devices, for example via mobile phone. Allowing you access whenever and wherever you are.

For further information visit the **https://www.bellflowsystems.co.uk/** or contact our sales team on **sales@bellflowsystems.co.uk**

Making Low Flow More Efficient – GSPLF Sealless Pump

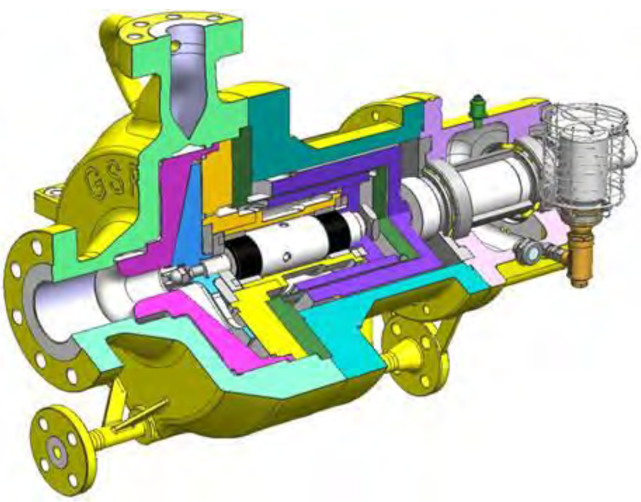
Combining the proven technologies of Sundyne Barske Wheel hydraulics with the HMD Kontro sealless magnetic drive, the GSPLF (LF for Low Flow) sealless pump has been developed to fill a gap in the market for a high-efficiency low flow magnetic drive centrifugal pump with a single stage high head capability. The GSPLF meets the requirements of API 685 and has full ATEX compliance, making it ideal for chemical and hydrocarbon processing applications.

Sundyne has over 50 years of experience in offering Barske Wheel pumps, designed to provide efficiency in the low specific speed regime often referred to as low flow, high head applications. These pumps have an open impeller with straight blades and a tapered conical diffuser to produce the desired performance. Development and testing demonstrates that this combination produces a head factor (ratio of developed head to theoretical head) considerably higher than that of traditional back-swept Francis vane impellers.

The combination of Sundyne Barske Wheel hydraulics with the HMD sealless magnetic drive, reliability, design flexibility, and efficiency is further optimised, ensuring trouble-free, safe and environmentally conscious plant operation. An additional advantage of the GSPLF is the flexibility inherent in the diffuser and impeller combination, which can easily be rerated should the duty point change without replacing the pressure casing.

HMD Kontro has more than 25 years' experience in API applications and a 70 year track record in magnetic drive technology, being the first company to develop a magnetic drive sealless pump.

Further information, including a copy of the GSPLF brochure can be seen and downloaded from the Sundyne HMD website at www.sundyne.com/hmdkontro. Alternatively, please telephone +44 1323 452141 or email vince.lee@sundyne.com.



Spray Nozzle People Re-brand Reflect Wider Product Range

Spray nozzle specialist BETE Ltd is re-branding to now trade as **THE SPRAY NOZZLE PEOPLE (SNP)**. BETE Fog Nozzle, a leading American manufacturer of spray nozzles, remains a key supplier and their nozzles are still available exclusively through SNP in the UK, Ireland, France and Spain.

SNP has grown over the years and, for some time now, has supplied more than just Bete Nozzles. Included in the SNP range now are couplers and nozzle holders from **Uni-Spray**, automated tank cleaning systems from **Dasic Tank Clean** and specialist paper industry nozzles from **ML Gatewood**. As a result of this expansion sharing the name with their initial principle manufacturer makes less sense, hence the rebranding to Spray Nozzle People which better reflects the breadth of products and solutions now available.

SNP's marketing director Ivan Zytynski said: *"The Bete product range remains central to the Spray Nozzle People and our rebranding is in no way indicative of any changes in the relationship with Bete Fog Nozzle. It is simply the case that we need to take into consideration the brand equity of our other key suppliers. Therefore, we have opted to develop an independent brand serving and promoting multiple manufacturers brands. Apart from the name change its business as usual."*

More details at: **http://www.spray-nozzle.co.uk/spray-nozzles**
Or contact: **ivan@spray-nozzle.co.uk Tel: +44 (0) 1273 400092**

L&W Bending Tester Code 160

L&W Bending Tester measures a material's resistance to bending. This can be done either by measuring the force needed to bend a test piece to a predetermined angle, or by measuring and determining the bending stiffness, which is an elastic property of the material. Bending resistance and stiffness affects the product performance in many converting operations and is important in handling and protection purposes of packaging products.

Unique features

L&W Bending Tester is quick and easy to use. The instrument is controlled through pushing one button on the instrument panel. The most common configurations are pre-set at the factory.

It has some unique features:

- Automated testing sequence to minimize the operator influence.
- Pneumatic clamping, for better repeatability.
- Retractable support, for perfectly horizontal positioning of samples.
- Automatic touch; no manual adjustment of load cell knife to the test piece is needed.
- Faster testing and operator independent measurements.
- Will always measures at exact required angle.
- Large, easy-to-read display
- Integrated printer which automatic print-out the test results
- Report all angles during one measurement
- Statistics
- Result on computer output
- PC-program "plot2XL" to receive data from instrument and to send it to Microsoft Excel

Measures creaseability too

Creasability evaluation using L&W Bending Tester code 160: a crease prevents board surface from cracking during box folding. Well defined folding lines, which facilitate the folding operation

Creasing variables

- the height and width of the creasing ruler
- groove width
- matrix thickness
- the accuracy and the hardness of the make-ready
- the pressure of the die-cutter
- paperboard thickness
- type of paperboard

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Bionetix® AeroBooster-O_2 Supplies Oxygen to Ponds and Wastewater

Oxygen is a key ingredient for healthy aerobic conditions in wastewater treatment plants, sewers, holding tanks, ponds, and lagoons. When oxygen is lacking, anaerobic conditions easily set in, allowing the formation of hydrogen sulphide, ammonia, and other chemicals that release bad odours and are toxic to aquatic life (oxygen deficiency causes mortalities and slow growth of fish and shrimp). When oxygen is abundant, it is easier for microorganisms to carry on biodegradation of contaminants and biological removal of excess nutrients, promoting cleaner ponds, more efficient wastewater treatment, and healthier aquatic species.

To encourage these beneficial aerobic conditions, Bionetix® International has released a new biostimulation product called AeroBooster-O_2. AeroBooster-O_2 supplies ponds and wastewater with an oxygen source to promote aerobic conditions, reduce bad odours, and accelerate the digestion of contaminants.

The slow-release supply of oxygen provided by AeroBooster-O_2 boosts the growth of biomass — helpful microorganisms that speed up the biodegradation of contaminants and excess nutrients in ponds and wastewater. AeroBooster-O_2 also fights bad odours by accelerating the oxidation of odorous substances such as hydrogen sulphide, ammonia, and other chemicals that form in anaerobic conditions. The product is stable in storage, easy to use, and can be handled without risks.*

AeroBooster-O_2 can be used to improve aerobic conditions in a variety of applications, including Ponds, Sewage, Wastewater Lagoons, Wastewater Treatment Plants, Holding Tanks, and Aquaculture.

While AeroBooster-O_2 can promote better aerobic conditions on its own, it is specifically intended to boost the performance of bioaugmentation products such as Bionetix's line of BCP natural wastewater treatments. Each BCP bioaugmentation formulation is designed to target and degrade specific types of waste common in certain industries (e.g., BCP55 for starch degradation, BCP11 for chemical waste, BCP25 for dairy waste, etc.). Non-pathogenic bacteria in the BCP products release special enzymes that digest contaminants subsequently used by the bacteria for energy and reproduction. Carbon dioxide and water are released as non-hazardous by-products.

By adding AeroBooster-O_2 to the water treatment equation, pond owners and wastewater facilities can encourage more efficient waste degradation processes that result in cleaner ponds, healthier biomass, and more efficient wastewater treatment plants. This breath of fresh oxygen may be just what is needed to provide an aerobic boost to an overwhelmed pond or wastewater system.

AeroBooster-O_2 should be initially applied as a full shock dose and then continued at half-strength to keep the situation stable. For the quickest oxidizing effect, AeroBooster-O_2 should be applied directly to the pond or wastewater. Varying dosages can be applied to address high anoxic conditions or to reduce sludge.

To learn more about Bionetix® products, please visit:
http://www.bionetix-international.com/

Cortec® Introduces EcoShield® Super Barrier Paper and Linerboard: An Environmentally Friendly Replacement for Polycoated and Waxed Papers!

Moisture is a major threat to raw materials and finished goods of all kinds—particularly those made of metal and prone to rust and corrosion. Greases and oils sometimes used as lubricants or rust preventatives on metal components add another problem by threatening to leak through packaging and contaminate surrounding areas. Waxed or polycoated papers are traditional moisture-resistant packaging options for problems like these. However, such coated papers pose an environmental problem because they are not recyclable and repulpable. Even if recycled back into the pulp and paper stream, they would first have to go through a costly process of separating the paper base from the coating.

To avoid this environmental problem, Cortec® Corporation has developed an environmentally acceptable replacement to unrecyclable polycoated and waxed papers. Cortec's new high gloss EcoShield® Super Barrier Paper and Linerboard relies on a water-based moisture barrier coating for moisture resistance. The technology makes the paper fully recyclable and repulpable without requiring costly processes to remove the coating from the paper. In addition to recyclability, Cortec's EcoShield® Super Barrier Paper and Linerboard demonstrated better water vapour barrier properties than polycoated paper and waxed paper during testing.

To evaluate the moisture resistance of EcoShield® Super Barrier and Linerboard, the barrier paper was tested against a comparable polyethylene coated paper and a commercial waxed paper according to ASTM E-96 at 73°F (23°C) and 50% relative humidity. The EcoShield® Super Barrier Paper and Linerboard showed a water vapor transfer rate of 0.32-0.37 grams per hour on a square meter of paper. A polycoated paper in the same test allowed slightly more water vapour to pass through in the same time frame, at the higher rate of 0.47-0.71 grams per hour. The waxed paper was much less resistant to water vapour, allowing it to transfer at a rate of 6.5-6.9 grams per hour on the same size of paper. Though it is not intended for applications involving constant water contact, the shiny side of EcoShield® Super Barrier Paper and Linerboard also has the ability to repel liquid water. Its TAPPI T-441 Cobb Water Absorption rate is less than 0.3 grams of water per square meter in 2 minutes.

The versatility of EcoShield® Super Barrier Paper and Linerboard as a flexible, moisture barrier material allows it to be used for a variety of packaging applications and beyond:

- Protecting moisture sensitive components
- Wrapping oily or greasy parts
- Lining wood pallets or corrugated boxes
- Packaging products
- Keeping work surfaces clean with a disposable cover

To find out more about EcoShield® Super Barrier Paper and Linerboard, please visit:
https://www.cortecvci.com/Publications/PDS/EcoShield_Super_Barrier_Paper.pdf

To find out more about Cortec's innovative packaging products, please visit:
http://www.cortecpackaging.com/

AXA unveils new forklift truck safety initiative

AXA Insurance has teamed up with CCTV and telematics firm VUE to launch a new safety initiative aimed at reducing forklift truck accidents.

As part of the scheme, AXA and VUE are offering companies video and telematics technology that allows them to monitor forklifts and driver behaviour much more closely.
Two cameras are placed on the forklift, one forward facing camera and one driver facing camera placed at the top of the driver cab. The cameras are hooked up to an online system so incidents can be reviewed immediately.

Meanwhile, a black box records the speed, braking, location and other relevant data in order to rate the performance of forklift truck drivers. Like the camera footage, driver ratings can be viewed on an online dashboard.

The roll out of the technology follows a successful trial with a number of AXA customers who are seeing positive changes in driver behaviours and a reduction in forklift truck accidents.
According to the Health and Safety Executive, 42% of work-related fatalities involve workplace transport. From March 2017 to March 2018, AXA received 281 claims from incidents involving forklift trucks.

> "Our work as an insurer goes much further than selling products and paying claims. Our aim is to make sure our policyholders minimise their risks and, more importantly, stay safe. Forklift truck accidents can result in life changing injuries for employees and have a lasting impact on their families.
>
> "Our partnership with VUE on forklift truck safety fits our ethos perfectly and we are encouraged that our pilot has already shown the impact proper monitoring can have on behaviour and on the number of accidents". [Douglas Barnett, Head of Mid-Market and Customer Risk Management, AXA Insurance]
>
> "We are delighted to be working in partnership with AXA on this project. Having worked closely with the AXA Risk Team for many years it is great to be able to take our learnings from the application of VUEmatics technology to vehicle fleets and implement them in the forklift truck environment. Together I am sure we can reduce the number of unnecessary workplace accidents.". [Glen Mullins, Group CEO, VUE]

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Latest Pallet Figures Give Interesting Insight Into State of Material's Handling Market

A total of 42.5 million new pallets were produced in the UK in 2016, and 41.4 million were repaired, according to a newly produced market survey commissioned by the Timber Packaging and Pallet Confederation (TIMCON) and the Forestry Commission.

The number of new pallets produced by UK firms in that time has remained virtually the same as the previous year, while the number of repaired pallets has risen by more than 6 percent.

The figures suggest that pallet companies are holding steady on new production, whilst pallet repairs are seeing a healthy, sizeable increase which is great news for those conscious of sustainability. Industry figures have long talked about the challenges facing pallet manufacturers and a shortage in the supply of small logs could be feeding into these numbers.

Speaking about the issues raised, Phil Chesworth – managing director of Midland Pallet Trucks – struck a cautionary, but hopeful tone. “These issues have been building up for more than a while. Speaking to clients, we know that short-log stocks have been hard to come by and we’ve been hearing a lot about the need to maintain and repair pallet stores. Many of the businesses we work with are weathering the shortage and improving their existing stock to extend life-cycle which is also having a really positive impact on sustainability for the industry overall.”

“Products like our 2500kg hand pallet trucks can be used with both new and repaired pallets but we’re also seeing that customers looking to take care of their stock are increasingly demanding solutions like the ERA25-A hand pallet truck because its improved technology makes for better handling and therefore less damage.”

The figures suggest those in industry are managing to accrue enough short-log stock to maintain current levels of new pallet builds for now. However, on-going shortages could see the numbers of repaired pallets rise even higher as firms look to take care of what they have at hand.

For more information about Midland Pallet Trucks and to browse the full range, visit **http://www.midlandpallettrucks.com.**

Complete Reliability and Lowest Running Costs with 2018 Tundra Air Driers

Hi-line Industries, an established and reputable UK manufacturer of high-quality compressed air purification equipment, has made a number of enhancements to its already class-leading Tundra range of refrigeration dryers. Thanks to an impeccable reliability rate, with zero failures from hundreds of models already sold, the 2018 series is offered with a new two-year warranty. Moreover, the latest dryers provide the lowest possible running costs and increased flow via a new Hi-Flo heat exchanger with larger ports.

Already long-established as the UK's market-leading refrigerant air dryer, the 2018 Tundra range is Hi-line's most energy efficient to date, with a robust and high quality build standard. Minimal energy consumption is crucial in today's competitive environment and the new Tundra dryer from Hi-line will help drive down energy costs by minimising pressure drop and lowering absorbed power.

Among many proprietary innovations, Hi-line's integral Direct Expansion technology offers a constant +3°C dewpoint at all times, unlike chilled mass dryers, which can be as high as +10°C during their thermal cycle. Furthermore, the new and improved single-cell, all-aluminium heat exchanger module gives the most efficient transfer of heat at the lowest energy cost.

Another important energy-saving features of the latest Tundra dryers is the variable-speed fan, which ensures only the required amount of energy is consumed. Moreover, by controlling the fan speed on the refrigerant circuit, Hi-line has been able to eliminate components such as fan-pressure switches, which can often become defective in this type of dryer. The fewer moving parts, the more reliable the product.

Tundra refrigeration air dryers are proven in applications such as workshop air and machine air in general manufacturing, as well as further uses in sectors that include packaging, textile, food, beverage, medical, dairy and automotive. Dryer selection is based on factors such as maximum compressed air flow, lowest operating pressure, maximum ambient air temperature and maximum air inlet temperature. Hi-line's applications team can help apply a corrected capacity formula to ensure the optimum dryer is selected.

The 2018 Tundra series comprises 16 models spanning compressed air flows from 22 to 1700 cfm (37 to 2888 m3/hr) and operating pressure from 4 to 16 barg. Maximum inlet air temperature is +60°C, with ambient air temperature up to +50°C. High pressure (up to 50 barg) and thermal mass versions can be ordered. Hi-line's standard range is available ex-stock at from the company's Burton factory for next-day delivery, with larger dryers up to 9988 cfm available on short lead-times.

Further information is available from:

Hi-line Industries Ltd, 5 Crown Industrial Estate, Oxford Street, Burton on Trent, Staffordshire DE14 3PG
Telephone: 01283 533377 **Fax: 01283 533367**
e-mail: enquiries@hilineindustries.com **www.hilineindustries.com**

Reduce waste and increase production with SmartMotion Web Guide Controllers

Industrial component supplier, CP Automation, now supplies SmartMotion web guide controllers from converting industry component manufacturer, RE-spa. The controllers improve feed accuracy and reduce waste for anyone winding, unwinding or printing on paper, aluminium, plastic or card.

The SmartMotion controller fuses drive technology with a stepper motor, reducing the amount of wiring and resulting in a single, compact device that can be incorporated into a new machine, or retrofitted to a machine already in use.

The motor is controlled to 1/128 step, to ensure the system is incredibly accurate, quick and almost silent. The high heat dissipation range of the controller also ensures a constant working temperature, which prevents the device from overheating.

"When operating a printing press in particular, if the web material is not aligned correctly you're wasting production time and potentially creating unnecessary waste," said Tony Young, director of CP Automation. "RE-spa web guides eliminate this problem. It uses a sensor to monitor whether the edge of the material is in line and automatically adjusts if not.

"People often consider automation as a large investment in robotics or artificial intelligence (AI). But, in truth, adding something simple like the SmartMotion controller improves the automated process and can save you time and money by reducing scrap material."

The controller can be supported by a WLigo display, which has been developed to support applications where there are more than one web guide system installed in a facility. This means that plant managers can control and manage all parameters of a system from one remote controller.

RE-spa web guide systems are available from CP Automation, along with the full range of converting machine automation equipment from RE-spa.

For further information contact:
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Unit 8, Ashley Industrial Estate, Exmoor Avenue,
Scunthorpe, DN15 8NJ
Telephone: +44 (0)1724 851 515
Fax: +44 (0)1724 851516
www: www.cpaltd.net
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Eaton announces new electrohydraulic cylinder

Power management company Eaton has today announced the launch of a new electrohydraulic cylinder featuring valve integration. The new product comprises a high-performance industrial cylinder, precision feedback transducer and control valve in one package to create a single-source solution which offers significant cost savings over custom assemblies.

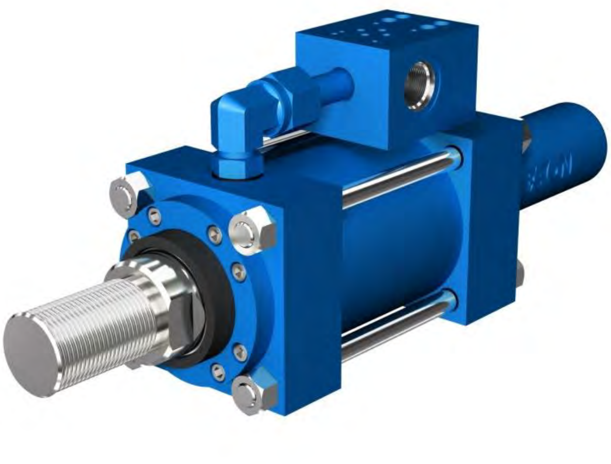
"With our latest electrohydraulic cylinder, customers and distributors no longer need to buy and assemble multiple components," said Andreas Kling, Business Development Manager Power & Controls Products, EMEA, Eaton. "Our new cylinder is a complete system with the customer's valve of choice pre-mounted on the cylinder. By eliminating the need for separate manifolds, plumbing between control valves and cylinders, transducer mounting brackets and other complex arrangements, we're providing the benefits of custom assemblies while reducing the complexity and cost."

Eaton's electrohydraulic cylinder offers:

- Reduced setup time: Simplified plumbing and electrical connections, along with the programmability of the AxisPro® valve, eliminates repetitive set-ups.
- Waste elimination: Infinite positioning with high repeatability can improve yield in the production cycle.
- Increased production: Programmable motion control enables faster cycles than conventional hydraulic circuitry.

Eaton electrohydraulic cylinders are offered in NFPA tie rod, mill duty, welded or threaded styles, and are available with a range of mountings, bore sizes and rod diameters. An Eaton proportional, servo, directional control or AxisPro valve can be mounted onto the configured cylinder and adjusted to customer specifications.

To learn more about Eaton's electrohydraulic cylinders, visit **Eaton.com/EHcylinder**.



Solenis Launches Tapestry[SM] Yankee Coating Solutions

Solenis, a leading global producer of specialty chemicals, has launched its new Tapestry[SM] Yankee Coating Solutions to help tissue makers produce a consistently reliable Yankee coating while improving manufacturing performance and controlling operational costs.

The new Solenis Tapestry Yankee Coating Solutions offering includes a family of advanced chemistries and technologies, a team of application and field service specialists experienced in optimizing Yankee coating properties, and R&D support focused on tissue-making science and innovation.

“Tissue makers face consumer demands every day — demands for softer, stronger and more absorbent products,” said Richard Cho, global marketing director, Tissue and Towel. “The Yankee cylinder is critical to meeting these demands, but difficulties with Yankee operation can affect manufacturing productivity, product quality and, in some cases, asset life. The new Tapestry Yankee Coating Solutions from Solenis can help tissue makers overcome these challenges.”

A reliable Yankee coating is essential for the efficient operation of a tissue machine, yet many mills struggle to achieve and maintain high performance due to inconsistencies in temperature, moisture and/or other operating conditions. The Solenis Tapestry Yankee Coating Solutions include the most advanced chemistries on the market to optimize Yankee performance.

Tapestry Yankee Coating Solutions enables the development of a coating that provides several benefits, including:

Doctorability – Solenis Tapestry chemistries deliver a coating with the right rheology for optimum creping — a coating that remains stable and consistent throughout the life of the creping blade and quickly reestablishes itself after the blade changes. It also absorbs potential blade vibrations.

Edge Control – The right coating leads to clean edges on the Yankee cylinder, which reduces sheet breaks and delivers predictable creping quality.

Coating Uniformity – Solenis Tapestry Yankee Coating Solutions produce a more uniform coating that helps to eliminate lumps or wrinkles in the finished roll of paper and improves the operational stability of the Yankee system.

The resulting improvements to creping performance and tissue quality can ultimately impact a tissue mill’s bottom line through enhanced productivity and improved product quality attributes such as softness and strength. In addition, a dependable coating is a key element in protecting tissue machinery.

Solenis will highlight its Tapestry Yankee Coating Solutions program at Tissue World Miami 2018, March 20-23, in booth M-300. In addition, the company will conduct a technical presentation on how to widen the operating window in premium quality tissue grades, during the Yankee Operations Workshop on continuous improvement.

For more information on Solenis Tapestry Yankee Coating Solutions, including a downloadable brochure, infographic and several case studies, visit:
www.solenis.com/tapestry-news.

New Online Guide on Strain Measurement

HBM Test and Measurement has launched a new Strain Measurement online guide, focusing on the selection, installation, data acquisition, and analysis of electrical as well as optical strain gauges. The new portal contains comprehensive information about measuring strain, including valuable tips from leading strain measurement experts.

When it comes to strain measurement, businesses and asset owners may feel intimidated due to the lack of information or, on the other hand, information overload. And often, in the absence of proper guidance from experienced professionals, they will give up the attempts to learn this topic and probably jeopardize cost-effective decisions when it comes to choosing the right measuring instrument.

Experts from HBM , test and measurement specialists, have dug deep to provide their best answers to relevant questions about strain measurement, either performed with strain gauges or with fibre optical strain sensors. Based on their knowledge, an ultimate step-by-step online guide has now been launched, with updated and unparalleled content about optical and electrical strain measurements, gauges, and sensors.

By navigating through the brand-new strain-related HBM webpages, readers may learn the “what”, “how” and “why” of strain measurement and related-technologies, including the definition of strain, tips for selecting and installing gauges and sensors, guidelines to acquire data, types of applications, among many others.

The journey starts at the strain measurements basics page: From there, users can choose to explore the world of strain gauges or the innovative field of optical fibre sensing.

The Strain Gauge Fundamentals

Strain gauges have been around for almost 80 years and continue to be key assets for measuring fatigue and testing materials for productivity and safety reasons. However, the following questions still remain tricky: How to calculate material stress from strain? How to select the right strain gauge and install it correctly? You can get the overview and all the answers here.

The Optical Strain Sensor Fundamentals

Optical strain sensors, namely those based on Fibre Bragg Grating (FBG) technology, have been gaining attention, particularly in the field of infrastructure monitoring over the past decades. But how does an optical sensor work? How many sensors can be integrated into one single fibre? You can unveil the secrets behind FBG technology here.

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Complimentary service protects drive investment from day one

ABB drives customers now benefit from a complimentary support agreement during the warranty period.

A new service from ABB gives users of medium- and high- power variable speed drives complimentary access to a host of services throughout the warranty period. Drive users now receive access to on-site repair, rapid exchange of faulty parts with access to original spares, telephone support during office hours and technical query escalation.

Customers only need to register the drive at the point of commissioning to activate the service. The registration can be handled by ABB directly or through one of its authorised value providers. Alternatively, customers can download a registration app and enrol the drive themselves.

Both telephone and ABB Ability™ cloud-based remote support offers advice, guidance and issue resolution. This benefits those customers who are trying to get a drive up and running or seeking reassurance that the drive operates as intended. Reduced downtime and plant interruption is further enhanced by escalation to global experts who handle advanced user queries. For medium voltage drives, rare instances of drive failure or condition monitoring can benefit from ABB Ability remote support from specialist teams.

Throughout the warranty period customers will receive continuous support and engagement for backup. This includes advice on maintenance techniques, trends and practices. Customers will obtain priority notifications of upgrades and enhancements.

The service is available for larger ABB industrial drives that includes: ACS880, ACS1000, ACS2000, ACS5000, ACS6000, ACS6080, ACS580MV, Megadrive-LCI, DCS880 .

“ABB Initial Care gets the best out of your investment without any extra costs, while maintaining seamless operation,” says Stuart Melling, ABB business unit manager, drives & controls, UK. “By simply registering your drive you get valuable access to ABB’s immense application know-how and product expertise. ABB Initial Care reduces the risk of downtime and offers peace of mind support throughout the warranty period; it also introduces the customer to the wider benefits of ABB Drive Care .”

Following the ABB Initial Care period, users have the option to transfer to a full ABB Drive Care service package with associated costs. This service includes preventive care, complete care and replacement care and features maintenance services, specialised support, ABB Ability digital activities such as remote assistance and remote condition monitoring and failure recovery.

www.abb.com

Valmet launches a new tool to monitor former dewatering

Valmet extends its quality control systems expertise to the paper and board machine forming section with the introduction of the Valmet IQ Dryness Measurement (IQ Dryness). Utilizing microwave technology, the IQ Dryness measures the water layer thickness on the web, which can be used to calculate the web dry content. As well as removing most of the water, the majority of paper properties are also developed in the forming section. The inclusion of IQ Dryness in Valmet's paper quality control family opens new possibilities as it helps to close the information gap between the stock approach system and dry end quality sensors.

"Perhaps the biggest effect is the better management of dewatering. This has a great influence on the amount of the subsequent drying energy needed with potentially big cost savings in paper production. An increase of just 1% in dryness before the dryer can reduce the amount of energy needed to evaporate the excess water by approximately 4%," says Marko Toskala, Director, Quality Management Solutions, Valmet.

All grades and furnishes

Unlike other measurement technologies, Valmet IQ Dryness is not sensitive to conductivity which makes it suitable for use with all grades of paper and board. As well as energy savings with vacuum optimization; quicker startups, faster grade changes, fewer breaks and improved break recovery are just a few of the benefits that continuous measurement of water removal makes possible.

Optimized dewatering not only improves bonding for multilayer board machines but can also reduce the problems of blow induced breaks caused by excess moisture in the middle layer entering the drying section. Additionally, the measurement facilitates the online monitoring fabric condition together with improved troubleshooting of pulsation, vibration and other quality destroying wet end problems. The sensor's small size enables measurement in places inaccessible earlier.

Complete moisture management

This new sensor joins the Valmet IQ family of single point and scanning measurements to provide papermakers with a complete picture of MD and CD moisture from the forming and press sections, dryer and size press right up to the reel. Together with sophisticated moisture controls and an extensive range of actuators to control moisture levels and profiles, Valmet can close the loop to offer improved efficiency and runnability as well as better paper quality and printing properties.

For further information, please contact:
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Vapour permeability and the strength, integrity & printability of card based products

Card, board and paper based products are critically dependent on vapour permeability for their strength, integrity and printability. Packaging also controls the contamination of food and pharmaceutical products. Tiny changes in composition or coatings can make a major difference to these physical characteristics.

Versaperm's latest of permeability measurement system is designed to measure this, not just for coatings and materials, but also for the complete finished package. This is often critical as manufacturing processes, such as forming, folding and adhering, can change, substantially, the package's vapour permeability,

The most important factor is often water vapour but the system can measure permeability for carbon dioxide, oxygen, hydrocarbons, aromatics and almost any other gas in commercial use. The system is ideal for product and coating developments as well as for quality control.

The Versaperm system is fast, reliable and easy to use - producing results that are accurate in the PPM (parts per million range), PPB ranges and for some materials, and can take as little as 30 minutes. Where desired the system can produce results under environmental controlled conditions including temperature, pressure and relative humidity.

Multi-chamber systems allow measurements to be produced on several samples at the same time and different designs and clamping systems cater for varying sample types.

As well as manufacturing the instruments, Versaperm offers a technical consultancy plus a permeability testing service for companies that need to test samples on an irregular basis.

For details see:
Versaperm Lt: 10 Rawcliffe House,
Howarth Road, Maidenhead, Berkshire, SL6 1AP, UK,
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web: www.versaperm.co.uk

Jarshire announces new agency agreement with SchäferRolls

Jarshire Limited continues its theme of expansion with the announcement that it has been appointed sole agent in the UK and Ireland for the German company SchäferRolls GmbH & Co. KG.

SchäferRolls has been producing polymer-based roll covers since 1946 and is a leading name in the industry. Renowned for its precision and technical expertise, the company operates within the highest levels of process engineering and process control which, together with state-of-the-art equipment, allows the company to exactly re-produce high quality roll covers with constant dimensional and shape stability.

Roll covers specifically manufactured for the converting, paper, tissue and web processing industries incorporate materials that have been designed to meet the chemical, thermal and mechanical requirements of modern paper manufacturing and converting processes, including tissue, adhesive labels and board. Rolls may be specified with an overall length of up to 15,000 mm, diameter of 2,000 mm and weight of 100 tons whilst production machinery can be adapted to the handling and processing characteristics of all types of rolls and sizes including embossing back rolls and size applicator rolls for converters, and rolls for the wire section, press section and reeling sections of paper mills.

SchäferRolls (**www.schaeferrolls.com**) operates in five locations worldwide including Nowack Gummiwalzen GmbH & Co KG, and Schäfer MWN GmbH with its brand :CCOR operating in Germany, as well as having subsidiaries in the USA and Slovenia.

Converting and Paper Mills Director, David Jobson says the new range adds a new dimension to the Division's portfolio of products for the converting and paper mills sectors.

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PAPERmaking!
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Volume 4, Number 1, 2018

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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 2017 and May 2018. 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	DESCRIPTION	START-UP
Ahlstrom-Munksjö Dettingen Mill Germany	TBA	To improve quality of pre-impregnated décor paper.	End 2018
Ahlstrom-Munksjö Pont Audemer France	TBA	To rebuild a converting line of sterilization wrap.	Q2 2019
ANON	Bekaert Solaronics	To install an infrared drying system in a decor paper impregnation line, just before the first drying oven, for a major industrial group in Europe.	H1 2018
ANON (various mills, China)	Valmet	To supply board machine key technology and machine control systems for three new containerboard machines.	2019
ANON (via E.I.L., an Italian system integrator)	Valmet	To supply three Valmet IQ quality control systems for installation on three new tissue machines in EMEA.	2018
ANON Zhejiang province China	Valmet	To supply a board production line (7.25m width) is designed to produce high-quality recycled fluting grades.	End 2019
Arctic Paper Munkedal Mill Sweden	TBA	To expand the hydro power plant.	Q4 2019
Azur Papier (belonging to Lilas SAH group) Zriba facility Tunisia	Recard	To supply a second tissue machine (PM2, 115tpd).	End 2018
BillerudKorsnäs Gruvön Sweden	Valmet	To supply online measurements, consistency transmitters and analyzers. Delivery to include one Valmet Pulp Analyzer (Valmet MAP), 24 Valmet Microwave Consistency Transmitters (Valmet MCA), 7 Valmet Rotating Consistency Transmitters (Valmet Rotary), 3 Valmet Retention Measurements (Valmet RM3) and one Valmet Wet End Analyzer (Valmet WEM).	2018 / 2019
Bohui Paper Group China	Cellwood Machinery AB	To supply six Krima Hot Dispersing Units for their PM5 & PM6-project.	NA
Chung Hwa Pulp Hualien Mill Taiwan	Veolia Water Technologies	To upgrade the black liquor evaporation system.	NA
Crown Paper Mill (CPM) Abu Dhabi	Valmet	To supply a complete tissue production line, including Focus rewinder and an extensive automation package (capacity 65,000tpy).	H2 2018
Delfort Olšany Czech Republic	TBA	To extend its leading position in the thin, lightweight paper industry with a new machine.	NA

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Dongguan Jianhui Paper Dongguan City Guangdong Province China	Andritz	To install three FibreFlow drum pulping systems.	Q2 2018
Dongguan Jianhui Paper Dongguan City Guangdong Province China	Greycon	To implement its trim solution, X-Trim, on four Paper machines.	End 2017
Drenik ND d.o.o. Hungary	Recard	To supply a 120tpd tissue plant.	Summer 2019
Gasum biogas plants and gas filling stations Finland and Sweden	Valmet	To supply extensive automation and data collection solutions.	H1 2018
Grupo Gondi Papel y Empaques Monterrey Mexico	Voith	To build an XcellLine board machine (capacity 400,000tpy) and stock preparation plant.	Early 2020
Hamburger Rieger GmbH Spremberg Mill Germany	Valmet	To supply a containerboard production line (PM 2) including automation solutions designed to produce high-quality testliner grades based on 100% recycled paper.	Mid-2020
Holmen Paper Hallsta Paper Mill Sweden	Andritz	To refurbish and install dewatering equipment for a new TMP washing stage at PM12	Q1 2018
Iggesund Workington UK	Pasaban	To supply two KB-2300 sheeters with highly automated rotary unwind stands able to process 170 to 400 gsm folding box board.	NA
Ittihad Paper Mill Abu Dhabi	Valmet	To supply long term service agreement.	Late 2018
KaiCell Fibers Ltd Paltamo Finland	Pöyry	To supply the Environmental Impact Assessment (EIA) process assignment, re a planned Biorefinery.	NA
Kartonsan Various facilities Turkey	Greycon	To implement its full range of solutions including opt-Studio for production planning, X-Trim for trim optimisation and GreyconMill as Manufacturing Execution System.	NA
Kimberly-Clark Mobile Alabama Mill USA	TBA	To upgrade the site.	
Kipas Holding greenfield paper mill in Söke Aydin Turkey	Valmet	To supply a multifuel boiler to this new paper mill.	Q1 2020
Klabin Ortigueira Mill Brazil	Savcor	Wedge order to improve process data analysis.	NA

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Klingele Group Werne site Germany	TBA	To extend the logistics centre which will provide space for approx. 20,000 pallets in the future.	End 2018
Kyiv Cardboard and Paper Mill JSC	Andritz	To modernise PM1, including supplying a new shoe press and calender.	End 2018 / Start 2019
Lecta Group (seven mills in Spain, France and Italy)	Tieto	To modernise IT systems based on Tieto Paper Solution on SAP and Tieto Integrated Paper Solution (TIPS) for the global paper industry.	NA
Lilas SAH (Société d'Articles Hygiéniques) Zriba facility (near Tunis) Tunisia	Recard	To supply 115tpd tissue plant (PM2).	End 2018
Lucart Group Porcari plant Province of Lucca Italy	Toscotec	To replace two old MG PMs with a new line (PM12) capacity 35,000tpy tissue.	H2 2018
Manipulados Emreser S.L. Murcia Spain	Pasaban	To supply a paper and board winder.	NA
Mariysky Pulp and Paper Mill Volzhsk Russia	Andritz	To upgrade the existing stock preparation line of PM1 with state-of-the-art equipment for thickening and high-consistency refining.	Q3 2018
Merkas Tekstil Sanayi VE Ticaret AS Turkey	A.Celli Nonwovens	To supply of a new generation STREAM® winder.	H2 2018
Metsä Board Husum Pulp Mill Sweden	SPM Instrument AB	To introduce online condition monitoring of production-critical equipment in its fibre line, specifically the Intellinova Parallel EN online system.	NA
Metsä Board Kaskinen Pulp Mill Finland	Valmet	To supply a baling line.	End 2018
Metsä Tissue Mänttä Mill Finland	Andritz	To modernise and upgrade the existing DIP line.	NA
Metsä Tissue Žilina Mill Slovakia	TBA	To install a new converting line.	End 2018
Mitsui Engineering & Shipbuilding Co., Ltd. Ichihara Chiba Prefecture Japan	Andritz	To supply a highly efficient, biomass-fired circulating fluidized bed boiler.	Q3 2020
Monalisa Co. Ltd. Jeonju South Korea	Andritz	To supply the key components for a new sludge dewatering process to be installed at its tissue production line.	NA

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Nine Dragons Industries Co. Ltd. (Dongguan and Quanzhou Mills) China	Valmet	Received orders for fifth and sixth successive containerboard machines The orders for the four previous machines were published in 2017 (PM39 and PM40, PM41 and PM42). The latest two production lines will be located in Dongguan (PM43) and Quanzhou (PM45) and are similar to the previous four containerboard production lines.	2019
Nordic Paper Åmotfors Mill Sweden	SPM Instrument AB	To install the Intellinova online system with DuoTech accelerometers for vibration merasurement on PM6 specialty paper machine.	NA
Oulun Energia biopower plant Laanila Finland	Valmet	To supply a multifuel boiler and a flue gas treatment plant. The biopower plant will produce 75MW of electricity and 175MWth of district heat.	NA
Pankaboard Lieksa Board Mill Eastern Finland	Valmet	To replace the first-ever Damatic Classic automation system delivered with a Valmet DNA automation system.	Mid-2019
Partex-Star Group Bangladesh	A.Celli Paper S.p.A.	To supply a turnkey tissue plant.	Q1 2019
PPM “Kama” Ltd. Krasnokamsk Perm Krai Russia	UMV Coating Systems AB	To modernise the existing TWIN™ Sizer, HSM coating machine on PM7.	H1 2018
Pori Energia power plant Aittaluoto Finland	Andritz	To supply a high-efficiency, biomass-fired bubbling fluidized bed boiler with flue gas cleaning system for an existing biomass power plant.	Q2 2020
Pori Energia power plant Aittaluoto Finland	Valmet	To deliver a flue gas condensation system.	NA
Pratt Paper (IN), LLC Wapakoneta Paper Mill Ohio USA	Valmet	To supply an OptiConcept M board production line with automation.	Q4 2019
PT. Buana Megah Pasuruan East Java Indonesia	Valmet	To supply automation technology to PM3 board machine.	Q3 2018
Resolute Forest Products Inc. Saint-Félicien Pulp Mill Lac-Saint-Jean region Quebec	TBA	To invest to increase production by 76tpd and reduce greenhouse gas emissions by 20%.	NA
Sappi Gratkorn Mill Austria	Valmet	To supply a wet end rebuild, the goal being to improve PM9 efficiency, reliability and overall energy efficiency.	2019

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Sappi Lanaken Mill Belgium	Valmet	To supply a vast grade conversion rebuild; currently producing lightweight coated (LWC) paper grades and will be rebuilt to also produce lightweight and high-quality woodfree coated paper grades.	2019
Sappi Southern Africa (Pty) Ltd Ngodwana Pulp Mill South Africa	Valmet	To deliver a new gravity feed chipper.	Q2 2018
Sappi Southern Africa (Pty) Ltd Saiccor Pulp Mill South Africa	ÅF	Awarded an engineering, procurement and construction management contract to expand the world's largest dissolving pulp mill	Q3 2020
Sappi Southern Africa (Pty) Ltd Saiccor Pulp Mill South Africa	Valmet	To deliver a new high capacity chipping line and chip handling system.	Q1 2019
SCA Munksund Paper Mill Piteå Sweden	Valmet	To rebuild cooking plant and brown stock washing equipment.	Q2 2019
SCG Packaging Ban Pong Paper Mill Ratchaburi Thailand	Andritz	To supply an EcoFluid fluidized bed boiler with flue gas cleaning system for a waste-to-energy power plant.	Q3 2018
Shandong Century Sunshine Paper Group Company Limited China	Greycon Ltd	To automate its scheduling process for its five cutters by integrating opt-Studio with its SAP ERP solution	Q2 2018
Shanghai Zhuyuan Wastewater Treatment Plant 3 China	Valmet	To deliver eight dry solids measurement units to boost sustainability.	Q2 2018
Shanying International Holdings Co., Ltd. City of Jingzhou Hubei province China	Valmet	To delivery of a mill waste-fired boiler plant.	Q2 2018
Shanying International Holdings Co., Ltd. City of Jingzhou Hubei province China	Valmet	To supply three more winders the capacity of which will cover the production of two board machines.	End 2018
Shanying International Holdings Co., Ltd. City of Jingzhou Hubei Province China	Valmet	To supply a containerboard production line with automation.	End 2018
Siam Kraft Industry Co., Ltd and Thai Cane Paper Public Co., Ltd. (both companies are under SCG Packaging) Thailand	Valmet	To supply three Valmet IQ Moisturizer systems for PM6 and PM7 at Wangsala mill and PM11 at Prachinburi mill.	H1 2018

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
Smurfit Kappa Cellulose du Pin France	TBA	To upgrade PM5, increasing capacity of white top kraftliner by 46,000tpy to 220,000tpy.	2019
Smurfit Kappa Piteå Sweden	SKF	To upgrade to a next-generation monitoring system. In addition to vibrations, the system can also incorporate other process parameters, such as pressure and temperatures, to further improve the insight of the machine health.	NA
Södra's Mönsterås Pulp Mill Sweden	Andritz	To supply a bio-methanol cleaning and purification plant.	Q3 2019
Star Paper Mill Ltd. Abu Dhabi	Recard and Voith	To equip the Crescent Former with the latest-generation NipcoFlex T shoe press.	NA
Stora Enso Enocell Mill Finland	Andritz	To upgrade evaporation plant, using lamella evaporation technology, which will increase the mill's black liquor evaporation capacity from 600 originally to 800 t/h.	Q3 2019
Stora Enso Imatra Mills Finland	Andritz	To supply a new flash drying line, including a Twin Wire Press, fluffer, and flash dryer.	Q1 2019
Stora Enso Narew Sp. z.o.o. Ostrołęka Poland	Andritz	To supply an FRX shredder and a metal separator.	Q1 2018
Stora Enso Narew Sp. z.o.o. Ostrołęka Poland	Valmet	To supply a warp control system.	Spring 2018
Svenska Pappersbruket AB Klippan Sweden	Recard	To supply a tissue machine (capacity 30,000tpy).	Q2 2019
Turun Seudun Energiantuotanto Oy Naantali Power Plant Finland	Valmet	To provide operator training tools, including Valmet Training Simulators and Valmet Online Learning courses, for Naantali's CFB boiler.	NA
Vantaan Energia Martinlaakso Biopower Plant Finland	Valmet	To supply a flue gas cleaning system.	Q1 2019
Varaka (part of the Albayrak Group) Balikesir Western Turkey	Andritz	To supply stock preparation and paper machine approach system for top layer of PM2, as part of a project to transform an ex-newsprint machine into brown packaging.	Summer 2018
Vinda International Group Xiaonan district Xiaogan Hubei	Toscotec	To supply four tissue machines.	End 2018

COMPANY, SITE	SUPPLIER	DESCRIPTION	START-UP
VPK Packaging Group Belgium	SPM Instrument B.V.	Supply various online Intellinova systems to monitor guide rolls in the dryer section of PM6, as well as pressure screens and various transmissions for PM6 and PM7, consisting of motor-gearbox and cardan shafts.	NA
WestRock Company Florence South Carolina USA	Valmet	To install a 330” kraft linerboard production line.	H1 2020
Xiamen Sin Yang Paper Co. Ltd China	Valmet	To supply a tissue machine restart-up package for TM1.	Q3 2018
Yibin Paper Industry Co., Ltd China	A.Celli Paper	To supply five high speed tissue machines, each capacity 25,000tpy.	H2 2018
Yuen Foong Yu Paper, Xinwu Mill Taoyuan Taiwan	Greycon Ltd	To implement X-Trim software as the mill works towards its goals of zero emissions and zero waste.	Q1 2018
Zellstoff Pöls AG Pöls Austria	Andritz	To supply a large paper machine for the production of bleached kraft MG paper grades.	Mid-2019
Zellstoff Pöls AG Pöls Austria	Andritz	To optimize operations at the pulp mill by using the Metris OPP system (OPP: Optimization of Process Performance).	NA

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 4, Number 1, 2018

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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*

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* 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*.

APPITA JOURNAL, Vol.70, No.4, Oct-Dec 2017

1. The potential of bagasse soda pulp as a strength enhancer for old corrugated pulp
2. Effect of blending banana stem and hardwood pulps on sizing, ash retention, physical strength and optical properties of paper
3. Preparation of strong and stiff papers through surface sizing with starch and APMS
4. Peroxide bleaching of mechanical pulp from *Pinus Radiata*
5. Expansion of Wesley Vale Mill Mechanical Pulp Production using Peroxide 'Steep' Bleaching

APPITA JOURNAL, Vol.71, No.1, Jan-Mar 2018

1. Application of laccase positive *Bacilis tequilensis* strain for pulp and paper mill wastewater treatment
2. How can we improve strength property of dry formed papers?
3. Strength improvement of dry-formed paper by spraying of dry strength agent and hot pressing
4. Improving floc stability of precipitated calcium carbonate by incorporation of cellulose nanofibres

IPPTA JOURNAL, Vol.29, No.2, Apr-Jun 2017

1. Effect of Morphological Characteristics of Indegenous Fibers (*E. Tereticornis* and *S. Officinarum*) and their Effect on Paper Properties
2. Low Chemical Pulping of Biotreated Jute Fibre for Making Handmade Paper
3. Pollution Reduction from Pulp Bleaching Effluents by Process Change
4. The Energy Structure and Innovative Energy Recovery Methods of a Typical Chinese Pulp Mill
5. Enhancing Printing and Optical properties of Paper by using Improved Techniques of Filler Retention
6. Growth and Yield of Poplar (*Populus deltoids*) Grown in Telangana / Andhra Prasdesh
7. Dependence of Softness Perception on Tissue Physical Properties and Development of Neural Model for Predicting Softness
8. Preparation of Flame Retardant and Smoke Suppression Paper using Ammonium Polyphosphate (APP)-Diatomite as Filler

IPPTA JOURNAL, Vol.29, No.3, Jul-Sep 2017

1. Buckman Develops Third Generation Maximyze® for Recycled Packaging
2. Future of Food Packaging Industry with New Generation Bio-Polymer
3. Improved Strength and Better Sheet Stability with Duoshake
4. Packaging Paper – New Forming Fabric Design for Operational Excellence
5. Prediction of Half Tone and Back Trap Mottle for Offset Printing
6. Proficient Ways of Paper Machine Design Concepts (Fluting / Linerboard machine)
7. Recycled Fiber used in Shanying Paper
8. Special Packaging Paper Development – for Carton which withstand Cold Storage and Sea Worthy Export
9. Technological Advancement in Bulk and Stiffness Improvement for Duplex Board Making Industries in India

IPPTA JOURNAL, Vol.29, No.4, Oct-Dec 2017

1. Best Maintenance Practices for Enhance Paper Machine Clothing Performance
2. Enhancing Black Liquor Evaporation Capacity Through Process Reengineering
3. Improvement in Equipment Reliability & Maintenance Planning Through Predictive Maintenance – a Case Study at Yash Paper Ltd.
4. Maintenance of Rollers for Paper Industry
5. Maintenance Strategies Cost Reduction and Quality Improvement
6. Need of Quality in Manufacturing of Equipment & Machines Coupled with Proper Alignment, Lubrication to Achieve Plant Reliability & Safety for Pulp and Paper Mills
7. Optimisation if De-inked Pulp (DIP) HD Tower Dilution Control (Re-Engineering)
8. Paper and Paper Board for Food Packaging Applications – Review of Standard Regulations
9. Re-engineering and Best Maintenance Practices (ITC Bhadrachalam)
10. Re-engineering and Best Maintenance Practices (ITC PSPD)
11. Sustained Growth with Maintenance Best Practices and Re-engineering Efforts in TNPL
12. Thermography as a Tool to Improve Reliability
13. Valmet Mill Engineering – Global Quality with Local Flavor
14. The Profile: Key to Reengineering Screening

J-FOR, Vol.6, No.5, 2017

1. Optimization of a biomass procurement network with integrated forest harvesting for an eastern Canadian newsprint mill
2. A study of kraft lignin acid precipitation in aqueous solutions using focused beam reflectance measurement (FBRM®)
3. Leagile strategy implementation for supplying forest raw materials to the bioeconomy

J-FOR, Vol.6, No.6, 2017

1. Keynote Speech by Derek Page at the 2010 Progress in Paper Physics Seminar in Montreal, Canada
2. Page's Theory of Tensile Strength and the Stress-strain Properties of Paper
3. Dr. Derek Page's Contributions to the Measurement and Impact of Fibre Strength and Structure on Paper Properties
4. Dr. Page's Contributions to Wood Fibre Characterization and Properties
5. A Fracture-based Description for the Development of Tensile and Tear Strength in Paper
6. Determination of Wall Thickness and Fibril Angle of Wood Pulp Fibres using Circularly Polarized Light

NORDIC PULP & PAPER RESEARCH JOURNAL, Vol.32 No.4, 2017 (Lignin Special)

1. Editorial: From understanding the biological function of lignin in plants to production of colloidal lignin particles
2. Carbohydrate-free and highly soluble softwood kraft lignin fractions by aqueous acetone evaporation
3. Variation in susceptibility to microbial lignin oxidation in a set of wheat straw cultivars: influence of genetic, seasonal and environmental factors
4. Filtration properties of kraft lignin: The influence of xylan and precipitation conditions
5. What are the biological functions of lignin and its complexation with carbohydrates?
6. On the effect of hemicellulose removal on cellulose-lignin interactions

7. Structural changes of lignin in biorefinery pretreatments and consequences to enzyme-lignin interactions
8. Self-association and aggregation of kraft lignins via electrolyte and nonionic surfactant regulation: stabilization of lignin particles and effects on filtration
9. Scaling Up Production of Colloidal Lignin Particles
10. Study on setting of the stepper motor current value for the dilution profile actuator
11. Preparation and synthesis of water-soluble chitosan derivative incorporated in ultrasonic-assistant wheat straw paper for antibacterial food-packaging
12. Process intensification in mechanical pulping
13. High purity dissolving pulp from jute
14. Using spent sulfite liquor for valuable fungal biomass production by Aspergilus oryzae
15. Successive twin-wire roll forming of two-ply paper with softwood kraft pulp and recycled pulp - effect of kraft-ply formation on Z-strength
16. Effects of the polymeric additives on the stickies formation in recycled fibers based papermaking process
17. Upgrading waste whitewater fines from a pinus radiata thermomechanical pulping mill
18. Fly ash based composite fillers modified by carbonation and the properties of filled paper
19. Suitable approach using agricultural residues for pulp and paper manufacturing
20. Strengthening wood fiber networks by adsorption of complexes of chitosan with dialdehyde starch
21. Effect of composting of paper mill sludge for land spreading

TAPPI JOURNAL, November 2017

1. Editorial: Celebrating Wayne Carr: A true recycling visionary
2. The Chinese ban on recovered paper imports: An international disruption
3. New automated method for macrocontaminant analysis: Industrial applications
4. Innovative technology for making improved paper from the poorest fibers
5. Improved deinking and stickies removal

TAPPI JOURNAL, January 2018

1. Editorial: The changing face of the coated paper industry
2. Slot die coating of nanocellulose on paperboard
3. Discrete element method to predict coating failure mechanisms
4. Contrasting underlying mechanisms of different barrier coating types
5. Print quality of flexographic printed paperboard related to coating composition and structure

TAPPI JOURNAL, February 2018

1. Static and dynamic sorption of lignin removed *Populus euramericana*
2. Functionalization of wood/plant-based natural celluslose fibers with nanomaterials: a review
3. Editorial: New lignocellulosics address consumer expectations and industry prosperity
4. Activated carbon from potassium hydroxide spent liquor lignin using phosphoric acid
5. Lignocellulose fibers elaborating super-swollen three-dimensional cellulose hydrogels from solution in N, N-dimethylacetamide/lithium chloride

TAPPI JOURNAL, March 2018

1. Guest Editorial: China's State Key Laboratory of Pulp and Paper Engineering
2. Lignin — a promising biomass resource
3. Controlling porosity and density of nanocellulose aerogels for superhydrophobic light materials
4. An effective method for determining the retention and distribution of cellulose nanofibrils in paper handsheets by dye labelling
5. Photo-catalytic degradation of gaseous pollutants in paper mills of southern China

TAPPI JOURNAL, April 2018

1. Editorial: Shifts and gains in research funding
2. Online measurement of bulk, tensile, brightness, and ovendry content of bleached chemithermomechanical pulp using visible and near infrared spectroscopy
3. Importance of specimen preparation for edgewise compressive strength (ECT) testing
4. On the nominal transverse shear strain to characterize the severity of creasing
5. Monitoring the free Lime Content in the Lime Mud Using Zeta Potential

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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 recent 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* 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*.

BIOMASS

Unravelling the effect of pretreatment severity on the balance of cellulose accessibility and substrate composition on enzymatic digestibility of steam-pretreated softwood, J.J. MacAskill *et al*, *Biomass and Bioenergy*, Vol.109. Pretreatment is essential for effective enzymatic digestion of lignocellulosic biomass. Steam pretreatments increase the digestibility by increasing the accessibility of the carbohydrates to the enzymes. However, they can also cause yield loss and lowered digestibility via increased non-productive binding of enzymes to lignin. The relative importance of these effects is not well defined, especially for softwoods which require more severe pretreatments than other types of biomass. This work shows that while increasing pretreatment severity does lead to greater enzyme inhibition, this was being overridden by increases in the accessibility.

Steam gasification of wood pellets, sewage sludge and manure: Gasification performance and concentration of impurities, Daniel Schweitzer *et al*, *Biomass and Bioenergy*, Vol.111. In the dual fluidised bed steam gasification process a product gas with a relatively high calorific value is produced. For clean biomass such as wood pellets or wood chips this process has been previously demonstrated in pilot-scale. Within this work, the applicability of waste biomass such as sewage sludge or manure as a fuel for this gasification process was investigated experimentally. The gasification experiments have shown, that the steam gasification of both biogenic waste materials is possible.

DEINKING

Biodeinking of mixed ONP and OMG waste papers with cellulase, Iman Akbarpour *et al*, *Cellulose*, Vol.25 (2). Development of qualitative properties and surface modification of mixed recycled 70% old newspaper and 30% old magazine pulp after enzymatic treatment with commercial cellulase was evaluated. The results of the present research demonstrated that the quality of the pulp and paper obtained from cellulase deinking process was comparable or even better than that from the chemical deinking.

Biodeinking of mixed ONP and OMG waste papers with cellulase, Iman Akbarpour *et al*, *Cellulose*, Vol.25 (2). Development of qualitative properties and surface modification of mixed recycled 70% old newspaper and 30% old magazine pulp after enzymatic treatment with commercial cellulase was evaluated. The results of the present research demonstrated that the quality of the pulp and paper obtained from cellulase deinking process was comparable or even better than that from the chemical deinking.

Studies on the environmentally friendly deinking process employing biological enzymes and composite surfactant, Feng Wang *et al*, *Cellulose*, online. In this study, biodegradable cardanol polyoxyethylene ether (CPE) was applied to the field of flotation deinking of mixed office waste paper (MOW), and its combination with fatty alcohol polyoxyethylene ether (AEO-9), fatty alcohol polyoxyethylene ether sulfate (AES) as a composite surfactant was also investigated for a green deinking process. According to this study, cutinase and amylase combined with cardanol polyoxyethylene ether and other surfactants provide an environmentally friendly and effective deinking strategy.

ENVIRONMENT

A systems approach to risk and resilience analysis in the woody-biomass sector: A case study of the failure of the South African wood pellet industry, Rebecca Bowd *et al*, *Biomass and Bioenergy*, Vol.108. Currently more than 600 million of the 800 million people in SSA are without electricity, and it is estimated that an additional 2500 GW of power is required by 2030. Although the woody-biomass market in the developed world is relatively mature, only four woody-biomass plants in SSA have been established, all of which were closed by 2013. With its affordable labour, favourable climate and well-established forestry and agricultural sectors, South Africa appears to have the potential for a successful woody-biomass industry. This paper documents a first attempt at analysing why these plants failed.

Efficiency and sustainability indicators for papermaking from virgin pulp—An emergy-based case study, F.Corcelli *et al*, *Resources, Conservation and Recycling*, Vol.131, April 2018. The pulp and paper sector is the fourth-largest industrial sector worldwide in terms of energy use, accounting for approximately 6% of the total industrial energy consumption and contributing to 2% of direct carbon dioxide (CO_2) emissions produced by industries. By means of EMA performance indices, this paper aims to assess the environmental sustainability associated to the production of pulp and paper, so as to identify those process steps that entail the highest environmental costs and require improvements. The research results show that the largest supply-side environmental costs are generated by the industrial processing activities, due to high energy, water and chemicals consumption. Only a minor role is played by forestry activities that supply the raw feedstock, although forestry management practices certainly affect both the final productivity and the energy balance, through the amount and use efficiency of the farm inputs.

Investigating external and internal pressures on corporate environmental behavior in papermaking enterprises of China, Zheng-Xia He *et al*, *Journal of Cleaner Production*, Vol.172. As China's ecological environmental problem becomes severe, corporate environmental behaviour (CEB) has become the focus of a range of stakeholders, policy makers and the whole society since the operating activities of companies is the main source of environmental pollution. This study used a questionnaire survey and structural equation model (SEM) to examine the relative importance of external and internal pressures (EIP) on driving CEB. Data was obtained from 702 papermaking companies in China.

Cleaner production solution selection for paper making – a case study of Latif paper products Co. Iran, Majid Azizi *et al*, *International Journal of Sustainable Engineering*, online. The objective of this research is to design an approach for selecting appropriate solutions to efficiently and productively reduce environmental pollution and water, energy and raw material consumption in a recycled paper manufacturing facility, the paper mill in Latif, Iran. To reach this goal, we develop a decision-making model using the Analytic Hierarchy Process (AHP).

Providing an evaluation model of Green Productivity in paper-making industries, F. Taher-Ghahremani *et al*, *International Journal of Environmental Science and Technology*, Vol.15 (2). Nowadays, the environmental protection is one of the most important duties of every person and organization. One of the industries that pollute the environment is the paper-making industry, which has high importance. The primary objective of this study is to provide a model to evaluate the Green Productivity in the paper-making industry. Results show that Green Productivity index depends on factors such as manpower, materials, energy and machinery and environmental factors. Results also demonstrate that in a stationary condition, a quality system such as ISO 9001 can be useful in increasing the Green Productivity. According to the results, it is recommended to concern organizational productivity, machinery, manpower, in addition to environmental effects (air, waste, and sewage) to increase Green Productivity in paper-making industry.

MOULDED FIBRE

Prospects for Replacement of Some Plastics in Packaging with Lignocellulose Materials: A Brief Review, Yanqun Su *et al*, *BioResources*, Vol 13 (2). There has been increasing concern regarding environmental problems arising from the widespread use of petroleum-based plastic materials for packaging. Many efforts have been made to develop sustainable and biodegradable packaging materials to replace plastic products. The current review summarizes recent research progress in developing cellulose packaging materials to replace plastics used for cushioning and barrier packaging functions based on pulp fibers, cellulose nanofibers, and regenerated cellulose films to benefit from their renewability, sustainability and biodegradability.

Production of Biomass Fiber Packaging Material by Microwave Foaming Method, Hao Sun *et al*, *Materials Science Forum*, Vol.916. In recent years, the production and application of plastic planting tray is subject to more restrictions, many scholars at domestic and abroad are actively to develop biodegradable biomass packaging materials. Based on these analysis and summarization, make use of treated sludge, waste paper fibres and industrial waste wood chips as raw materials, adding other environmental protection additives to prepare a kind of biomass foaming material which has low quality, low density and good mechanical properties.

NANO-SCIENCE

Preparation and characterization of tree-like cellulose nanofiber membranes via the electrospinning method, Kai Zhang *et al*, *Carbohydrate Polymers*, Vol.183. A novel tree-like cellulose nanofiber membrane was controllably fabricated via the electrospinning method by adding certain amount of tetra butyl ammonium chloride (TBAC) into the cellulose acetate solution followed by a deacetylation treatment process. The morphological structure, material structure and air filtration performance of both the cellulose and the cellulose acetate tree-like nanofiber membranes were characterized.

A novel enzymatic approach to nanocrystalline cellulose preparation, Carbohydrate Polymers, Facundo Beltramino *et al*, *Carbohydrate Polymers*, Vol.189. In this work, conditions for an enzymatic pretreatment prior to NCC isolation from cotton linter were assessed. Different cellulase doses and reaction times were studied within an experimental design and NCC were obtained. Evidence presented in this work would reduce the use of harsh sulfuric acid generating a cleaner stream of profitable oligosaccharides.

Production of nanofibrillated cellulose with superior water redispersibility from lime residues via a chemical-free process, Saranya Jongaroontaprangsee *et al*, *Carbohydrate Polymers*, Vol.193. Water removal during drying of nanofibrillated cellulose (NFC) generally results in the formation of hydrogen bonds between fibres, leading to irreversible fibre agglomeration and hence their poor water redispersibility. The feasibility of using lime residues after juice extraction to produce dried NFC possessing superior redispersibility was here investigated.

A comparative study on the preparation and characterization of cellulose nanocrystals with various polymorphs, Jie Gong *et al*, *Carbohydrate Polymers*, Vol.195. Polymorphic changes of cellulose nanocrystals (CNCs) are strongly associated with its properties and applications. In this study, CNCs with different polymorphs were produced by a simple polymorphic transformation treatment. The polymorphic changes of CNCs, and their properties including morphology, crystallinity, thermal stability, and re-dispersion ability were systematically investigated.

Toward a deeper understanding of the thermal degradation mechanism of nanocellulose, Karin Lichtenstein & Nathalie Lavoine, *Polymer Degradation and Stability*, Vol.146. Understanding the thermal degradation process of cellulose-nanofibers (CNF) is necessary for developing high-value added CNF-based materials with e.g. fire retardant properties or high thermal stability. This study compares the thermal degradation behavior of softwood pulp before and after TEMPO-mediated oxidation, and that of the respective CNF and TEMPO-oxidized CNF with either sodium carboxylate (T–CNF COONa) or carboxylic acid surface groups (T–CNF COOH).

NOVEL PRODUCTS

Novel bioactive surface functionalization of bacterial cellulose membrane, Wei Shao *et al*, *Carbohydrate Polymers*, Vol.178. Bacterial cellulose (BC) membrane is a promising biopolymer which can be used for tissue implants, wound healing, and drug delivery due to its unique properties, such as high crystallinity, high mechanical strength, ultrafine fibre network structure, good water holding capacity and biocompatibility. However, BC does not intrinsically present antibacterial properties. In the present study, functionalized BC membranes were prepared.

Self-assembled cellulose materials for biomedicine: A review, Jisheng Yang & Jinfeng Li, *Carbohydrate Polymers*, Vol.181. Cellulose-based materials have reached a growing interest for the improvement of biomedicine, due to their good biocompatibility, biodegradability, and low toxicity. Self-assembly is a spontaneous process by which organized structures with particular functions and properties could be obtained without additional complicated processing steps. This article describes the modifications, properties and applications of cellulose and its derivatives, which includes a detailed review of representative types of solvent. Additionally, the applications of cellulose-based materials which can self-assemble into micelles, vesicles and other aggregates, for drug/gene delivery, bioimaging, biosensor, are also discussed.

Comparative study of ultra-lightweight pulp foams obtained from various fibers and reinforced by MFC, Y. Liu *et al*, *Carbohydrate Polymers*, Vol.182. A range of cellulose-based, ultra-lightweight pulp foams with different morphologies were prepared and reinforced with microfibrillated cellulose (MFC). By careful design of the pulp foam forming process, free-standing ultra-lightweight pulp foams were obtained through high velocity mixing and air/oven drying from cellulose fibre in the presence of surfactant, MFC, and retention aid. The effects of different types of fibres and surfactants on the air uptake volumes and mechanical properties of the foam were systematically investigated. The process developed in this work provides a cost effective approach to fabricate the strong and ultra-lightweight pulp foam, with a density lower than 0.02g/cm^3, using a standard handsheet former.

Fabrication of cellulose/graphene paper as a stable-cycling anode materials without collector, Chunliang Zhang *et al*, *Carbohydrate Polymers*, Vol.184. Flexible and foldable devices attract substantial attention in low-cost electronics. Among the flexible substrate materials, paper has several attractive advantages. In our study, we fabricate cellulose/graphene paper by wet end formation (papermaking).

Novel biorenewable composite of wood polysaccharide and polylactic acid for three dimensional printing, Wenyang Xu *et al*, *Carbohydrate Polymers*, Vol.187. Hemicelluloses, the second most abundant polysaccharide right after cellulose, are in practice still treated as a side-stream in biomass processing industries. In the present study, we report an approach to use a wood-derived and side-stream biopolymer, spruce wood hemicellulose (galactoglucomannan, GGM) to partially replace the synthetic PLA as feedstock material in 3D printing. Combining with 3D printing technique, the biocompatible and biodegradable feature of spruce wood hemicellulose into the composite scaffolds would potentially boost this new composite material in various biomedical applications such as tissue engineering and drug-eluting scaffolds.

Design and preparation of metal-organic framework papers with enhanced mechanical properties and good antibacterial capacity, Liwei Qian *et al*, *Carbohydrate Polymers*, Vol.192. In this study, a biodegradable paper-based composite with good mechanical and antibacterial properties was obtained by first reinforcing the cotton pulp-based paper with carboxylated cellulose nanofiber (CNF) via the Williamson reaction, followed by in situ generating zeolitic imidazolate framework-67 (ZIF-67) nanoparticles on the surface of the resulting cellulosic material. The mechanical properties and antibacterial activities of the resulting composite were investigated. This biodegradable composite could be potentially used in the field of medical and health security.

Converting untreated waste office paper and chitosan into aerogel adsorbent for the removal of heavy metal ions, Zhanying Li *et al*, *Carbohydrate Polymers*, Vol.193. The utilization of waste paper, an obsolete recyclable resource, helps to save resources and protect environment. In this paper, an aerogel was prepared to convert the waste paper into a useful material, which was used to adsorb heavy metal ions and handle water pollution. The low cost, environmental friendliness, excellent adsorption capacity and regeneration ability made this novel aerogel a promising adsorbent for heavy metal ions.

Microstructural characterization of nanocellulose foams prepared in the presence of cationic surfactants, Marcos Mariano *et al*, *Carbohydrate Polymers*, Vol.195. In this work, we explore the architecture of highly porous foams based on cellulose nanofibers (CNFs) prepared by using cationic surfactants as modifying agents.

A study on the transmission haze and mechanical properties of highly transparent paper with different fiber species, Panpan Zhou *et al*, *Cellulose*, Vol.25 (3). Transparent paper with high transmission haze has garnered great attention due to its potential applications in light management of optoelectronics as a bulk optical material. Herein, we investigated the transmission haze and mechanical properties of transparent paper with different fibre species. This work sheds light on the preparation of highly transparent and strong paper with excellent light scattering behaviour for manipulating light behaviour of optoelectronics as a bulk optical material.

Regenerated cellulose from *N*-methylmorpholine *N*-oxide solutions as a coating agent for paper materials, Marta Krysztof *et al*, *Cellulose*, online. 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.

PACKAGING TECHNOLOGY

A comparative study of gelatin and starch-based nano-composite films modified by nano-cellulose and chitosan for food packaging applications, S.M. Noorbakhsh-Soltani *et al*, *Carbohydrate Polymers*, Vol.189. Environmental concerns have led to extensive research for replacing polymer-based food packaging with bio-nano-composites. In this study, incorporation of nano-cellulose into gelatin and starch matrices is investigated for this purpose. Chitosan is used to improve mechanical, anti-fungal and waterproof properties. The results show that increasing nano-cellulose composition to 10% leads to increase the tensile strength at break to 8121 MN/m2 and decrease the elongation at break. Also, increasing chitosan composition from 5% to 30% can enhance food preservation up to 15 days.

Mechanically improved polyvinyl alcohol-composite films using modified cellulose nanowhiskers as nano-reinforcement, Cristiane Spagnol *et al*, *Carbohydrate Polymers*, Vol.191. Cellulose nanowhiskers (CWs) extracted from cotton fibers were successfully modified with distinct anhydrides structures and used as additives in poly(vinyl alcohol) (PVA) nanocomposite films. A significant increase in mechanical properties such as tensile strength, elastic modulus, and elongation at break showed a close relationship to the amount and chemical surface characteristics of CWs added, suggesting that these modified-CWs could be explored as reinforcement additives in PVA films.

Antimicrobial wrapping paper coated with a ternary blend of carbohydrates (alginate, carboxymethyl cellulose, carrageenan) and grapefruit seed extract, Shiv Shankar and Jong-Whan Rhim, *Carbohydrate Polymers*, Vol.196. A functional biopolymer-coated paper was prepared by coating a ternary blend of the alginate, carboxymethyl cellulose, and carrageenan with grapefruit seed extract (GSE) for the substitute use of synthetic polymer-coated paper. The biopolymer-coated paper showed a high potential for disposable food packaging applications to increase the shelf-life of packaged food.

Nanofibrillated bacterial cellulose and pectin edible films added with fruit purees, Rayra Melo Viana *et al*, *Carbohydrate Polymers*, Vol.196. Bacterial cellulose (BC) is a water resistant and strong material for edible films. Previous studies have been conducted on edible films containing fruit purees, but not using BC. The partial or total replacement of pectin in these films with NFBC resulted in improved physical properties, making the films stronger, stiffer, more resistant to water, and with enhanced barrier to water vapour. Fruit containing films based on pectin are suggested for sachets, whereas applications for food wrapping or coating may benefit from the use of NFBC.

PAPERMAKING

Effect of retention rate of fluorescent cellulose nanofibrils on paper properties and structure, Qijun Ding *et al*, *Carbohydrate Polymers*, Vol.186. In this work, we report a new characterization method using fluorescent cellulose nanofibrils to analyze retention and loss rates in the papermaking process. A thorough investigation of the relation between the retention rate and paper sheet performance was conducted.

Sonication-assisted surface modification method to expedite the water removal from cellulose nanofibers for use in nanopapers and paper making, Jatin Sethi *et al*, *Carbohydrate Polymers*, Vol.197. This paper addresses the issue of high water retention by cellulose nanofibers (CNFs) that lead to exorbitant time consumption in the dewatering of CNF suspensions. This has been a bottleneck, which is restricting the commercialization of CNF derived products such as nanopapers and CNF reinforced paper sheets. As a remedy, we suggest an eco-friendly water-based approach that involves the use of sonication energy and lactic acid (LA) to modify the surface of CNFs.

Cellulose nanofibers from residues to improve linting and mechanical properties of recycled paper, Ana Balea *et al*, *Cellulose*, Vol.25 (2). The production of high filler-loaded recycled papers is often affected by high values of linting and low values of strength. In the first case, the accumulation of lint particles from paper's surface on the printing blanket affects the quality of the printed paper and the pressroom's productivity. In the second case, increasing the use of fillers and recycling cycles lead to poor paper strength. The objective of this research is, therefore, to quantify the effect of applying lower grade, more sustainable CNFs on linting phenomena and on the mechanical properties of recycled papers.

Influence of relative humidity on the strength of hardwood and softwood pulp fibres and fibre to fibre joints, Marina Jajcinovic *et al*, *Cellulose*, Vol.25 (4). Cellulosic materials are highly sensitive towards environmental changes such as temperature and especially towards humidity. Besides morphological changes like swelling and/or shrinking, the mechanical properties of pulp fibres and fibre to fibre joints change as well. The current study sets to elucidate the changes and the extent to which elevated or decreased relative humidity (RH) influences the load bearing capacity of individual hardwood and softwood fibres and joints.

Preparation of a modified diatomite filler via polyethyleneimine impregnation and its application in papermaking, Wei Shang *et al*, *Journal of Applied Polymer Science*, Vol.135. In this study, we sequentially modified diatomite (DM) particles with sodium dodecyl sulfate and polyethyleneimine with an impregnation method. Modified DM was used as both a filler and an anionic trash catcher in the papermaking process. The results show that the modified DM could be used as a good, novel filler in papermaking..

Unique alkyl ketene dimer Pickering-based dispersions: Preparation and application to paper sizing, Qi Zhao *et al*, *Journal of Applied Polymer Science*, Vol.135 (4). Herein, particle-stabilized alkyl ketene dimer (AKD) dispersions were prepared using dodecyl trimethyl ammonium chloride (DTAC)-modified laponite as the stabilizer, and sodium alginate (SA) as the protective colloid. The dispersions were fully characterised and their effect on paper properties assessed.

Water-Soluble Pressure-Sensitive Adhesives Containing Carboxymethyl Starch with Improved Adhesion to Paper, Katarzyna Wilpiszewska & Zbigniew Czech, *Journal of Polymers and the Environment*, Vol.26 (4). Water-soluble pressure-sensitive adhesives (PSA) based on acrylic acid and carboxymethyl starch (CMS) have been prepared. The tack and peel adhesion to various paper types (newsprint, hygienic, packing, fax and art paper) as well as dynamic shear adhesion at higher temperatures (70–240 °C) have been tested with the aim of applying such PSA in a form of double-sided splicing tapes for paper industry.

Multilayer assembly of ionic starches on old corrugated container recycled cellulosic fibers, Hamidreza Rudi *et al*, *Polymer International*, Vol.67 (1). In this study, old corrugated container recycled fibers were treated with polyelectrolyte multilayers consisting of biopolymer cationic starch with two degrees of substitution (DS) each in combination with one anionic starch. The results indicated a significant interaction between the DS of cationic starch and the number of ionic starch layers formed.

PULPING

Bio-based products from xylan: A review, Darrel Sarvesh Naidu *et al*, *Carbohydrate Polymers*, Vol.179. Obtaining chemicals and materials in sustainable ways is of growing importance. A potential source of sustainable chemicals and materials is lignocellulosic biomass residues generated as waste from agriculture. Hemicellulose which is a large component in lignocellulosic biomass residues, provides many potential applications such as the generation of chemicals, packaging materials, drug delivery and biomedical applications. This review deals with the various techniques which can be used for the extraction of hemicellulose from biomass residues, purification and some potential applications of the extracted hemicellulose.

Chemical modification of cellulose-rich fibres to clarify the influence of the chemical structure on the physical and mechanical properties of cellulose fibres and thereof made sheets, Verónica López Durán *et al*, *Carbohydrate Polymers*, Vol.182. Despite the different chemical approaches used earlier to increase the ductility of fibre-based materials, it has not been possible to link the chemical modification to their mechanical performance. In this study, cellulose fibres have been modified by periodate oxidation, alone or followed either by borohydride reduction, reductive amination or chlorite oxidation. It was found that the modifications studied improved the tensile strength of the fibres to different extents, but that only periodate oxidation followed by borohydride reduction provided more ductile fibre materials. Changes in density, water-holding capacity and mechanical performance were also quantified and all are dependent on the functional group introduced.

Study of steam explosion pretreatment and preservation methods of commercial cellulose, Ana Lorenzo-Hernando *et al*, *Carbohydrate Polymers*, Vol.191. Steam explosion (150–200 °C, 5–30 min) was performed on a commercial cellulose presented in two configurations (fiberized and compact sheet) and its effect on their chemical and physical properties was studied, along with the influence of two different preservation methods (acetone drying and freezing) after pretreatment. Both acetone and freezing processes extremely affected cellulose properties. Acetone drying counterbalanced crystallinity and enzymatic accessibility variations of pretreated samples, while decreasing polymerization degree. Freezing dramatically decreased enzymatic accessibility of pretreated samples down to 15.8%.

A study on pulping of rice straw and impact of incorporation of chlorine dioxide during bleaching on pulp properties and effluents characteristics, Daljeet Kaur *et al*, *Journal of Cleaner Production*, Vol.170. The world is facing challenges to reduce global environmental issues including waste management, greenhouse gas emissions, pollution, deforestation and depletion of non-renewable resources originated due to speedy industrial and urban development. Rice straw, a lignocellulosic residue is abundantly available in wood short countries like India and China and can be utilized in pulp and paper industry. This article shows that using agricultural waste as a raw material for making paper can prove to be valuable towards waste utilization, pollution control and for sustainable growth of industry.

Environmental performance of straw-based pulp making: A life cycle perspective, Mingxing Sun *et al*, *Science of The Total Environment*, Vol.616–617. Agricultural straw-based pulp making plays a vital role in pulp and paper industry, especially in forest deficient countries such as China. However, the environmental performance of straw-based pulp has scarcely been studied. A life cycle assessment on wheat straw-based pulp making in China was conducted to fill of the gaps in comprehensive environmental assessments of agricultural straw-based pulp making.

Environmental Aspect of Using Chlorine Dioxide to Improve Effluent and Pulp Quality During Wheat Straw Bleaching, Daljeet Kaur *et al*, *Waste and Biomass Valorization*, online. This paper illustrates the need of using the agro waste (wheat straw) as a substitute for forest products in paper industry. It aims on using the soda-AQ pulping process for converting waste to fibrous pulp. Further, it emphasizes on use of chlorine dioxide in place of elemental chlorine and hypochlorite during bleaching with aim of reducing the wastewater load and improving the pulp quality.

TESTING

On the origin of sorption hysteresis in cellulosic materials, Lennart Salmén & Per A. Larsson, *Carbohydrate Polymers*, Vol.182. Moisture sorption and moisture sorption hysteresis of carbohydrates are phenomena which affect the utilisation of products made thereof. Although extensively studied, there is still no consensus regarding the mechanisms behind sorption hysteresis. This article reviews how different chemical and physical modifications affect the phenomenon.

Molecular deformation of wood and cellulose studied by near infrared spectroscopy, Fei Guo and Clemens M. Altaner, *Carbohydrate Polymers*, Vol.197. Wood (Eucalyptus regnans and Pinus radiata) and paper samples were stretched to different strain levels using a purpose-built tensile test device fitted into a near infrared (NIR) spectrometer while collecting transmission spectra. Consistent spectral changes caused by mechanical strain, assigned to OH stretching bands, were observed.

Water retention value for characterizing fibrillation degree of cellulosic fibers at micro and nanometer scales, Feng Gu *et al*, *Cellulose*, online. This study examined in detail the utility and validity of water retention value (WRV) for characterizing the extent of fibrillation of micro and nanofibrils. A bleached pulp fibre sample was either refined to different degrees using a PFI mill or milled for different time periods using a SuperMassColloider (SMC), to produce micro and nanofibril samples. These fibril samples were then characterized by electronic microscopic imaging (SEM and TEM), degree of polymerization (DP), Canadian Standard Freeness (CSF), enzymatic adsorption (EA), enzymatic cellulose digestibility (ED), as well as WRV measured under different relative centrifugation forces and durations.

Dielectric Losses of Paper in the THz Domain: Literature Review, Needs for Future Research, and Prospective Solutions, Patrick Huber *et al*, *Physica Status Solidi*, Vol.212 (12). High frequency paper-based electronics is developing fast, with smart yet low cost applications in view. However, the dielectric losses of paper remain a difficult hurdle to overcome. First, the literature on the topic is reviewed and the contributions from moisture, air, mineral filler, and wood constituents to dielectric losses are highlighted. Then, the guidelines for future research are defined, including the need for systematic comparisons in controlled moisture conditions. In an effort to produce low loss materials for paper-based electronics, it is proposed here to impregnate paper with a low loss substance, after removing residual water.

Hydroxyl accessibility and dimensional changes of Scots pine sapwood affected by alterations in the cell wall ultrastructure during heat-treatment, Michael Altgen *et al*, *Polymer Degradation and Stability*, online. There is a complex link between the water sorption behaviour and the presence of accessible hydroxyl groups in the wood cell wall, which can be altered by heat-treatment (HT). This study analyses the effect of changes in the cell wall ultrastructure caused by two HT techniques on the hydroxyl accessibility, water vapour sorption and dimensional changes of Scots pine (Pinus sylvestris L.) sapwood.

Comparison of test methods for oxygen permeability: Optical method versus carrier gas method, Kajetan Müller *et al*, *Polymer Testing*, Vol.63. The oxygen permeability of films is relevant for packaging related and technical applications. An increasingly used test method for the measurement of oxygen permeability is the optical test method, because it allows a simple and cost-efficient measurement setup. This method is based on optical chemical sensors. However, not much is known about its validity. Therefore, method validation is necessary which is subject of this study. The optical method is compared with the carrier gas method for a variety of film samples.

Optical coherence tomography image analysis of polymer surface layers in sound-absorbing fibrous composite materials, Eulalia Gliścińska *et al*, *Polymer Testing*, Vol.63. The material surface layer affecting sound absorption was identified by optical coherence tomography (OCT) image analysis. To characterise this layer, a special algorithm was developed to distinguish the polymer surface layer in thermoplastic composite materials, define its structure and thickness, and specify differences in these properties. The results of the measured sound absorption coefficient were analysed together with the OCT results. The use of OCT for the study of materials with specific acoustic characteristics was successfully demonstrated.

Study on the method for testing the water vapor diffusion resistance of membranes, Wei Li and Ye Yao, *Polymer Testing*, Vol.69. Water vapour diffusion resistance is an important property of porous membranes. In the paper, a new apparatus for specially measuring the water vapor diffusion resistance of porous membranes was developed. The new apparatus is a simple, low-cost and time-saving alternative for measuring the water vapour diffusion resistance of porous membranes.

WASTE TREATMENT

Screening Predominant Bacteria and Construction of Efficient Microflora for Treatment of Papermaking White Water, Huixia Lan *et al, BioResources*, Vol.13 (2). Three strains of bacteria were isolated and purified from activated sludge for white water treatment in the laboratory. These strains were identified as *Bacillus subtilis*, *Bacillus cereus*, and *Virgibacillus pantothenticus* through a morphological analysis, the MIDI Sherlock automatic microbial identification system, and 16S rRNA methods. The results of the construction of efficient microflora for white water showed that a mass percentage ratio of *B. subtilis*, *B. cereus*, and *V. pantothenticus* of 50%:35%:15% achieved an optimal treatment effect.

Metallo-Terpyridine-Modified Cellulose Nanofiber Membranes for Papermaking Wastewater Purification, Mohammad Hassan *et al*, *Journal of Inorganic and*

***Organometallic Polymers and Materials*, Vol.28 (2).** Metallo-terpyridine compounds and polymers exhibit unique optical, electrical, magnetic and antimicrobial properties. Recently, metallo-terpyridine-modified cellulosic films with interesting porous structure, that exhibit these properties, have been prepared. Herein we report the use of Cu-terpyridine-modified oxidized cellulose nanofibers (OXCNF-Cu-Tpy) as membranes for treatment of effluents of paper mills to produce re-usable water.

Photoactive polymeric and hybrid systems for photocatalytic degradation of water pollutants, Maria Nowakowska & Krzysztof Szczubiałka, *Polymer Degradation and Stability*, Vol.145. The review presents recent developments in the synthesis of polymeric photosensitizers and hybrid photocatalysts of various physicochemical and photochemical properties and their possible application for the degradation of water pollutants. The mechanisms of their action are also presented.

Dissolved oxygen control strategies for the industrial sequencing batch reactor of the wastewater treatment process in the papermaking industry, Yi Man *et al*, *Environmental Science: Water Research & Technology*, online. This paper proposes two strategies for controlling the dissolved oxygen concentration in the sequential batch reactor of the wastewater treatment process in the papermaking industry. Based on a previously developed sequential batch reactor simulation model, a fuzzy logic system and a neural network are integrated with a PID controller separately. Simulation results reveal the superiority of the developed fuzzy-PID control strategy in the dissolved oxygen control of the sequential batch reactor of the wastewater treatment process in the papermaking industry.

WOOD PANEL

Cellulose nanofiber board, Hossein Yousefi *et al*, *Carbohydrate Polymers*, Vol.187. A cellulose nanofibre board (CNF-board) with a nominal thickness of 3 mm was fabricated without adhesive or additive. To provide comparison, a cellulose fibre board (CF-board) was also fabricated. A novel cold pre-press apparatus was made to dewater highly absorbent CNF gel prior to drying. The specific flexural and tensile strengths of CNF-board obtained were higher than those of CF-board as well as some other traditional wood-based composites, polymers and structural ASTM A36 steel.

Hydrothermal treatment of strand particles of pine for the improvement of OSB panels, Amélia Guimarães Carvalho *et al*, *European Journal of Wood and Wood Product*s, Vol.76 (1). The aim of this study was to evaluate the effect of hydrothermal treatment in strand particles of pine used for oriented strand boards (OSB) production. Strand particles of pine were hydrothermally treated at 130, 150 and 170 °C for 7 and 21 min, for the determination of chemical composition, pH, equilibrium moisture content, particles mass loss, and contact angle of these particles with phenol–formaldehyde resin.

Stiffness modelling of particles in the core layer for the manufacturing of wood-reduced particleboard, Matthias Schneider *et al*, *European Journal of Wood and Wood Products*, Vol.76 (3). A great demand for wood material has led to an increase in the price of industrial wood in the past and will raise it even further in future. Industry and research have reacted to this increasing price of wood, for example, by developing weight-reduced particleboard. One approach to achieve this reduction in weight is to use suitable chip geometries in the core layer instead of lightweight, resource-saving filling materials. For this purpose, particle geometries were analysed with regard to this property within a project for the development of weight-reduced particleboards.

Practical properties and formaldehyde emission of medium density fiberboards (MDFs) recycled by electrical method, Bita Moezzipour *et al*, *European Journal of Wood and Wood Products*, online. In this study, the performance of the electrical method in MDF waste recycling was determined. For investigating the practical aspect of the electrical method, the hydrothermal method as a known recycling method was studied too. The results of this study confirmed the positive effect of recycled fibers on reducing the formaldehyde emission from MDF boards which can be considered as an excellent benefit for the recycling process due to the importance of environmental and human health issues.

Recovering fibres from fibreboards for wood polymer composites production, F. Yağmur Bütün *et al*, *International Wood Products Journal*, online. In most countries, fibreboards are not recovered after utilization but burned for energy production. This study aims at recovering fibres from industrial fibreboards and reusing them as reinforcement elements in wood polymer composites (WPC). The study indicates that recovered fibres are suitable to produce WPC with very similar physico-mechanical properties as those from 'virgin' fibres.

All Natural High-Density Fiber- and Particleboards from Hemp Fibers or Rice Husk Particles, Daniele Battegazzore *et al*, *Journal of Polymers and the Environment*, Vol.26 (4). In the present study, long hemp fibres and rice husk particles have been used for producing all natural-based boards for building, automotive and in-door furniture, employing a simple and economic transformation process (namely, compression moulding). In order to have the required consistence and mechanical strength, corn starch was employed as binder. By this way, fibre- and particleboards have been prepared and characterized in terms of morphology, mechanical properties (flexural modulus and strength).

Improving Water Resistance of Soy-Based Adhesive by Vegetable Tannin, Saman Ghahri *et al*, *Journal of Polymers and the Environment*, Vol.26 (5). In this research tannic acid was used to prepare soy-based adhesives for making plywood and fibre board. The different resin formulations were analysed. Overall, the mechanical and physical properties such as MOR, MOE, IB, and water resistance of fibreboard were improved, by adding tannic acid to the soy-based adhesive.

Investigating the interaction between internal structural changes and water sorption of MDF and OSB using X-ray computed tomography, Wanzhao Li *et al*, *Wood Science and Technology*, Vol.52 (3). Both medium density fibreboard (MDF) and oriented strand board (OSB) are increasingly used in construction, yet when exposed, water sorption can cause internal structural changes, as such decreasing mechanical strength and increasing decay risk. It is, therefore, essential to understand the interaction between structural changes and water sorption of MDF and OSB. This article makes a detailed study of physical changes caused by water sorption.

PAPERmaking!

FROM THE PUBLISHERS OF PAPER TECHNOLOGY

Volume 4, Number 1, 2018

Paper Industry Technical Association
5 Frecheville Court, Bury, Lancashire BL9 0UF, United Kingdom
Tel: +44 (0)300 3020 150 Fax: +44 (0)300 3020 160
Email: info@pita.org.uk Website: www.pita.org.uk

Events

Details of selected forthcoming world events. In this edition:

A detailed World Calendar of Events can be found at:

https://www.pita.org.uk/what-we-do/events-activities/calendar-of-world-events

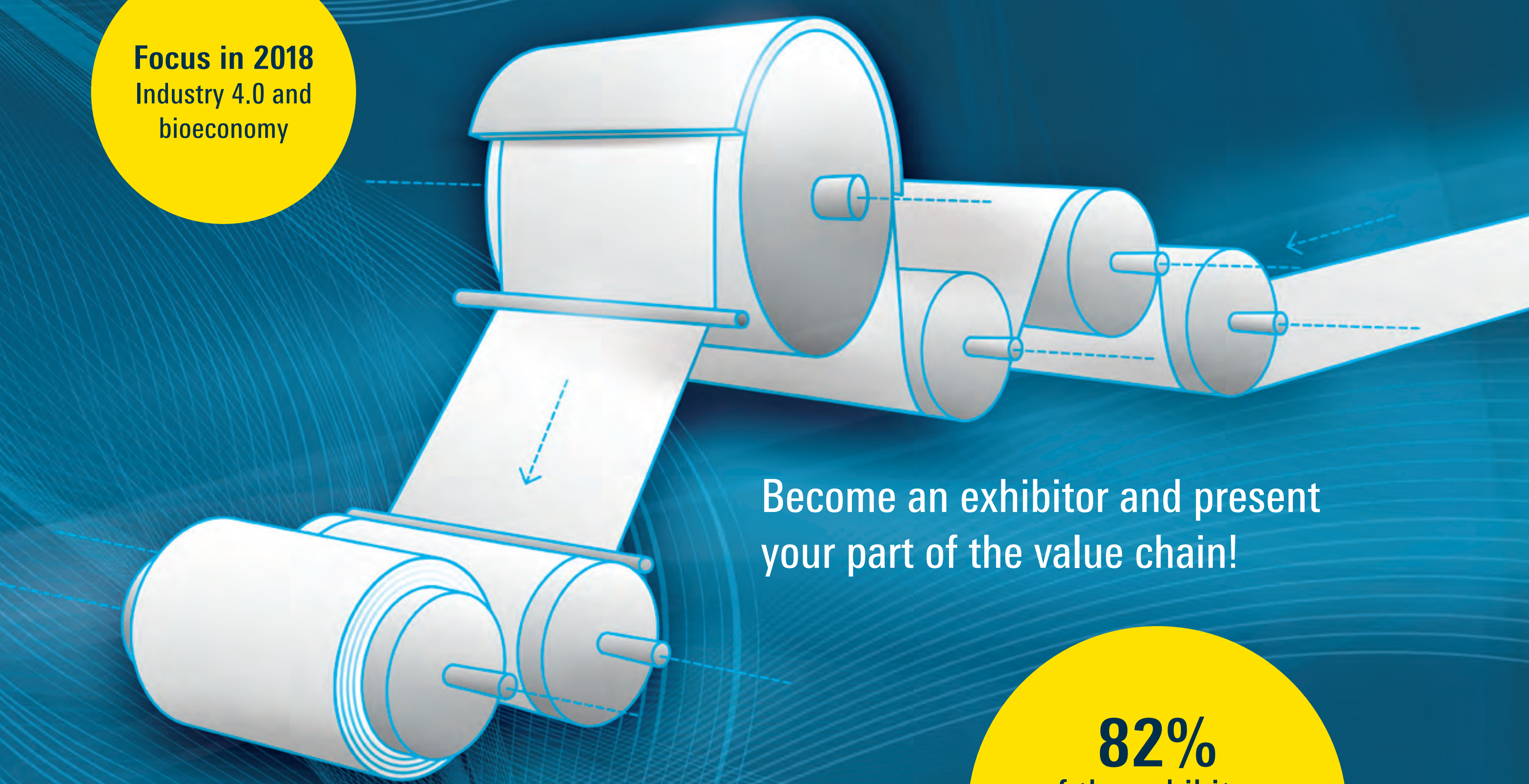
ZELLCHEMING-Expo

Exhibition and 113th Annual General Meeting
Pulp, paper and supplier industry
as well as fiber based materials

Frankfurt a.M., Germany, 26 – 28 June 2018

Tradition and innovation side by side

Focus in 2018
Industry 4.0 and bioeconomy



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*Source: Exhibitor survey ZELLCHEMING-Expo 2017/statistically verified

PITA Training & Conferences

Kate Leach presents . . . .

"An Introduction to Tissue Manufacture"

Essential Background Knowledge for Anyone involved in the Tissue Sector

18th – 20th September 2018 / PITA Office

This Three Day Introductory course provides an insight into the modern tissue mill and the peculiarities of tissue when compared with conventional paper products.

Kate will lead attendees through the process of manufacturing tissue from fibres to finishing and explore key aspects of the 'Tissue Machine' including the Yankee Cylinder, Tissue Properties, Costs, Quality and, perhaps most mysterious of all, Softness.

This course is essential training for anyone (manufacturer or supplier) new to the Tissue Sector or those wishing to broaden their understanding of this fascinating paper product.

Day One:

Day One will look at the full tissue production process, from fibre to shelf

- ***Fibres:*** *the basics, the different types, how they impact on final sheet properties*
- ***Pulping****: a look at the major types of virgin fibre pulping techniques, & secondary fibre treatments*
- ***Papermaking:*** *a guide through the papermaking process, from pulp preparation & approach flow through to the end of the paper machine*
- ***Chemical Additives****: talking through the most common categories of chemical additives used through the tissue making process*
- ***Finishing & Converting****: from the parent reel-up to the customer - what processes are likely to be involved in turning a parent reel into saleable tissue*

Day Two:

Building on the knowledge gained, Day Two looks at tissue properties & process costs

- ***Tissue Properties*** – *identifying what properties are desirable in different types of hygienic paper, looking at how our manufacturing processes impact on these. Is it possible to enhance all our properties together? Or are there trade-offs to be considered?*
- ***Considering Quality*** - *What does "quality" mean to each of your customers throughout the process? How can we influence final sheet properties right from the start of the process? Look at root cause issues of quality defects*

Day Three:

Day Three consolidates earlier learnings & focuses on the importance of the Yankee Cylinder

- ***Focus on the Yankee Cylinder*** *–A look at Yankee performance & operation. Where to look when trying to trouble shoot the root cause of issues that may be seen & experienced at the Yankee*
- ***Measurement Methods*** - *Making sure there is a common language for quality standards between customer & supplier. An overview of the type of measurements that are taken in tissue manufacture, & the equipment used*
- ***Softness*** – *looking at softness in a logical progression, from the definition of softness, through to how it is measured & finally looking at ways to enhance softness perception through papermaking processes*

Only £699 (plus VAT) per person for the three day course, including full course notes, refreshments & six months complimentary membership of PITA

For further details &
to book your place on this course,
contact Helen in the PITA Office
(0300 3020 150 / helen@pita.org.uk)

Paper Industry Technical Association

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.

5 Frecheville Court
Bury
Lancashire
BL9 0UF

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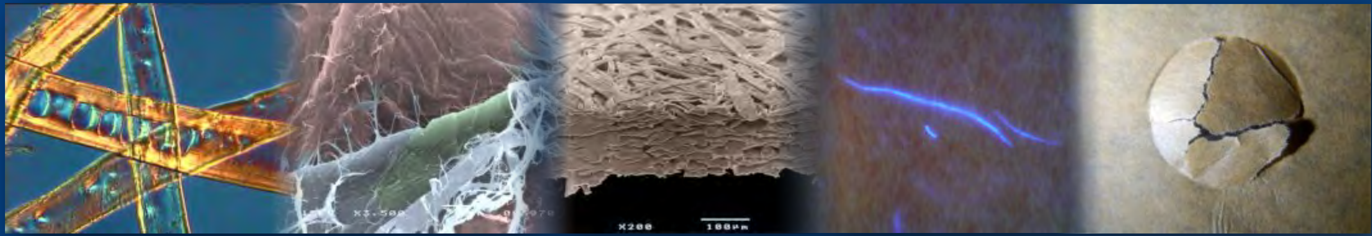
If calling from outside the UK: +44 161 764 5858
Fax: 0300 3020 160
E-mail: info@pita.co.uk



Progress in Paper Physics Seminar

PPPS2018

Objectives of the Seminar

Presentation, promotion and information-sharing on the most up-to-date fundamental research and knowledge related to a wide range of topics:

- structure and properties of fibres, fibre network and fibrous materials
- microstructure of fibres, fibre modification, bonding behaviour
- physical and physicochemical mechanisms
- fibre network and finished paper sheet
- testing methods of paper structure and paper properties including modeling and simulation
- materials used for paper modification (e.g. NC, MFC)
- paper-based composites

Important dates:

20th of May, 2018 Submission of detailed abstracts

15th of June, 2018 Acceptance of abstracts

20th of July, 2018 End of early-bird registration

15th of September, 2018 End of registration

23rd of September, 2018 START of the Seminar

PPPS2018

Organiser and Seminar Office:
Lodz University of Technology
Institute of Papermaking and Printing
Wolczanska 223
90-924 Lodz
tel: +4842 631 38 03
fax: +4842 631 38 01

email: ppps2018@info.p.lodz.pl
www.ppps2018.pl

Seminar location:
Lodz University of Technology
International Faculty of Engineering
Zwirki 36
90-924 Lodz
(CAMPUS A)

TAPPI Paper Physics Committee

and

Institute of Papermaking and Printing of Lodz University of Technology

invite to:

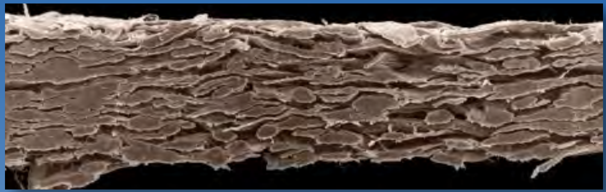
PROGRESS IN PAPER PHYSICS SEMINAR 2018

Lodz, 23-27 of September 2018

www.ppps2018.pl

www.ppps2018.pl

Patronage:
The Association of Polish Papermakers
Media patronage:
Polish Paper Review



Invitation

TAPPI Paper Physics Committee and the Institute of Papermaking and Printing invite to the PROGRESS IN PAPER PHYSICS SEMINAR. We do hope that the Seminar will provide opportunities for exchange of information, creative discussions and further integration of researchers from around the world. We are looking forward to welcome you among our participants.

Organisers

Official Language

English

Papers Submission

Persons interested in presenting a paper should fill in the Registration Form and send it to the Seminar Office, giving paper title, authors' names, affiliation data, keywords and abstract. All abstracts will be included in Seminar proceedings. Depending on the decision of the Scientific Committee, paper may be qualified either for oral or poster presentation.

Abstracts of papers should be delivered via e-mail not later than:

30th of April, 2018.

Please use common text in Microsoft Word® format or Adobe® pdf format.

Participation in the Seminar

Persons interested in participating in the Seminar are requested to fill in the Registration Form (available for download on http://www.ppps2018.pl) and send it to the Seminar Office before **15th of September, 2018**.

Seminar fee should be paid to Organiser's account:

PL 56 1240 3028 1978 0000 2822 2358
Bank PEKAO SA, Lodz
Piotrkowska 270
90-361 LODZ
SWIFT: PKOPPLPW

Important! please add the Seminar identifier: PPPS2018 during money transfer.

Prices

Early-bird registration fee (before 20th of July, 2018):

Regular participant: 465 € (23% VAT included)
Student: 342 € (23% VAT included)

Regular registration fee (after 20th of July, 2018):

Regular participant: 588 € (23% VAT included)
Student: 465 € (23% VAT included)

The fee entitles the participant to:

- Participation in all seminar lectures & poster presentations
- Seminar materials (memory stick with Seminar proceedings, promotional materials)
- Lunches & refreshments
- Gala dinner
- Cultural programme

Printed version of Seminar proceedings should be ordered separately (additional cost: 10 €, VAT included).

The fee does not include accommodation. Please book your accommodation individually.

List of the hotels which are close to location of the Seminar can be found on the website.

Organising Committee

Agnieszka Wysocka-Robak
Wojciech Swiekatowski
Michal Glebowski
Anna Stanislawska
Katarzyna Dybka
Tomasz Ganicz
Piotr Pospiech

Scientific Committee

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Members:

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Jean-Francis Bloch (Universite de Grenoble Alpes, France)
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Samuel Schabel (Technische Universität Darmstadt, Germany)
Martin M. Thuo (Iowa State University, USA)

For more information visit: http://www.ppps2018.pl

"Technical Boilerhouse Risk Assessment"
To achieve "BG01 Compliance"

DO YOU COMPLY WITH YOUR LEGAL OBLIGATIONS?
Risk Assessments are a legal requirement under the Management of Health & Safety at Work Regulations 1999 (MHSWR) Section 3.

Cheltenham Chase Hotel, Cheltenham 25th, 26th, 27th September 2018	Tankersley Manor, Sheffield 4th, 5th, 6th December 2018

Technical Conference Workshop (two-day event) + (One day for MCPD, BG04, I-GAS)

The Combustion Engineering Association (CEA) has been running a series of conferences to help industry understand the changes that have been published in the HSE guidance, INDG 436: Safe Management of Industrial Steam and Hot Water Boilers.

In October 2011, PM5 was replaced by INDG 436, supported by BG01. The CEA have carried out a number of conference workshops across the country supporting these guidance documents.

BG01 has become recognised as industrial best practice for steam and hot water boilers and highlights the legal requirement to carry out a "Technical Boilerhouse Risk Assessment" under the Management of Health and Safety at Work Regulations 1999 (MHSWR)

Delegates attending previous conferences have requested further support from CEA to help them understand **what is required, who is responsible** and **who needs to take action** within the organisation to comply with **the law**. (Non-compliance with HSE guidance and the law are attracting substantial fines and potentially custodial sentences*).

Having responded to this request, CEA and its members created the Technical Boilerhouse Risk Assessment Conference Workshop to achieve compliance with BG01.

This workshop will explain in detail what is required to carry out the Technical Boilerhouse Risk Assessment.

This assessment is not focused on slips, trips and falls but as the title suggests is a comprehensive technical assessment carried out by a small team of staff.

It is essential for owners, operators and managers to ensure their staff are aware of the risks and their respective responsibilities for the safe operation and management of their industrial steam and hot water boiler plant.

*** The Judiciary have been given new sentencing guidelines and penalties have increased significantly. HSE can prosecute you even if you haven't had an accident??? If HSE knock on your door they have more power than the police, they can prosecute you and the company if they think you are in breach of guidance even if nothing has happened.**

*** Your insurance company may well be looking at things differently today. The Competent Person has a duty to report to HSE if they believe your system has serious defects or imminent danger - PSSR Regulation 10.**

Technical Boilerhouse Risk Assessment

To achieve 'compliance with BG01'

CEA
Combustion Engineering Association

CONFERENCE / WORKSHOP PROGRAMME

DAY 1	
08:45 - 09:30	**Registration** - Tea & Coffee
09:30 - 09:35	**Welcome and Overview** - David Kilpatrick (Director CEA)
09:35 - 09:45	**Introduction** - Paul Whitehead (Energy and Environmental Solutions) Conference and Workshop Chairman
09:45 - 10:30	**HSE – The Safe Operation of Boilers** - Derry Carr (CEA Immediate Past Chairman) HSE's expectations, from the industry and boiler users, the status of guidance, its purpose and a brief guide on how to carry out an appropriate risk assessment
10:30 - 11:00	**Risk Assessment** This will be an introduction and a practical exercise in creating a very brief risk assessment as requested by delegates at previous conferences
11:00 - 11:30	**Coffee Break & Exhibition**
11:30 - 12:15	**Legal Requirements for Boiler and System Inspection -** Moore Holmes/Andy Wright (British Engineering Services) Why are periodic inspections necessary? What should be inspected, how and when? Who can carry out maintenance, repairs and modifications? The requirements for documentation and record keeping
12:15 - 12:35	**The CEA Boiler Operation Accreditation Scheme (BOAS) and Approved Training Courses for Operators & Managers -** (CEA Director and BOAS Approved Training Provider) An overview of BOAS, the approved training course, the approved training providers who deliver the course and the assessment process
12:35 - 13:30	**Lunch & Exhibition**
13:30 - 14:15	**Technical Risk Assessment and Compliance with BG01 -** Derry Carr (CEA Immediate Past Chairman) Why is it necessary to carry out an in-depth technical risk assessment, who should do it and what needs to be considered?
14:15 - 14:45	**Why Boiler Water Quality Matters and the Implications of Poor Water Treatment -** Andy Perkins (Deep Water Blue Ltd) Boiler water quality issues are the major cause of boiler failures and also lead to poor boiler efficiency and environmental impact. How do you achieve optimum water quality, operational performance and efficiency, and do it all safely?
14:45 - 15:00	**Coffee Break & Exhibition**
15:00 - 15:45	**BG04 Why Use Specialists in Boiler Water Treatment -** Mick Casey (Deep Water Blue Ltd) 95% of all boiler failures and serious incidents are because of poor boiler water treatment, more often caused by the poor management of boiler watertreatment. Optimum water quality is paramount if you want a safe system of work in your boilerhouse
15:45 - 16:45	**The Risk Factors in "Wet Side Controls" -** Adrian Rhodes (Byworth Boilers and CEA Chairman) What are the issues and risks when you operate any boiler plant? What are your safety devices intended to do, why are they on your boilers and what do YOU need to do?
16:45 - 17:00	**Q & A and Close**

CONFERENCE / WORKSHOP PROGRAMME

DAY 2	
08:30 - 09:00	**Registration - Tea & Coffee**
09:00 - 09:05	**Welcome** – David Kilpatrick (Director CEA)
09:05 - 09:50	**Combustion Safety and Controls** **SAACKE Combustion Services** An explanation of the risks both operational and environmental arising from fuels and combustion, and how they can be effectively managed
09:50 - 10:50	**How to carry out a risk assessment and its legal implications** **Dr Ian Roberts – (Byworth Boilers)** Establishing the principles of risk assessment particularly in the boilerhouse, managing risks within steam and hot water systems, particularly those concerning your own employees, contractors and other third parties. To establish the principles then focus on how to respond to dangerous occurrences and accidents
10:50 - 11:10	**Coffee Break & Exhibition**
11:10 - 12:30	**Practical application of a Boilerhouse Technical Risk Assessment and Management process** Participation by all attendees – Various types of boilers and boilerhouses to be assessed as a "team table" for each of the scenarios presented (Hot Water Boilers, Shell Boilers, Water Tube Boilers and CHP Waste Heat Boilers)
12:30 – 13:30	**Lunch & Exhibition**
13:30 – 15:00	Participation by all groups – Feedback on each of the scenarios.
15:15	Q & A and Close

EXHIBITING

Day 1 - Registration commences 8:45, event starts 09:30, event concludes 17:00, lunch and refreshments provided.

Day 2 - Registration commences 8.30, event starts 9:00, event concludes 15:30, lunch and refreshments provided.

Tel: **01740 625538** Email: **info@cea.org.uk**

"Technical Boilerhouse Risk Assessment" To achieve "BG01 Compliance"

CEA Combustion Engineering Association

Why attend?

INDG 436 was released by the HSE in October 2011 when PM5 and PSG2 were officially withdrawn. Now in 2018 the HSE and Engineering Insurance Companies are looking to see if companies are complying with the guidance given in BG01, as this guidance is now seen as **"Industrial Best Practice".**

BG01 was written to explain the roles and responsibilities when owning, operating or managing hot water and steam boiler plant. To date over 1000 people have attended the BG01 conferences across the UK and as part of the delegate feedback, a significant proportion said they would like more help with carrying out a Technical Boilerhouse Risk Assessment.

In response, CEA has organised risk assessment conference workshops with more practical hands-on training as part of the two days which is extremely valuable.

CEA have redesigned the conference workshop into a two-day event that will provide all of the necessary information regarding INDG 436 and BG01. The second day will primarily be dedicated to a practical workshop. The delegates will work through some risk assessment scenarios and discuss these with other attendees. Mentors will be on-hand to work with each group and help steer you through the examples.
Several CEA member companies are also available to work with you at your site, working alongside some of your company staff who know your plant and to create your own risk assessments.

Who should attend?

All Managers and Engineers responsible for the operation and selection of boiler plant and ancillaries especially those in the following sectors:

Suppliers of services to the boiler user including:

- Boilers insurers
- Consultants to the energy industry
- Contract energy management companies
- Developers
- Fuel suppliers
- Industry development agencies
- Mechanical service contractors
- Plant designers

All organisations using boilers for steam and/or hot water production, such as:

- Breweries
- Chemicals
- Dairies
- Distillers
- Dyers
- Food processing
- Horticulture
- Hospitals
- Paper mills
- Pharmaceuticals
- Textiles
- Laundries
- Facilities companies
- All companies running any boiler

When and where:

25th, 26th, 27th September 2018
Cheltenham Chase Hotel, Shurdington Road, Brockworth, Gloucestershire, GL3 4PB

4th, 5th, 6th December 2018
Tankersley Manor, Church Lane, Tankersley, Sheffield, S75 3DQ

Registration and fees

CEA Member Two Days:
£290.00 (incl. VAT)
CEA Non-Member Two Days:
£390.00 (incl. VAT)

CEA Member One Day Only:
£200.00 (incl. VAT)
CEA Non-Member One Day Only:
£290.00 (incl. VAT)

CEA Member Three Days:
£400.00 (incl. VAT)
CEA Non-Member Three Days:
£550.00 (incl. VAT)

For further Information:
Email: info@cea.org.uk
Tel: 01740 625 538

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PITA Training & Conferences

Paper
Industry
Technical
Association

Roy Fairhurst presents the all new & improved . .

"PITA Paper Appreciation Course"

The Essential Guide for everyone in the Paper Industry

9th & 10th October 2018 / PITA Office, Bury

Known to many of today's Mill Managers, over the years Roy has introduced literally thousands of individuals to the world of Pulp & Paper through his teaching days at Bury College.

This comprehensive, yet easy to assimilate, two day training course is a fantastic jargon buster for those not directly involved in the paper making process and at the same time, shows how individual products and processes fit in with global papermaking practice!

The course walks you through each stage of the paper making process, from sourcing and choosing raw materials to preparing them ready for sheet formation. forming them into paper, board or tissue.

" I have heard many of the words and phrases before, but never really understood what they meant"

"This course has something for everyone"

DAY 1

INTRODUCTION:
Very brief history and some global numbers for P&B production and consumption.

FIBROUS RAW MATERIALS:
Fibre types and fibre structure. Overview of mechanical and chemical pulping and recycled fibre treatments.

WATER:
Water sources. Water contaminants and the problems they cause in papermaking.

CHEMICAL ADDITIVES:
Process and Functional aids. Sizing types and mechanisms. Retention aids. Filler types and function.

WET END OPERATIONS:
Stock Prep, approach flow, sheet formation on single wire, and multi-wire machines and vat formers. Mechanism of refining, screening and cleaning.

MILL VISIT:
Depending on numbers commuting and Travelling, PITA will organise an optional evening Mill Visit.

DAY 2

TISSUE PRODUCTION:
Machine development, drying and creping.

PRESSING:
Press types, press configurations, factors affecting water removal, passive & active cambers. Press felts, design and cleaning

DRYING:
Traditional cylinder dryers. Drying mechanism, heat transfer. Importance of good ventilation. Condensate removal and heat recovery.

FINISHING OPERATIONS:
Breaker stack, surface sizing, calendaring, coating, MG drying, embossing, winding, slitting and sheeting.

CONVERTING PROCESSES:
Laminating, embossing, creping, impregnating, corrugating and printing.

PRINCIPLES OF PROCESS CONTROL:
Reasons for process control. Open and closed control loops, feed forward and feed back. Elements of a control system.

PRINTING PROCESSES:
Letterpress, off-set, gravure, photocopy.

PROPERTIES OF PAPER AND BOARD:
Refining curves. Strength, surface and optical properties. Effects of papermaking parameters and additives on these properties. Methods of measurement.

"Much more interesting than I expected"

Only £599 (plus VAT) per person for the two day course, including full course notes, refreshments and six months complimentary membership of PITA

For further details or to book your place on this course, contact Helen in the PITA Office
(0300-3020150 / info@pita.co.uk)

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Tel: 01300 3020 150
Fax: 0300 3020 160
E-mail: info@pita.co.uk

MIAC
10-12 October 2018, Lucca, Italy

Free exhibition and four associated free conferences:

MIAC TISSUE CONFERENCE – **FIRST SESSION**
10 October 2018 – time 13.40/16.50

Toward the Tissue Paper Mill 4.0

1. **Opening of the Conference**
   Massimo Ramunni – Deputy Director General (ASSOCARTA)

2. **PrimeLineTIAC – One machine, various configurations**
   Klaus Gissing – Director TIAC and Air & Energy Systems (ANDRITZ)

The ANDRITZ PrimeLineTIAC Tissue Innovation and Application Center, in Graz, Austria, comprises a complete, state-of-the-art tissue production line, including laboratory facilities for tests and trials to develop new products and processes for the tissue industry. It is available to tissue producers and suppliers, research and development companies, and universities. The pilot tissue machine at the ANDRITZ Tissue Innovation and Application Center (TIAC) is, unlike any other in the world, offering the utmost flexibility: Dry-creped tissue can be produced on a vertical CrescentFormer with either a suction roll or shoe press (the PrimePress XT Evo, the latest shoe press technology available). Textured tissue can be produced by a new, patented Textured Module. For structured tissue, wet molding creates a 3D arrangement of the fibers that is preserved by means of Through-Air Drying (TAD), and Advanced TAD. The machine can be configured with different TAD arrangements to investigate impacts on energy consumption.
The PrimeLineTIAC has already proven to be a birthplace of new products and processes. A place were not only tissue producers, but also suppliers and R&D institutes can come to fine-tune their products.

3. **Recent achievements in TAD technology**
   Stefano Marenco – R&D Director (TOSCOTEC)

Structured tissue processes are nowadays entering an increasingly close connection with the request for premium paper quality and the need for reduced energy demand. Through Air Drying (TAD) is the main process for producing structured paper for tissue and towel grades, and although the quality is far more superior to conventional processes, the energy is still high compared to standard dry crepe technologies. The TAD process develops functional properties by molding the fiber mat into a structured fabric (TAD fabric). The resulting structured tissue product will have higher bulk and absorption due to air passing through the sheet forming a sheet with differentiated density areas. Although newer hybrid technologies have been recently introduced on the market, structured tissue technology still represents the reference process for the production of premium quality tissue. Latest developments in TAD process technology design can reduce the energy demand of the production maintaining unchanged the final quality targets, by means of energy recovery, reduced energy losses, improved dewatering. Water consumption can also be reduced by means of optimized water systems and fiber recovery units.

4. **1+1=3. Combination of Pressing and heating technologies enables increased dryness, production and product quality**
   Bjorn Magnus – Sales Director Tissue Mills business unit (VALMET)

The introduction of the flexible Advantage ViscoNip press has changed the view of what pressing can achieve in the tissue making process. Today pressing is not only a way to remove water from the web. By utilizing the flexibility built in the adjustable pressing element you can significantly reduce drying energy and improve bulk, softness and uniformity. The ViscoNip press has become standard in new installations but has also proven to be a good way to save energy and increase capacity by rebuilds of existing tissue machines. The Advantage ReDry™ web heater use exhaust heat from the Yankee hood to increase the pressing temperature, reduce water viscosity and improve press dryness. Results from recent rebuilds of the pressing section, have exceeded the expectations showing significant capacity increase and savings in drying energy as well as paper quality improvements. The key for the results comes from the synergy effect gained when combining the ViscoNip press and the ReDry web heater. The flexible press has a unique ability to adapt to the Yankee dryer shell and is boosted by the heating of the web which will increase post pressure consistency. Energy and production performances are controlled with the Valmet DNA DCS and monitored with the Energy Efficiency Monitoring and Historian applications. These features are fully integrated in the Valmet DNA platform with Industrial Internet advanced capabilities for data analysis, performance optimization and remote assistance. In this speech, we will explain the technology behind and bring examples of how the solution has been realized and what can be achieved.

5. **Yankee Press Load Verification**
   John Holton (BTG AMERICAS)

There is normally a limit on the maximum linear load which can be applied to the Yankee dryer, around 90 kN/m. This is important because Yankee press load is a key element of the Yankee derate curve, which tells us how much internal steam pressure and how much linear press load the Yankee dryer is rated for. Beyond safety, the press load is important because the suction press roll is the most important dewatering point on a tissue machine. Operating at the highest uniform load allowable is important to energy cost and the reduction of greenhouse gases. Until recently, there were no efficient means of measuring press load, so tissue producers loaded the press to a calculated load curve, which might be 10, 20, or 30 years old without any idea of the actual load. Now, systems to directly measure the press load are being introduced to our industry. This is a significant safety enhancement and a technical advance. This paper will discuss a press load verification method which is both faster and more accurate than measurement systems currently being utilized, saving both machine downtime and improving the result.

6. **Predict, avoid, improve: Oradoc solution for chatter marks**
   Maurizio Tomei – Sales & Customer Service Manager (ORADOC)

At the end of 2017 the OraTec FX-20S – the new release of Oradoc vibration monitoring system for creping process conditions and for detecting the presence of chatter marks potential risk – was installed on PM6 in Lucartgroup Spa, Diecimo plant. The updated version was released along with the Remote Monitoring Service, which started functioning in March 2018, after 2 months of setting-up. The system features 4 sensors, 3 of them installed on the creping position and 1 on the cleaning beam position of the 3-meters machine that produces tissue from recycled fibers at a maximum speed of approx. 1700m/min. After having made many adjustments due to the presence of chatter marks on the Yankee cylinder surface, Lucart staff wanted to detect their origin in order to find a solution to improve quality and runnability. That's exactly what OraTec FX-20s does: the online system monitors the creping process from an objective point of view, collecting actual data that, once analyzed, could help improving the creping process without having to proceed by trial-and-error in changing humidity levels, coating and other process parameters. The remote service allows for 24/7 monitoring with weekly checks and monthly reports in order to share with the customer the data collected. In this way the customer is relieved of the task of constantly checking the creping process and, taking advantage of the data collected, skilled engineers provide precise instructions on how to improve the current creping conditions. This is possible thanks to the OraTec FX-20S new settings and algorithms and the possibility to customize its functions even when machine is running. The new vibration monitoring systems' features, together with the remote service, is the perfect solution to meet each customers' needs.

7. **Voith Paper Yankee OnSite Service**
   Fabio Bargiacchi – Senior Sales Manager (VOITH PAPER)

Tissue producers are fighting daily to optimize their paper production process and to raise quality and safety standards. The Yankee cylinder is one of the key parts, the pulsing heart of the Tissue machine and has to be preserved in perfect conditions during the whole lifetime, keeping or improving the energy performance, granting a stable and correct surface condition and imposing a careful, controlled and safe use. New diagnostic technologies, competent calculation skills, a reliable and proven engineering background and operational methodology can solve original design issues. As well as improper modifications applied during previous services can be changed by OnSite services and will grant a long, safe and efficient life of the yankee and tissue machine performance.

8. **TP-Soft Touch – Winding technology for Structured/Super Soft Tissue**
   Mauro Della Santa – Sales Manager (TECNO PAPER)

The demand by the market of Structured/Super Soft Tissue products is constantly increasing. Tissue makers have therefore to handle "low density" reels that are difficult to be processed in rewinding and converting lines. The high deformability of both mother and finished reels is the main cause of problems in rewinding this type of Tissue grades. Tecno Paper has developed, and patented, solutions purposely dedicated to such "difficult to wind" products. They avoid the reels are permanently deformed and the loss of bulk is huge during unwinding and rewinding operations. The last equipment which joined the TP-Soft Touch technological family is the new Unwinder. The main components of the TP-Soft Touch Unwinder are two large diameter carbon fiber rolls (carrying and driving rolls) – sustaining the reel and giving it the rotation movement – and a center drive assist, still with variable speed motors, that nullifies the rotation inertia, thus avoiding any torsion effect in the structure of the reel. The accurate relieving movement is obtained by a mechanical system.

9. **A.Celli Paper: Bulk Control System**
   Alessandro Dal Pino – Sales Application Manager (A.CELLI PAPER)

Further to its ongoing research into preserving the characteristics of tissue paper, A.Celli has developed an innovative system for the control of bulk paper that can be used for Tissue rewinders. This system allows for optimal and constant performance with the automation of operations that, in the case of traditional systems, are carried out manually by the operator. It is now essential to have not only an efficient winding section, but also an unwinding process that plays an active part in the fine and precise control of reducing the loss of thickness of the tissue paper. The system is also able to store and use data in an intelligent way to improve production and maintain standards of quality.

MIAC TISSUE CONFERENCE – **SECOND SESSION**
11 October 2018 – time 09.40/12.50

Toward the Tissue Converting Plant 4.0

1. **Opening of the Conference**
   Massimo Ramunni – Deputy Director General (ASSOCARTA)

2. **New Products and Innovations to Improve Market Position**
   Pirkko Petaja – Principal & Mikko Helin – Principal (PÖYRY MANAGEMENT CONSULTING)

New products and innovations can provide profitable growth. However, their impact does not limit to the direct increase of sales and profits but they can improve the brand awareness, complement the private label offering supporting that way the whole product portfolio. Companies can leverage the tissue value chain also for new products. The topic is discussed especially from the European perspective.

3. **Gambini's new AirMill embossing technology brings a portion of the paper mill into the converting process**
   Paolo Lazzareschi – Technical Director (GAMBINI)

A stunning breakthrough in tissue converting has been born with a revolutionary new technology which has become a reality with the new AirMill machine. It anticipates the essence of innovation giving the paper characteristics that before could only be obtained in the paper mill while improving its bulk, softness, absorbency, strength and stability. Today, textured and structured paper provide very high quality but can only be produced in the paper mill, and require large investments. AirMill allows customers to obtain products with similar characteristics in the converting process, starting from conventional paper. Furthermore, AirMill can operate on the line with a dual ON/OFF mode based on customer needs guaranteeing high efficiency while optimizing costs and downtime. Gambini's new AirMill represents a bridge between the paper mill and converting activities. AirMill ensures the optimization of the process while keeping the properties of the paper and limiting the use of all types of resources; from economics to energy, chemicals and raw materials. Therefore, a machine that is perfectly in line with the new sustainability trends.

4. **Nuove applicazioni dei prodotti piegati**
   Marco Calcagni – Sales Director (OMET)

Il mercato del tissue è sempre in cerca di nuovi prodotti che possano attirare l'attenzione del consumatore finale. I prodotti tissue piegati come i tovaglioli, i facial tissue e gli asciugamani interfogliati stanno avendo un forte sviluppo grazie alla tecnologia delle macchine di produzione. Grazie ad un'avanzata ricerca tecnologica si stanno sviluppando principi di funzionamento del tutto innovativi, diversi da quelli presenti sul mercato. Queste nuove macchine rispondono ai requisiti essenziali da sempre ricercati dall'utilizzatore: alti livelli qualitativi e quantitativi di prodotto, semplicità di utilizzo, investimento contenuto e completa automazione, che permette un risparmio considerevole sui costi del personale. OMET presenta sulle sue nuove macchine della linea ASV Line una testa interfogliatrice automatica, che consente la più alta velocità produttiva sul mercato grazie ai cilindri di piega con sistema a vuoto, nastro trasportatore a tappeto con motorizzazione indipendente e sistema di separazione automatica della steccata. La modularità di questa macchina permette l'aggiunta di diversi moduli funzionali come svolgitori, goffratori, laminatori, gruppi di taglio longitudinale, fasciatrici e troncatori. La possibilità di diversificare i settori di applicazione dei propri prodotti piegati è un'opportunità molto interessante per tutti gli operatori del mercato del tissue. Un'altra opportunità di recente sviluppo è la possibilità di realizzare tovaglioli con stampa personalizzata grazie all'applicazione della stampa digitale in linea sulle macchine per la produzione di tovaglioli. Questa interessante novità permette di stampare qualsiasi immagine o personalizzazione direttamente da file pdf sui propri tovaglioli, realizzando anche tirature di un solo tovagliolo per tipo, con pacchetti contenenti tovaglioli tutti diversi fra loro. Le potenzialità di queste nuove tecnologie sono enormi e stanno rapidamente prendendo piede sul mercato grazie al crescente interesse dei consumatori.

5. **Customer Care Digital Solutions**
   Gianfranco Agnusdei – Global Customer Service Director (FABIO PERINI)

The need to supply a unique, fast and efficient worldwide service, to maximize value chain production, improve performance and optimize production cost, is for Fabio Perini one of the main ongoing targets. Therefore, it's not anymore only a matter of building smart machines; the time has now come for service to go digital. Fabio Perini is focusing on the development of smart life cycle solutions to optimize Overall Equipment Effectiveness of converting and packaging lines: a wide range of smart and high added value solutions for the tissue industry, that apply the latest digital technologies, to meet customers' production needs for their market requirements. Following the great success driven by the introduction on the market of the Weareable device solution for technical remote assistance, under the new Customer Service WeCare concept, further more cutting-edge digital novelties are going to be presented during this year's MIAC.

6. **When the Roll of the Future becomes the real Tissue Solution**
   Trefor Hughes – Senior Sales Manager (PCMC ITALIA)

Do new products exist on the market Sustainability, innovation, evolution and care: these are the principles that have guided PCMC in developing a unique finished product. After attentive research, today this product exists and it is already present on European supermarket shelves. We are speaking about the NO-CORE ROLL: 100% SUSTAINABLE TISSUE PAPER, 100% made with care in Italy, 100% high quality consumer product. But that's not all. PCMC has also applied the same innovation and sustainability criteria to primary and secondary packaging. A full-circle endeavor expressed in the care for technological details and embodied in a new term: CAREVOLUTION. Let us explain to you why We've got the real Tissue Solution.

7. **Be ready to the upcoming trends of Packaging Machine into the Tissue Market**
   Fiorenzo Donetti – CEO (MACDUE)

The demand for packaging machines for tissue products will be soon affected by a strong growth. This due to the commercialization of industrial tissue products into the supermarkets. Based on this trend, MACDUE has implemented its solutions like AC80S6 - ACZ, which is a unique ALL-IN-ONE industrial packaging machine. This machine has been designed from a mechanical and software point of view to be able to handle both poly reel "shrink polyethylene as bundler machine or shrink printed polypropylene as wrapper machine". Maximum flexibility into a single compact solution.

8. **Quatis, Quality Inspection Machine – Installation Case History**
   Massimo Franzaroli – Managing Director (PULSAR ENGINEERING)

Quatis, quality inspection machine, is the result of the application of quality controls, based on vision systems, to the tissue converting productive process. This machine inspects the quality of tissue wrapped (primary and secondary packaging) and un-wrapped (BR, KR industrial rolls and folded) products. The product inspection is 100% reliable as the machine analyses every single product and is performed by dedicated vision systems. The philosophy that inspired Pulsar Engineering is to develop a machine starting from producers' needs through respecting tissue products special requirements. In the presentation, we will explain a case history of one of the first Quatis machines for unwrapped products installed. We considered a period of 6 months during which our dedicated engineers collected and analyzed real data, evaluating how non-compliant products could affect the whole converting line (jam, downtimes, etc). There are no limits to the analysis that can be performed by consulting such an amount of data.

9. **Software platform SM.I.LE80, Smart Integrated Logistics**
   William A Nelson – President (ELETTRIC80 INC & ELETTRIC80 S DE RL)

Elettric80 & BEMA provide solutions for production planning and control, storage and shipping activities, with a significant increase in factory efficiency and ensuring the total traceability of handled products. The whole process is managed centrally by a single software platform, named SM.I.LE80, which ensures a "direct link" between systems and production processes, and the optimal and effective management of all internal and external plant operations: from incoming raw materials to complete warehousing and shipping management.

MIAC ENERGY – ASSOCARTA CONFERENCE
11 October 2018 – time 14.00/16.45

1. Opening of the conference
   Silvia Pieraccini (IL SOLE 24 ORE)

2. Fossil vs Renewable energy: which will be the Mix for the Paper Mill of the Future?
   Alessandro Bertoglio – Energy Manager (ASSOCARTA)

CEPI, the Confederation of European paper industries, realized the CEPI 2050 Roadmap showing the way the sector must follow to reduce CO2 emissions to reach the 2050 target. In the Roadmap there are measures to reduce direct and also indirect emissions but also highlights the need to support strong investment to reach the same target. European CO2 saving targets are more and more challenging and make necessary a deep analysis on the future energy mix for Italian paper mills. Natural gas is widely use at mill level in a very high efficiency way by extracting more than 80% of the energy content with high efficiency cogeneration but also biogas and bioenergy from solid by-streams of the papermaking process.

3. Roundtable moderated by Silvia Pieraccini, Il Sole 24 Ore

With the participation of: Ministero dello Sviluppo Economico, GSE, Legambiente, Cartiera dell'Adda, Consorzio Italiano Compostatori, Iveco

BEST PRACTICES

4. Energy 4.0: Emerging Technologies reducing Green House Gases in the Pulp and Paper Industry by capturing all energy saving opportunities with Solar Turbines Energy Solution
   Thomas Schulze (SOLAR TURBINES)

The Pulp and Paper industry is one of the most energy-intensive industries worldwide – Solar Turbines cogeneration plants and direct drying integrations are already helping its customers to reduce this share. An efficient operation is one of the most important and cost-effective means for the reduction of energy consumption as well as carbon dioxide emissions and a good opportunity to enhance the plant management, representing an actual instrument regarding the enterprise corporate communication concerning its environmental performance. The most common question is: how can I integrate my heat and power production following production loads, tariffs variations, incentives and load sharing opportunities to maximise cost saving while enhancing my competitiveness with the best respect to the environment? In this presentation, Solar Turbines will expose new 8MW range machine designed specifically for paper and tissue applications, equipped with intelligent ultra-low emission system, which aims at optimising the cogeneration plant management by the full integration into the production system by the monitoring of external and internal parameters fully leveraging the industry 4.0 opportunity.

5. Energy solutions: with and for the Customers
   Paolo Della Negra – Manager, Sales Department (VALMET)

In 2015 Valmet carried out an energy study at one Papermill in South America. The machine is a double-width crescent former supplied by Valmet in 2000. Purpose of this energy study was to draw a road map for future improvements of the energy performances related to the machine drying section. One of the first actions – after the on-field optimization which immediately led to a remarkable decrease of gas and electric consumption – was the installation of an Advantage BalanceControl system (ABC) on the air system. The ABC was installed and started-up at the end of 2016 and the customer was very satisfied. Following the success of ABC, the Customer decided to continue investing as advised on the Road Map and installed a Waste Heat Steam Generator to generate high and low steam pressure. The new system will be installed and started-up at the end of 2018. The same project comprises also the modification of the ABC algorithms to be able to handle the steam generation and the new 'drying mix cocktail' of the machine.
16.30

6. Conclusions
   Girolamo Marchi – President (ASSOCARTA)

MIAC RECYCLING – COMIECO CONFERENCE
12 October 2018 – time 10.00/12.30

1. What happened in the past and proposals for the development of the separate collection and recycling of paper to be recycled
   Marco Frey (UNIVERSITY SANT'ANNA, PISA)

2. The quality of separate collection and the improvements of ComiecoCarlo Montalbetti – General Director (COMIECO)

3. Forum - Amelio Cecchini – Chairman (COMIECO)

Conference Agenda

Session Overview

Date: Monday, 22/Oct/2018

8:00am - 4:00pm	**Side event: Visit to St1 Cellunolix® plant in Kajaani**

Date: Tuesday, 23/Oct/2018

8:00am - 6:00pm	**Registration**
8:30am - 10:05am	**Opening: Opening of the conference, Keynote 1 and panel discussion**
10:05am - 10:30am	**Coffee & poster viewing**
10:30am - 11:30am	**Policies** **Wealth from bio economy - national economy perspective on integrated bio- and low carbon technologies** **Antti Arasto, Tiina Koljonen** VTT Technical Research Centre of Finland, Finland **Policy schemes cans ensure economic viability of forest-based biofuel production in the Nordic countries** **Eirik Ogner Jåstad, Per Kristian Rørstad, Torjus Folsland Bolkesjø** Norwegian University of Life Sciences, Norway **Sustainable forest-based bioeconomy: A case of biorefinery** **Jenni Miettinen, Markku Ollikainen** University of Helsinki, Finland
11:30am - 12:30pm	**Lunch and Poster viewing**
12:30pm - 2:10pm	**Concepts 1: Industrial developments** **Zambezi Biorefinery: "Pure" glucose and lignin from 2nd generation feedstocks** **Annelie Jongerius, Ed de Jong, Jan Kees van der Waal, Gerard van Klink** Avantium, Netherlands, The **Ultra-low cost ionic liquids for waste wood biorefining** **Florence Josefine Virginia Gschwend[1,2], Jason Patrick Hallett[1,2], Agnieszka Brandt-Talbot[1,2]** 1: Chrysalix Technologies, United Kingdom; 2: Imperial College London **Butanol production from volatile lignocellulosic feedstocks. Development of an optimized bioprocess** **Florian Gattermayr[1], Viktoria Leitner[1], Christoph Herwig[2]** 1: Kompetenzzentrum Holz GmbH Linz, Austria; 2: Vienna University of Technology - Institute of Chemical Engineering, Austria **Crude Tall Oil-based Renewable Diesel as Sustainable Biofuel Component** **Ville Tapani Vauhkonen, Sari Anneli Mannonen** UPM, Finland **Biorefining at Borregaard: Recent developments** **Oskar Bengtsson** Borregaard, Norway
2:10pm - 2:40pm	**Coffee & poster viewing**
2:40pm - 5:00pm	**Concepts 2: New concepts and applications from wood based raw materials** **Replace fossil gas in industrial burners with renewable biogas** **Thomas Bräck[1], Fredrik Weiland[2], Esbjörn Pettersson[2], Henry Hedman[2], Alexey Sepman[2]** 1: Meva Energy, Sweden; 2: RISE ETC **Turning bio-sludge into bio-carbon through zero-energy hydrothermal carbonization** **Erik Anders Oden** C-Green, Sweden **Designing from Scratch – Challenges of Dialogue between Material Research and End Products when Application Areas are in Architecture** **Heidi Turunen** Aalto University, Finland **FROM WOOD TO FOOD: ADDRESSING THE PROTEIN GAP IN ANIMAL FEED AND HUMAN FOOD WITH LIGNOCELLULOSIC BIOMASS** **Amelie Drouault** Arbiom, France **Water post-hydrolysis of hardwood kraft pulp to produce viscose-grade pulp and xylan** **Marc Borrega** VTT Technical Research Centre of Finland Ltd., Finland **The Bioeconomy Research Programme 2018–2020** **Fredrik Aldaeus** RISE, Sweden

	Evaluation of Alternative Routes for production of Bio-oil from Forest Residues and Kraft Lignin **Marie Anheden[1], Ida Kulander[1], Karin Pettersson[1], Johan Wallinder[1], Lennart Vamling[2], Carl Johan Hjerpe[3], Malin Fugelsang[3], Åsa Håkansson[4]** 1: RISE Bioeconomy, Sweden; 2: Chalmers Unversity of Technology; 3: ÅF Industri AB; 4: Preem AB
6:00pm - 9:00pm	**Welcome Reception at Bioruukki Pilot Center**

Date: Wednesday, 24/Oct/2018

8:00am - 6:00pm	**Registration**
8:30am - 10:00am	**Keynote 2 and panel discussion**
10:00am - 10:30am	**Coffee & poster viewing**
10:30am - 12:10pm	**Side streams: Processing of bark and wood to value-added products** **Purification scheme for the production of phenolic compounds from subcritical water extracts of chestnut wood** **Nicolas Beaufils[1,2], Luc Rigal[1], Gérard Vilarem[1], Laure Candy[1], Pierre-Yves Pontalier[1]** 1: Laboratoire de Chimie Agro-industrielle, LCA, Université de Toulouse, INRA, Toulouse, France; 2: Fibre Excellence Saint Gaudens SAS, Rue du Président Saragat BP 149, 31803 Saint Gaudens cedex **Polyphenols from softwood bark in adhesive applications** **Sami Alakurtti, Tarja Tamminen, Kristiina Kruus, Christiane Laine** VTT, Finland **A novel process for biomass extraction: The basis for a pine bark biorefinery** **Alex Berg** Universidad de Concepción, Chile **Bark-Based Biorefinery for Production of Biocomposites** **Hongbo Li[1], François Bru[1], Minh Tan Ton-That[1], Adrien Faye[1], Marzouk Benali[2], Jawad Jeaidi[2], Olumoye Ajao[2]** 1: National Research Council of Canada, Canada; 2: Natural Resources Canada, CanmetENERGY, Canada **Bio4Products: Unlocking the potential of biomass for a new range of bio-based products** **Hans Heeres** BTG Biomass Technology Group, Netherlands, The
12:10pm - 1:10pm	**Lunch and Poster viewing**
1:10pm - 3:30pm	**Lignin 1: Processing & tailoring properties** **LigniOx lignins – High performance concrete plasticizers and versatile dispersants** **Anna Katariina Kalliola, Tapio Vehmas, Tiina Liitiä, Tarja Tamminen** VTT Technical Research Centre of Finland Ltd, Finland **Aqueous solvent fractionation of kraft lignin - technoeconomical perspective** **Juha Leppävuori, Tiina Liitiä, Tarja Tamminen, Anna-Stiina Jääskeläinen** VTT, Finland **Enzymatic Modification of Lignin from a Hydrothermal Biorefinery Concept and Use Thereof in Polymer Compounds** **Xihua Hu, Irina Smirnova** Institute of Thermal Separation Processes, Hamburg University of Technology, Germany **Laccase pretreatment to decrease lignin-induced fouling in the membrane filtration of birch hot-water extracts** **Tiina Virtanen[1], Jussi Lahti[1], Anna Kalliola[2], Tarja Tamminen[2], Mika Mänttäri[1], Mari Kallioinen[1]** 1: Lappeenranta University of Technology, School of Engineering Science, Competence Area of Separation and Purification Technology, P.O. Box 20, FI-53851, Lappeenranta, Finland; 2: VTT Technical Research Centre of Finland Ltd, P.O. Box 1000, FI-02044 VTT, Espoo, Finland **Cyclic organic carbonates as reagents for the functionalization of lignins and hemicelluloses** **Isabell Kühnel[1], Youssef Akil[1], Dominic Lorenz[1], Bodo Saake[1], Youssef Akil[1], Ralph Lehnen[2]** 1: University of Hamburg, Department of Wood Science; 2: Thünen Institute of Wood Research, Germany **TAILORING PHYSICAL PROPERTIES IN LIGNIN PARTICLES** **Joana Gil[1], Stefan Heinrich[2], Irina Smirnova[1]** 1: Institute for Thermal Separation Processes, TUHH; 2: Institute of Solids Process Engineering and Particle Technology, TUHH
3:30pm - 3:50pm	**Coffee & poster viewing**
3:50pm - 5:50pm	**Lignin 2: Applications** **Designing kraft lignin based dispersants for clay suspensions** **Mohan Kalyan Konduri, Dr. Pedram Fatehi** FPInnovations,Canada **Lignin as novel renewable binder in pigment-based paper coating formulations** **Gibson S. Nyanhongo[1], Karina A Stadler[1], Verena Braunschmid[1], Hedda Weber[3], Wolfgang Bauer[4], Antonino Biundo[1], Doris Ribitsch[1,2], Georg Guebitz[1,2]** 1: University of Natural Resources and Life Sciences, BOKU, Vienna, Austria; 2: Austrian Centre for Industrial Biotechnology (ACIB), Konrad Lorenz Straße 22, 3430 Tulln, Austria; 3: Sappi Papier Holding GmbH, Brucker Strasse 21, 8101 Gratkorn, Austria; 4: Graz University of Technology, Institute of Paper and Fibre Technology, Inffeldgasse 23, Graz, Austria

DES-lignin as a biobased hydrophilicity promoter in polyethersulphone (PES) membranes

Ikenna Anugwom[1], Mohammadamin Esmaeili[2], Mika Mänttäri[2], Mari Kallioinen[1]
1: LUT Re-Source Research Platform,Lappeenranta University, Finland; 2: School of Engineering Science, Competence Area of Separation and Purification Technology, Lappeenranta University

Recent achievements in the valorization of technical lignins

Mikhail Balakshin[1,2], Ewellyn A. Capanema[3], Zeen Huang[4], Irina Sulaeva[2], Orlando Rojas[1], Martin Feng[4], Thomas Rosenau[2], Antje Potthast[2]
1: Aalto University, Finland; 2: BOKU, Austria; 3: RISE, Sweden; 4: FP Innovations, Canada

Lignin based Carbon fibres in batteries, supercapacitors and composites

Sverker Danielsson
RISE Bioeconomy, Sweden

Synthesis of Bio Adhesive from Waste Biomass from Pulp and Paper Industry for Wood based Industry

Vipin Chawla, B.N. Mohanty
IPIRTI, MOEF&CC, Government of India, India

7:00pm - 10:00pm	**Conference Dinner**

Date: Thursday, 25/Oct/2018

8:00am - 4:00pm	**Registration**
8:30am - 9:00am	**Keynote 3**
9:00am - 9:30am	**Coffee & poster viewing**
9:30am - 11:10am	**Processing 1: Piloting & equipment design** **Pilot scale pretreatment of lignocellulosic biomass: design considerations vs operational challenges** **Raimo Van der Linden, Peter Flippo, Anton Happel, Rob Verlinden** Bioprocess Pilot Facility (BPF), Netherlands, The **Production of nanofibrillated cellulose reinforced nanopaper using pilot scale Experimental Paper Machine (XPM)** **Zoheb Karim[1,2], Anna Svedberg[1], Lars Wågberg[2], Daniel Söderberg[2], Lars Berglund[2]** 1: MoRe Research Örnsköldsvik AB, SE-891 22 Örnsköldsvik, Sweden; 2: Wallenberg Wood Science Center, KTH, SE-100 44 Stockholm, Sweden **Increase accessibility for enzymatic hydrolysis of Norway spruce by organosolv pre-treatment in a novel reactor** **Mihaela Tanase-Opedal, Øyvind Eriksen, Kai Toven** RISE PFI, Norway **Degradation of cellulose by hydrogen chloride gas under elevated pressure in a custom-built reactor** **Eero Kontturi[1], Aaro Knuts[2], Eric Enqvist[2], Timo Pääkkönen[1]** 1: Aalto University, Finland; 2: SciTech Services, Finland **On-site production of tailored cellulases to cut costs in biorefining** **Simo Ellilä** VTT Technical Research Centre of Finland Ltd
11:10am - 12:10pm	**Lunch and Poster viewing**
12:10pm - 1:30pm	**Processing 2: Fundamentals** **Impregnation of wood chips for acidic processes and the influence of wood chips length** **Jessica Gard Timmerfors[1], David Blomberg[2], Torbjörn Sjölund[3], Leif J. Jönsson[1]** 1: Umeå University, SE-901 87 Umeå, Sweden; 2: RISE Processum AB, SE-891 22 Örnsköldsvik, Sweden; 3: MoRe Research, SE-891 22 Örnsköldsvik, Sweden **Lignin carbohydrate complexes studies on sulfite dissolving pulps** **Raghu Anant Deshpande[1,2], Gunnar Henriksson[2], Martin Lawoko[2], Lars Sundvall[1], Hans Grundberg[1]** 1: MoRe Research Örnsköldsvik AB, Sweden; 2: Wallenberg Wood Science Center, School of Chemical Science and Engineering, Royal Institute of Technology, KTH, Sweden **Solubility and Compatibility of Various Lignins in Solvents and Polymers: Experimental and Computer-Based Evaluation** **Olumoye Ajao[1], Jawad Jeaidi[1], Marzouk Benali[1], Yacine Boumghar[2]** 1: Natural Resources Canada, CanmetENERGY, Canada; 2: Centre d'études des procédés chimiques du Québec, Canada **Digging in the structure and functionality of lignocellulosic raw material – from academic knowledge towards industrial applications** **Jerk Rönnols, Anna Jacobs, Fredrik Aldaeus** RISE Bioeconomy, Sweden
1:30pm - 2:00pm	**Coffee & poster viewing**
2:00pm - 3:20pm	**Processing 3: Separation, purification and recovery** **Recovery of high-added value functional monomeric lignin derivatives from lignin oil: a comparison of separation technologies** **Kelly Servaes[1,2], Pieter Vandezande[1,2], Korneel Van Aelst[3], Laura Trullemans[3], Stef Koelewijn[3], Joost Van Aelst[3], Karolien Vanbroekhoven[1,2], Anita Buekenhoudt[1,2], Bert Sels[3]** 1: Flemish Institute for Technological Research - VITO, Separation & Conversion Technology, Mol, Belgium; 2: Biorizon, Green Chemistry Campus, Plasticslaan 1 - Port 1, Bergen-op-Zoom, The Netherlands; 3: KU Leuven, Center for Surface Chemistry and Catalysis, Celestijnenlaan 200F, Heverlee, Belgium **HYDROXY CARBOXYLIC ACIDS FROM SPENT ALKALINE PULPING LIQUORS** **Jari Petri Kalevi Heinonen, Tuomo Olavi Sainio** Lappeenranta University of Technology, Finland **A-Recovery+ - the next generation of chemical recovery cycle** **Lauri Ilmari Pehu-Lehtonen, Pauliina Charlotta Sjögård** Andritz Oy, Finland **Possibilities of membrane filtration processes in recycling of Deep Eutectic Solvents (DES)** **Mari Kallioinen[1], Ikenna Anugwom[1], Jussi Lahti[1], Mika Mänttäri[2]**

	1: Lappeenranta University of Technology, LUT-Resource Research Platform,Finland; 2: Lappeenranta University of Technology, School of Engineering Science, Finland
3:20pm - 3:30pm	**Closing the conference and announcing the next NWBC**

PAPEREX SOUTH INDIA 2018

on

Recycling and Packaging

Chennai Trade Centre, Naandambakkam, Chennai, India
Conference- 15th Nov. 2018 ; Exhibition 15-17th Nov. 2018

Inpaper
Indian Agro and Recycled Paper Mills Association;
404-Vikrant Tower, 4-Rajendra Place, New Delhi-110008
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PAPEREX has gained international name and fame as "World's largest event in pulp, paper and allied fields" attracting pulp and paper industries, machinery manufacturers, chemical, mineral and other material suppliers, scientists, engineers and experts from all over the world. The Technical conference held during this event in New Delhi every alternate year, comprises of technical papers with latest technologies, products and processes in the pulp, paper and allied fields.

In this international event, the issues and concerns, facing the Indian pulp and paper industries at national level, do not get highlighted, hence this conference in Chennai in Nov. 2018. Similar conferences were held earlier in Mumbai, 2 times in Coimbatore and in Chennai in 2014 and 2016. This conference intends to focus on the burning issues, hovering over the Indian Pulp, Paper and Allied Industries**.**
Topics of interest are:

- **Challenges and Success in Better Collection of Waste Paper & Processing for Paper and Board-making & Packaging**
- **Advanced Technologies for Waste Water Treatment and Recycling**
- **Monitoring of Discharge Water and Emissions**
- **Recovery Boiler/ Appropriate Technologies for Processing Agro-based Raw Materials**
- **Technologies for Disposal/ Product Development of Solid Wastes**
- **Strategies and Technical challenges adapted by Mills in Summer**
- **Environmental Improvement - Zero Liquid Discharge**
- **Minerals and Additives**
- **New Technologies in Packaging and Converting**
- **Design and Improving Quality of Corrugated Boxes**
- **Research & Development and Quality Control**

*All interested delegates and speakers are requested to send an abstract relevant to the theme before **30th July 2018** with title of the paper, name(s) of the author (s), name of the Organisation with full address for contact and an extended abstract in about one page.*

Dr M. Patel
Coordinator
PAPEREX-South India 2018
Mobile 91-9871787870

2018 Fibre Value Chain Conference

Appita is pleased to be hosting the biennial Pan Pacific Conference in conjunction with the **Appita Fibre Value Chain Conference, Distinction Hotel, Rotorua, New Zealand 4 -7 December**. We welcome our sister associations, ATCP Chile, Indonesian Pulp & Paper Association, Japan TAPPI, PAPTAC (Canada), Korea TAPPI, Taiwan TAPPI, TAPPIP (Philippines), and TAPPI (USA) as co-hosts.

The **2018 Pan Pacific Fibre Value Chain Conference** offers a unique opportunity for the Australasian pulp, paper, packaging and bioproducts industries to network and share ideas.

Themed, ***"Current research & perspective on the Fibre Value Chain"***, this year's conference will explore current research and perspectives on the Fibre Value Chain. Respected key industry leaders and international presenters will share their knowledge, thoughts and experience on how technologies and innovations are leading to new opportunities in developing sustainable and high value products from forest resources.

The event will feature breakout sessions, forums and workshops on pulp, paper, packaging as well as bio-manufacturing and related industries. The conference attracts CEOs, mill managers, superintendents, researchers, process engineers, suppliers and consultants from across the globe for a comprehensive program that includes a peer-reviewed technical program, forums, symposia and multiple networking opportunities. Our conference social events are a great opportunity to network with your peers and build lasting business relationships.

PROGRAM OUTLINE

TUESDAY 4 DEC 2018

- Breakfast Meet & Greet
- Conference Opening & Awards
- Bioproducts Manufacturing Symposium
- Maintenance Forum

WEDNESDAY 5 DEC 2018

- Plenary
- Bioproducts Manufacturing Symposium
- Food Contact Material Forum
- Technical Sessions
- New Speakers Competition

THURSDAY 6 DEC 2018

- Plenary
- Papermakers Forum
- Young Professionals Network Forum
- Mill Managers Forum

FRIDAY 7 DEC 2018

- Young Professionals Network Team Building

PAPERmaking!
FROM THE PUBLISHERS OF PAPER TECHNOLOGY
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Latest Recruitment Opportunities

In the last year, a number of international companies have advertised recruitment opportunities with PITA, viz.:

Arjowiggins	*Technical Manager (December 2017) (FILLED)*
Ahlstrom-Munksjö	*Production Manager (October 2017) (FILLED)*
BillerudKorsnäs Beetham Ltd	*Chemical Process Engineer Vacancy (August 2017) (FILLED)*
SchäferRolls	*Sales Agent (June 2017) (FILLED)*
Valmet Ltd	*Rolls Product Sales Manager (September 2017) (FILLED)*

Adverts can be found in our *PITA Affairs* e-newsletter, on the PITA website, and in appropriate editions of *Paper Technology International* and the *PAPERmaking!* e-journal.

Currently we have two positions still open:

Whakatane Mill Limited (New Zealand)

Mechanical Maintenance Coordinator (March 2018)

Electrical and Instrumentation Maintenance Manager (March 2018)

See below for further details.

Paper Industry Career Opportunities

Whakatane Mill Limited

We currently have two vacancies at the Whakatane Mill for a
Mechanical Maintenance Coordinator and an **Electrical and Instrumentation Maintenance Manager.**

THE MECHANICAL MAINTENANCE COORDINATOR will lead a small team of tradesmen in one of our production areas. This role is responsible for the planning, scheduling and coordination of mechanical maintenance activities to maximise plant reliability at a minimum cost.

The successful person will have:

- **At least five years of experience leading a mechanical maintenance team, ideally within the manufacturing or process industry maintenance fields.**
- **An industrial mechanical or maintenance trade qualification (Trade Cert, Advanced Trade or equivalent) or a tertiary qualified engineer with hands-on experience.**
- **A proven ability to manage a significant maintenance budget.**
- **A proactive approach to improving Health and Safety performance.**
- **Previous experience in using a computerised maintenance management systems (CMMS).**
- **Experience of maintenance resource and shutdown planning.**
- **A sound understanding of predictive and preventative maintenance practices such as root-cause failure analysis and condition based maintenance**

The Mechanical Maintenance Coordinator will also be involved in continuous improvement projects therefore previous experience in Lean Manufacturing would be an advantage; as would previous knowledge of paper making machine maintenance.

THE ELECTRICAL AND INSTRUMENTATION MAINTENANCE MANAGER role is responsible for developing and managing the strategic direction for E & I of the plant in order to maximise and improve plant reliability. You will need to be a reliable, motivated professional able to provide expert technical support, advice and solutions. You will use your initiative and proven problem solving expertise to focus on enhancing plant and equipment reliability, thereby actively contributing to achieving long term, measurable improvements in performance and efficiency.

Responsibilities in this role include:

- **Identify new processes and systems that will improve performance and improve Electrical and Instrumentation systems reliability.**
- **Provide technical support and ensure continuous improvement opportunities are being identified and implemented in order to improve performance in all areas.**
- **Responsible for best practices implementation for waste elimination within department i.e. Lean Manufacturing, 5S, Six Sigma etc.**
- **Responsible for setting and managing the performance standards expected.**
- **Defining and managing performance requirements and ensuring consistent delivery.**
- **Developing a culture of collaboration where continuous improvement opportunities are continually being identified and implemented at all levels.**

To be successful in this role you will need to possess the following: **• Degree level Tertiary Qualification in Electrical Engineering; • At least 5-10 years' strong proven experience in an E & I focused role within a heavy industrial process environment; • Have proven experience in areas such as high voltage systems, AC drives, process instrumentation and distributed control systems; • Have demonstrated experience implementing strategic improvements to achieve maintenance best practice; • Have operated at a senior technical level and provided sustainable change; • Driven by problem solving, root cause elimination and continuous improvement.**

Whakatane Mill Limited offer market leading packages and benefits including relocation and immigration facilitation and financial support.

Please contact Debbie Anderson at the Whakatane Mill for a copy of the position descriptions and further information Debbie.Anderson@sig.biz.

For full details of current opportunities, visit the PITA website (www.pita.co.uk)

SIG Whakatane (Whakatane Mill Limited) is owned by SIG Combibloc. SIG is one of the world's leading solution providers for the food and beverage industry within the field of carton packs and filling technology.

WML

Whakatane Mill Limited, is Australasia's only manufacturer of virgin fibre-based, coated cartonboard for the consumer market. The company provides innovative Liquid Packaging Board (LPB) and Folding Box Board (FBB) solutions to markets worldwide.

Whakatane Mill is a coated carton board manufacturer with one board machine (wire width 4.6m, design speed 350m/min) and an integrated stoneground wood pulp mill. The mill produces 135,000 tonnes of liquid packaging board and folding boxboard annually (basis weight 190-450gsm).

Whakatane is located in the spectacular Eastern Bay of Plenty of New Zealand, right beside the Pacific Ocean and has an urban population of approximately 20,000. With more sunshine hours than any other main centre in New Zealand, Whakatane is a paradise for anyone who enjoys the great outdoors. Please see **www.whakatane.com** and **www.whakatane.info** for more information.