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Thermoplastic Cellulose Based Fibre Materials

5/6.2020

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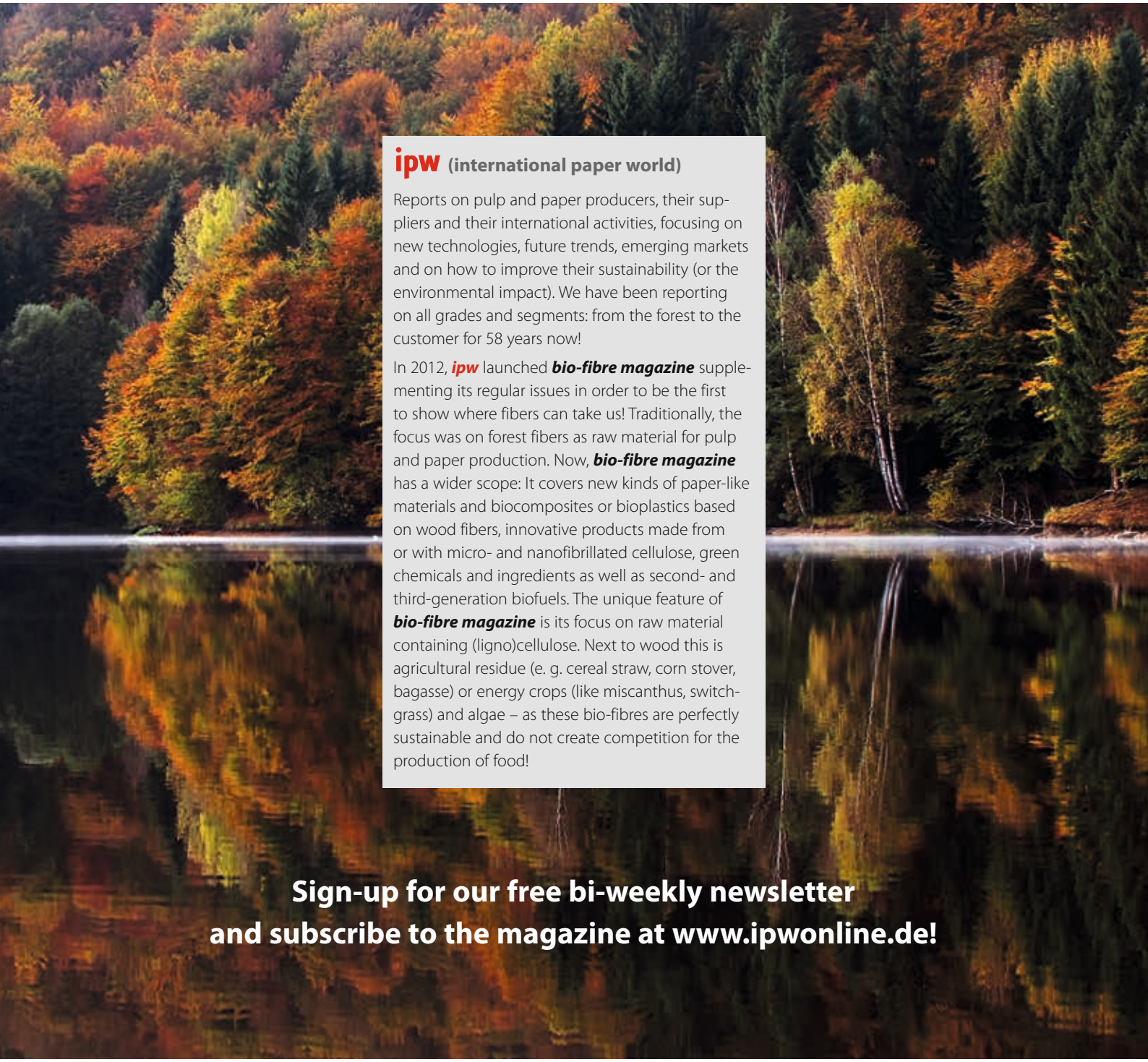

ipw (international paper world)

Reports on pulp and paper producers, their suppliers and their international activities, focusing on new technologies, future trends, emerging markets and on how to improve their sustainability (or the environmental impact). We have been reporting on all grades and segments: from the forest to the customer for 58 years now!

In 2012, ***ipw*** launched ***bio-fibre magazine*** supplementing its regular issues in order to be the first to show where fibers can take us! Traditionally, the focus was on forest fibers as raw material for pulp and paper production. Now, ***bio-fibre magazine*** has a wider scope: It covers new kinds of paper-like materials and biocomposites or bioplastics based on wood fibers, innovative products made from or with micro- and nanofibrillated cellulose, green chemicals and ingredients as well as second- and third-generation biofuels. The unique feature of ***bio-fibre magazine*** is its focus on raw material containing (ligno)cellulose. Next to wood this is agricultural residue (e. g. cereal straw, corn stover, bagasse) or energy crops (like miscanthus, switchgrass) and algae – as these bio-fibres are perfectly sustainable and do not create competition for the production of food!

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Dear Readers,

sustainability still drives the industry. So says the industry. And all the people in charge would do well to stick to this idea; from many a dark corner a musty whispering could be heard that Corona might be a welcome incident to free oneself from the yoke of sustainability in both supply chain management and production and sink the good resolutions (and more) in the ocean again. After all, we have bigger worries now, right? – Do we really have to emphasize the shortness of sight in such lines of thought? One cannot even speak of self-interest in this context. Saving one's own skin (and purse) while burning the ground we all stand on – well, old-fashioned sometimes is a very gentle word, isn't it?

"Responsible handling of the resources available to us is more important than ever," states Voith CEO Andreas Endters (read the whole interview from p. 18), and that these challenges "at the same time offer huge opportunities". That's the right way! Sustainability and innovation pay off – in many ways and especially under the current circumstances. Several stories in our new ipw issue illustrate that, up to and including Eero Aarnio's Eco-Playhouse.

Without wanting to downplay anything: We would do well not to lose focus on the real priorities. Corona will – with whatever consequences – pass. Man-made problems remain!

Have a great read & stay safe!

Stefan Breitenfeld
Editor-in-Chief

Photo: private

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Mission Statement ipw

To report on pulp and paper producers, their suppliers and their international activities, focusing on new technologies, future trends, emerging markets and on how to improve their sustainability (or the environmental impact). We report on all grades and segments: from the forest to the customer.

ipw has been the official trade publication of ZELLCHEMING, the Association of Chemical Pulp and Paper Chemists and Engineers, serving the industry since 1957.

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Photos: Fraunhofer IAP / Alexander Krause, VOITH, Södra, ABB

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Valco Melton

Low-Pressure Glue Pumps for Core-Winding

Boasting more than 68 years of experience in the design, manufacture, distribution and support of adhesive dispensing systems for the tissue, pulp, and paper industries, Valco Melton has first-hand knowledge of the most common concerns of core-winders when investing in their glue supply system. Contrary to the general feeling, the output pressures generated by the more expensive piston pumps are unnecessarily oversized for core winding. Adhesives commonly used in this process contain solids that may damage the pump seals and reduce its lifespan resulting in increased machine downtime and complex maintenance tasks.

Diaphragm pumps however are an excellent alternative to piston pumps offering numerous benefits. Low-pressure pumps work with all kinds of adhesives with minimal wear and required less maintenance resulting in a more cost-effective option.

Valco Melton's DD-1 diaphragm pump features a unique electronic-reversing mechanism which allows the pump shaft to creep slowly and avoids stroke stalling. The adhesive feed rate for a core winder extrusion line is so low that the pump strokes extremely slow. In consequence, our DD-1 pump is the best choice for a continuous core winding process with no unexpected machine stops.

Valco Melton offers the tissue manufacturing industry including core-winding and the others being tail tie, adhesive pick up for tissue machines, ply lamination, and tissue tack & reel (full sheet transfer system for tissue machines). •

Kelheim Fibres

Head of New Business Development

Dr. Marina Crnoja-Cosic has been appointed Head of New Business Development at Kelheim Fibres. She will also serve as a member of Kelheim's Management Board.
The chemist with a doctorate degree brings with her long-time experience in fibre and application development as well as in business development. Customised and market-oriented solutions, crosscompany cooperation along the value chain and constant attention to long-term industry and particularly to textile trends have shaped her career path for the past 20 years. •

Informa Markets

Postponement of Tissue World 2020 Events

Informa Markets has decided to postpone the upcoming 2020 Tissue World events due to the coronavirus situation. The decision was made following extensive consultations with exhibitors, delegates, speakers, industry partners and taking into consideration the effects on the tissue and related industries. Current and foreseeable international travel restrictions were also discussed.
Tissue & Paper Bangkok 2020 will be taking place middle of 2021. Exact dates will be announced shortly.
Tissue World Istanbul 2020 will be postponed and new dates will be secured and announced soon.
Tissue World Miami 2020 will be postponed and new dates have been secured at the Miami Beach Convention Center from 16 to 18 March 2022. •

Smurfit Kappa

Vitop® Tap Surges Past 5 Billion Mark

Smurfit Kappa, provider of innovative Bag-in-Box packaging solutions, has seen volumes of its Vitop® tap pass the five billion mark. The Vitop® tap forms an integral part of the Smurfit Kappa Bag-in-Box range, a collection of sustainable packaging solutions for liquid and semi-liquid products.

The Bag-in-Box products have a low carbon footprint throughout the lifecycle of the packaging due to the efficient use of materials and resources. There has been a series of sustainable innovations made to the product range to date including a reduction in film thickness for the bags and the introduction of a more compact Vitop® tap. A dedicated Bag-in-Box Circular Economy Team is also exploring further product innovations including the introduction of bio-based raw materials.

First designed in 1989 and produced at the Smurfit Kappa state-of-the-art facility in Alessandria, Italy, the Vitop® tap has revolutionised Bag-in-Box packaging through a combination of its tamper-proof design and high oxygen barrier that significantly contributes to extend product freshness and shelf life. Combining science, design and convenience, its success is also partly due to the fact that it is extremely easy to use. •

Photos: Valco Melton, Kelheim Fibres, Smurfit Kappa, Valmet, BTG, PMP

Valmet

Biomass Fuel Feeding System for Indonesia

Valmet will supply a new biomass fuel feeding system for one of the circulating fluidized bed (CFB) boilers owned and operated by PT. Cikarang Listrindo Tbk at their Babelan Power Station, Indonesia. The investment is part of Cikarang Listrindo's initiative for greener energy production and environmentally friendlier operation by reducing greenhouse gas emissions.

The order was included in Valmet's orders received of the first quarter 2020. The first installation works were conducted in June 2020 and the commissioning of the complete biofuel feeding system is scheduled by the end of the year 2020.

"Sustainability is one of the cornerstones of our strategy. We have targeted for highly efficient electricity production and low emissions from the very beginning. This project is one of the company's strategic steps towards greener energy production," says Sami Sivola, Station Manager at Cikarang Listrindo's Babelan Power Station.

"We have been cooperating with Cikarang Listrindo since 2013 with our CFB technology, automation and services. Valmet's proven technology for renewable energy as well as the experience and trust gained over the past years were key factors for receiving the order for the biofuel upgrade of Babelan CFB Unit 1. This delivery is a continuation of our long-standing cooperation," says Fredrik Wilgotson, Vice President, Pulp and Energy, Asia Pacific, Valmet. •

BTG

200th Single Point Kappa Analyzer

The 200th BTG Single Point Kappa Analyzer (SPK) was supplied to the Oji Group, manufacturer of paper and paperboard, headquartered in Japan. Oji was among the early adopters of the SPK, and this latest order is a key element in replacing an existing multi-point kappa analyzer system.

The Single Point Kappa offers the unique capability to measure kappa number directly at the installation point, rather than in a lab or through a traditional centralized analyzer. This allows a higher frequency of analyses and no need to have a dedicated sample line. •

Dynamic Development

PMP Supports Arctic Paper Kostrzyn S.A.

Arctic Paper Kostrzyn S.A. has been continuously working on modernizing its machine fleet over the last years. The priority is an increase of production capacity, an improvement of final products' quality parameters and the implementation of environmentally friendly & energy-saving solutions. Arctic Paper Kostrzyn S.A. for years has been partnering with PMP, applying ambitious technological projects. In addition, both companies support the idea of "good, because it's Polish".

In 2019, PMP successfully rebuilt a press section of PM#1 with a new Intelli-Nip® shoe press included. The solution improved dryness after press from 43% before rebuilt to 48% after rebuilt. The technology of the shoe press also enhanced properties of paper and significantly improved PM efficiency.

PM1, 5300 mm @reel, after rebuild, produces offset paper, with a grammage range from 60 to 100 gsm. The operating speed after rebuilt is 1000 mpm. PMP's scope of delivery included: press section equipped with the Intelli-Nip® shoe module (maximum design pressure 600 kN/m, shoe module diameter 1100 mm); this is the first PMP reference for a module with a smaller diameter. In addition, PMP provided controls, replacement parts and assembly and commissioning supervision.

As a result of a so far fruitful cooperation, in April 2020, PMP signed another contract with Arctic Paper for a revamp of a press section, this time for another machine. The purpose of the rebuild is to improve the condition of the section framework and to eliminate vibrations.

PM2, 5300 mm @reel and an annual capacity of 160,000 tons, produces single-layer wood-free graphic paper with a grammage range from 60 to 170 gsm. The scope of supply will cover an entire new framework, including press roll swing arms, savealls, platforms, mechanical drives as well as assembly and commissioning supervision service. The framework will be entirely made of stainless steel. The investment is planned for summer 2021. •

About to close: UPM Kaipola paper mill in Finland.

UPM

Plans for Restructuring

To ensure future competitiveness of UPM Communication Papers, UPM announces plans for permanent closing of UPM Kaipola paper mill in Finland, sale of UPM Shotton paper mill in Wales and streamlining Communication Papers business function teams. In addition, UPM Biorefining and UPM Specialty Papers announce plans for reorganising and streamlining activities in Finnish pulp mills, UPM Forest and UPM Tervasaari mill in Finland. The planned actions would result in annual cost savings of EUR 75 million. Decisions on the final plans will be made after the co-determination procedures have been concluded.

Planned actions in UPM Communication Papers

Continued long-term decline in graphic paper demand combined with weakened economic outlook require prompt actions to ensure performance in UPM Communication Papers. In a declining market, competitiveness in company operations as well as local operating environment is of utmost importance.

In 2020, the COVID-19 pandemic related lockdown measures have caused a short-term demand disruption in the graphic paper market. While there are early signs of normalisation in paper demand after lockdowns, the ensuing economic outlook has deteriorated globally.

UPM is committed to maintaining competitive operations under all circumstances. It means adapting capacity to customer demand and increasing the efficiency of operations. Consequently, UPM Communication Papers plans to permanently close its Kaipola mill in Finland latest by the end of 2020. The planned closure of UPM Kaipola's three paper machines would impact approximately 450 positions and lead to a permanent reduction of 720,000 tonnes of graphic paper capacity, thereof 450,000 tonnes of newsprint and 270,000 tonnes of coated mechanical paper.

"This is devastating news to Kaipola. While Kaipola has competent teams and well operated machines, external factors such as high logistics costs, regulatory and tax burden, high cost of labour and increasing fibre costs make it the least competitive among UPM's paper mills," says Winfried Schaur, Executive Vice President of UPM Communication Paper.

UPM also announces its intention to sell its UPM Shotton paper mill for conversion purposes. Current production capacity of the mill is 250 000 tonnes of newsprint in Deeside, Wales. The mill assets include the materials recollection and recycling facility, deinking plant, paper machine line and energy infrastructure as well as established access to the UK recycled paper market.

Planned actions in UPM Biorefining and UPM Specialty papers

UPM will begin employee consultation process at its Kymi, Kaukas and Pietarsaari pulp mills regarding planned changes in the mill and support organisation. The planned changes aim to increase flexibility and efficiency in the areas of mill maintenance, production and administration. At most, these plans would lead to a reduction of 110 positions. •

Photo: UPM

Our field services cover everything from fast, on-call troubleshooting to planned, practical, and strategic maintenance carried out on a continuous basis at your production site. We plan, execute, manage and develop maintenance activities according to your needs.

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Valmet FORWARD

Research project

Thermoplastic biocomposites based on agro waste materials

Wheat straw fibres and their effect on reinforcement, filling and odour formation

Fig. 1: Use criteria of plant residues for compounding biocomposite materials.

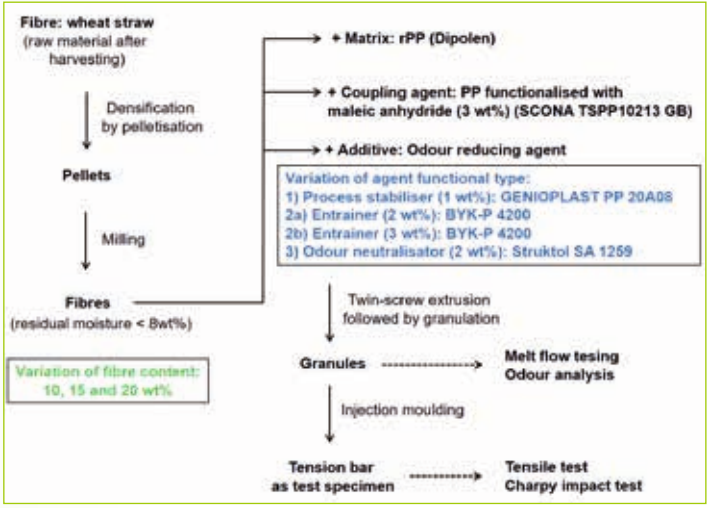

Fig. 2: Processing route for wheat straw/rPP biocomposites, varying the fibre content and type of odour reducing agent.

This report is based on a collaborative research project entitled valuation of plant residue materials for generating sustainable biocomposites where the potential of wheat straw as agro waste material for thermoplastic biocomposites was investigated. This project was funded by the Federal Ministry for Economic Affairs and Energy (BMWi, Germany, funding code 16KN065222), and the project partners were IfBB – Institute for Bioplastics and Biocomposites at the University of Applied Sciences and Arts in Hannover and the company PCM Green Energy GmbH & Co. KG located in Haunetal. The presented results in this article focus on the development, testing and optimisation of thermoplastic wheat straw compounds and corresponding experiments were performed at IfBB.

The processed wheat straw pellets were provided by the project partner PCM Green Energy – an innovative company for high-quality, mobile and self-sufficient pelletizing plants for biomasses. The Institute for Food Chemistry located at the Leibniz University Hannover is expert in the field of aroma analytics and performed odour analyses of the polymer-wheat straw compounds developed.

The growing awareness of environmental issues and resource scarcity explains the increasing interest surrounding the use of bio-based materials in a wide variety of applications, e.g. for the mobility, packaging and construction sector. Furthermore, stringent legislative policies have forced many industries to seek new materials from renewable sources to take place of traditional materials derived from non-renewable resources [1].

The use of agro waste materials is one promising approach to counteract the resource scarcity, especially with focus on the plastics industry [2]. Plant residues show high substitution potential, and a wide variety of plants offer various possibilities for innovative material development and compounding acting as filling material, reinforcement material or functional additive. However, plant residues have to fulfill vari-

Infographics: Figures 1 to 5

ous use criteria for being an attractive candidate for bio-based materials as shown in Fig. 1. The more use criteria are fulfilled, the higher the chances that the plant residue of interest can be successfully integrated into marketable products [3].

One example of agricultural by-products with high application potential for the (bio) plastics industry is wheat straw [4]. As a natural fibre retrieved from annual agricultural by-products, wheat straw offers diverse advantages when applied as an ingredient in biocomposite materials. Such fibres are harmless, annually renewable and worldwide available, having the lowest cost in comparison to other natural fibres available in the industrial fibre market. The retail price for wheat straw in 2020 in Germany for the raw material was EUR 88 per tonne in relation to round bales produced directly after harvesting of the main product (cereal grains) without further post-processing [5]. To be cost-effective, it is important to guarantee a regional availability, reducing transport and logistic costs as well as convenient and local pretreatment techniques. Wheat straw has to be converted from initial round bale to extrudable bulk material, involving milling, conditioning and pressing to pellets. These pellets show low residual moisture, being storable and less susceptible against microbial contamination, but pelletising leads to destruction of the initial fibre structure. Furthermore, the generated pellets are not suitable for compounding and have to be grinded followed by classification into milling fractions in relation to the particle size. Therefore, the initial fibre structure is transferred to particulate wheat straw showing more filling than reinforcement properties.

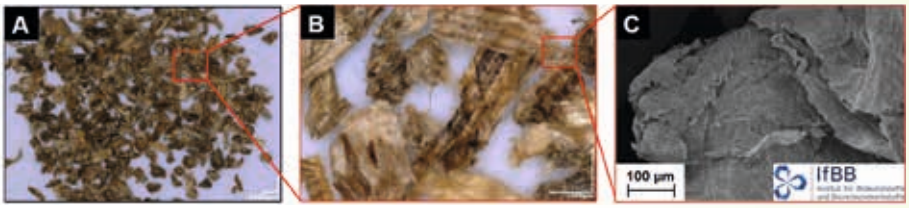

Fig. 3: Digital microscope images (A, B) and scanning electron micrograph (C) of milled wheat straw fibres.

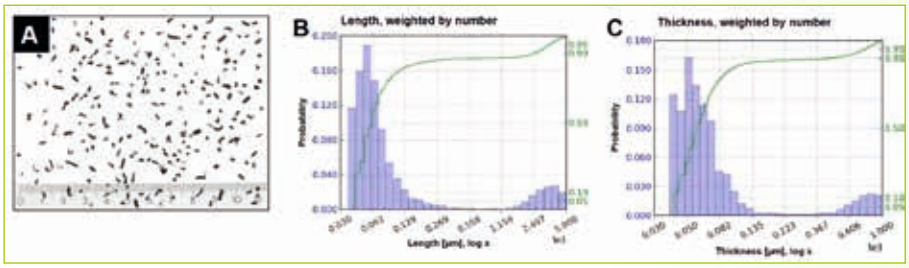

Fig. 4: Particle size measurement according to test standard ISO 13322-1 using wheat straw fibres: Scanned image of wheat straw fibres (A) and quantitative determination of the particle size distribution by means of FiberShape with relation to the fibre length (B) and fibre thickness (C).

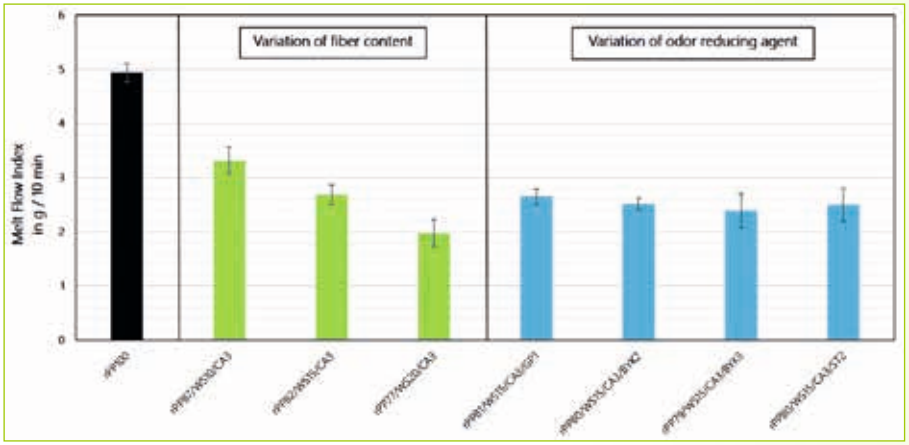

Fig. 5: Melt flow index of wheat straw/rPP biocomposites, varying the fibre content and odour reducing agent (ISO 1133 B, 190 °C, 2.16 kg).

2. Materials and methods

Fig. 2 shows the processing route for wheat straw/rPP biocomposites, varying the fibre content and type of odour reducing agent. Wheat straw as raw material is densified after harvesting by palletisation, and the obtained pellets are milled resulting in extrudable fibres with relatively low residual moisture (< 8 wt%). Recycled polypropylene (rPP, Dipolen®PP) was chosen as polymer matrix to ensure sufficient material properties, processability and low costs. PP functionalised with maleic anhydride (SCONA, 3 wt%) was used as coupling agent assuring an adequate bonding between matrix and fibre. Recycled polymers, especially rPP, often show moderate to high odour production. Furthermore, thermal decomposition of wheat straw during the extrusion process can intensify odour formation. To counteract odour formation, so-called odour reducing agents were used, which can differ in their function. Agents with high application potential are process stabilizers (GENIOPLAST), entrainers (BYK-P) and odour neutralisators (Struktol).

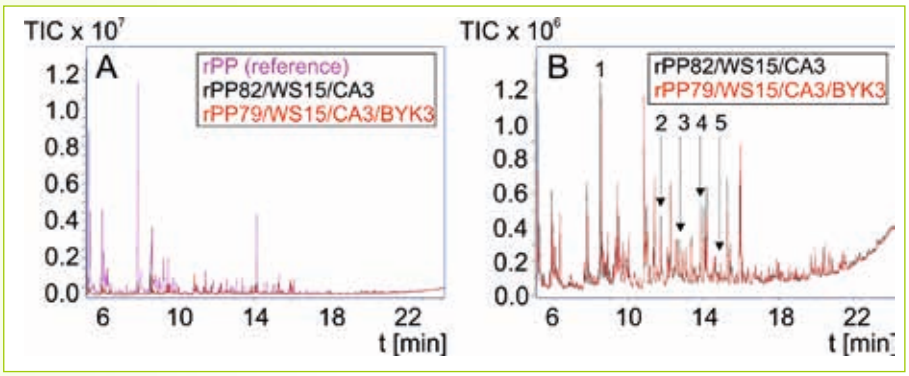

Fig. 6: Chromatograms derived from TDS-GC-MS for rPP and wheat straw/rPP biocomposites without and with odour reducing agent (entrainer, BYK) [A] and detailed view of the biocomposite samples [B].

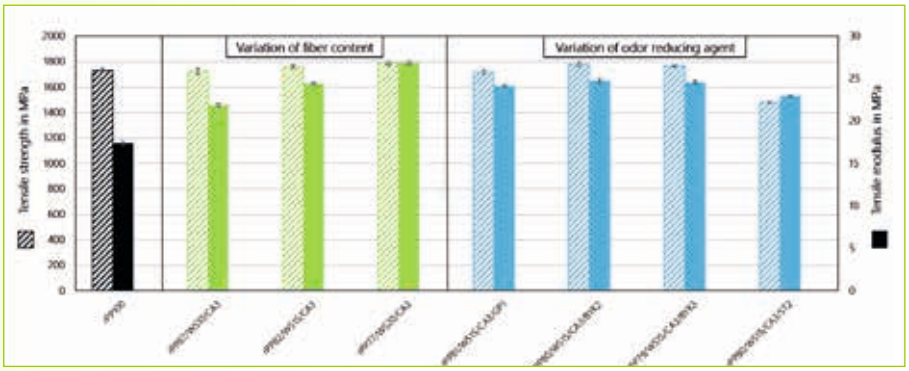

Fig. 7: Tensile modulus and tensile strength of wheat straw/rPP biocomposites varying the fibre content and odour reducing agent type (DIN EN ISO 527-2).

Twin-screw extrusion was performed using an extruder from KraussMaffei Extrusion GmbH (ZE34Basic), equipped with an innovative side feeder responsible for controlled and homogeneous addition of wheat fibres. The process temperatures were between 170–180° C depending on the process zones of the extruder. The experiments were carried out at a throughput of 40 kg/h with a screw speed of 250 min-1, and granules were obtained by conventional strand pelletising. For initial characterisation, granules were investigated by melt flow testing (ISO 1133 B) and qualitative odour analysis in relation to VDA 270 (association of the automotive industry). For odour quantification, selected samples were analysed by Thermal Desorption-Gas Chromatography-Mass Spectrometry and olfactometry (TDS-GC-MS/O), using an Agilent 6890N gas chromatograph equipped with a DB-WAX MS (30 m, 0.25 mm, 0.25 µm, Agilent Technologies, Santa Clara, USA) coupled to a mass selective detector (Agilent 5975B; interface: 230° C, ion source: 200° C, quadrupole: 100° C, electron impact ionization: 70 eV, scan range m/z 33–500 amu; Agilent Technologies, Santa Clara, USA). Samples were injected according to the following method: TDS 3, 20° C for 3 min, 60° C/min to 230° C held for 2 min, splitless mode; CIS 4 with a liner filled with Tenax TA, –10° C, 10° C/s to 230° C held for 2 min, solvent vent splitless mode (Gerstel, Mülheim, Germany). After separation (1.3 mL/min helium; 40° C for 3 min; 10° C/min to 230° C, 230° C for 10 min) the effluent was split 1:2 to the MSD and to the olfactory detection port (ODP3, Gerstel, Mülheim, Germany). The olfactometric evaluation was performed by seven panelists focusing on odour impression and intensity. Tentative identification was based on the NIST 14 database. Furthermore, granules were processed by conventional injection moulding (KraussMaffei 50-180 AX) and obtained tension bars were tested according to DIN EN ISO 527-2 and DIN EN ISO 179 to determine the mechanical properties in form of tensile modulus and tensile strength as well as impact strength, respectively.

Parameter variation was initially performed changing the wheat fibre content (10, 15 and 20 wt%), and compounds with optimal fibre content were treated with different odour reducing agents. Sample codes are therefore indicated as follows referring to the material composition, where given numbers represent the mass percentage of each individual component: rPP (polymer matrix)/WS (wheat straw)/CA (coupling agent)/GP-BYK-ST (type of odour reducing agent).

3. Results

3.1 Wheat straw fibre morphology and dimensions

Fig. 3 shows digital microscope images (A, B) and a scanning electron micrograph (C) of milled wheat straw fibres. Densified pellets were successfully milled and the fibres obtained showed relatively low residual moisture, being a convenient candidate for (bio)polymer processing. The fibre morphology was inhomogeneous; fibres were not well orientated and showed partially edgings. Based on these visual analyses it was expected that the wheat straw fibres used acted more as a filling than as a reinforcement material.

To quantify fibre dimensions, size measurements according to test standard ISO

Infographics: Figures 6 and 7

13322-1 were performed. Fig. 4 shows a scanned image of milled wheat straw fibres (A) and results of FiberShape measurements with relation to the fibre length (B) and fibre thickness (C) as given by size distribution curves. In reference to both fibre length and thickness, bimodal particle size distribution was obvious, where the first peak represented the milled fibres and the second peak was most probably related to unspecific agglomerates. Therefore, the indication of mean values did not represent the actual wheat straw fibre dimensions. With a focus on the first peaks, length and thickness values ranged from 30 to around 300 µm and from 30 to around 200 µm, and average values (50% percentile) were very similar, being 63 µm for fibre length and 59 µm for fibre thickness, respectively. By only referring to these average values the initial fibre morphology was converted into a particulate form after milling. With focus on the determined size distribution results of the first peaks the aspect ratios were approximately in the order 1:1 up to 10:1, representing both particles and fibres with a transition range between both geometries. However, during extrusion wheat straw fibres can be homogeneously added to the polymer melt using a side feeder with adapted screw geometry, and wheat straw/rPP biocomposites including a coupling agent and odour reducing agent were successfully fabricated.

3.2 Processability and melt flow behaviour

In contrast to capillary rheometry the melt flow rate (MFR) test is an easy and fast-forward method to point out the MFR value for a material at a single point on a curve that characterises viscosity as a function of shear rate. MFR values are needed to evaluate the processability of generated compounds (granules) for e.g. injection moulding. Fig. 5 shows the melt flow index for wheat straw/rPP biocomposites, varying the fibre content (green columns) and odour reducing agent (blue columns) in comparison to the reference material rPP (black column). Compared to the reference rPP, the MFR values were expectedly reduced by fibre addition and higher fibre contents led to lower MFR values ranging from 3.3 to 2.0 g/10 min. Ensuring an adequate viscosity and therefore a good processability in combination with a sufficient mechanical material performance, a fibre content of 15 wt% seemed to be a good compromise for wheat straw/rPP biocomposites. As expected, the addition of odour reducing agents varying in type and concentration had no significant influence on the melt flow behaviour.

3.3 Olfactometric analysis

For qualitative olfactometric odour tests based on VDA 270, a rating system is used to primarily evaluate the odour production of fabricated granules and grades from 1 to 6 are indicated as followed: 1 = not noticeable; 2 = perceptible, but not disturbing, 3 = clearly noticeable, but not disturbing, 4 = disturbing, 5 = very disturbing and 6 = unbearable. The reference sample rPP was a recycled polymer from post-consumer waste showing an inherent odour assigning to grade 2. Compounding of wheat straw effected an increase of odour formation to grade 3 (10 wt% fibre) up to grade 4 (15 and 20 wt% fibre), respectively, which can be related to thermal decomposition of the fibre working at extrusion temperatures of nearly 200° C. While the process stabiliser (Genioplast) had no odour reducing effect, the used entrainer (BYK) reduced odour formation by one level from grade 4 to 3 independent from applied concentration. Utilisation of an odour neutralisator (Struktol) led to the same effect, where granulate samples showed a clearly noticeable odour, which was not disturbing (grade 3).

For quantification, selected samples were analysed by TDS-GC-MS/O (Fig. 6). Compared to the reference (rPP), wheat straw/rPP biocomposites showed a significant reduction of odours by a factor of 10, presumably due to the thermal treatment during extrusion (part A of Fig. 6). Some overlapping peaks prevented a safe identification of all aroma active compounds. However, comparing wheat straw/rPP biocomposites without and with odour reducing agent 46 olfactory impressions were noticed (part B of Fig. 6), and the effects of entrainer addition (3 wt% BYK) were as follows: 34 olfactory impressions were reduced, 3 remained unchanged, 7 were increased, and 2 olfactory impressions could not be attributed to a peak signal. Noteworthy were 2,6,11-Trimethyldodecane (1), 2-Nonenal (2), 4-tert-Butylcyclohexanol (3) and

4-tert-Butylcyclohexyl acetate (4), which were detected in rPP and in both biocomposite samples, where entrainer addition led to both an intensity increase (for 1 and 2, unpleasant smelling) and reduction (for 3 and 4, pleasant perfume-like scent). 3,7-Dimethylocta-1,6-dien-3yl-propanoate (5) was not detected in the references rPP and wheat straw, but occurred in the biocomposite sample suggesting addition during production.

3.4 Mechanical properties

To analyse the mechanical properties of wheat straw/rPP compounds derived from extrusion, the granules were processed by injection moulding into standard tensile bars. As shown in Fig. 7, tensile strength and tensile modulus of wheat straw/rPP biocomposites varying the fibre content and odour reducing agent were determined according to DIN EN ISO 527-2. Compared to the reference rPP the tensile strength of fibre containing samples was slightly increased, while higher fibre contents led to higher strength values, and a maximum level of around 2000 MPa was reached by the addition of 20 wt% wheat straw. This behaviour of the mechanical properties was consistent with the determined morphology and size dimensions of the wheat straw used, showing aspect ratios in the order of 1:1 up to 10:1, representing both particles and short fibres with a transition range between both geometries (Fig. 3 and 4). As expected, the tensile modulus also increased in relation to higher fibre contents. The addition of odour reducing agents did not change the tensile properties significantly, except for samples containing an odour neutralisator (trading name Struktol®). This odour reducing agent is only available in powder form and insufficient integration into the compounds during extrusion probably led to slight lower tensile properties.

Based on charpy impact tests the amount of energy absorbed by a material during fracture was determined. In agreement with the information from the data sheet (Dipolen®PP, mtm plastics GmbH) the reference material rPP showed an impact strength value of around 72 kJ/m^2. Due to addition of wheat straw fibres the impact strength was significantly reduced to values of around 15 kJ/m^2, where no differences in relation to the fibre content (10, 15 vs. 20 wt%) and type of odour reducing agent were obvious (data not shown). Natural fibre reinforced plastics have generally low impact strength because of the natural fibre structure itself being heterogeneous and hydrophilic. If higher impact strength for selected applications is needed, elastic fibres can be added as second fibre material, and process parameters have to be adapted. •

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[5] Wheat straw prices: https://markt.agrarheute.com/futtermittel-3/stroh-19, 19.05.2020.

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Fraunhofer IAP

From Old Jeans to New T-Shirts: An Efficient Way of Recycling Cotton Clothes

The technical hurdles to recycling clothing made of cotton have been too high in the past, but now a team of researchers at the Fraunhofer Institute for Applied Polymer Research IAP and a Swedish company have cleared that obstacle. They are the first to produce a viscose filament yarn made of recycled cotton. This fiber can even serve to mass-manufacture textiles.

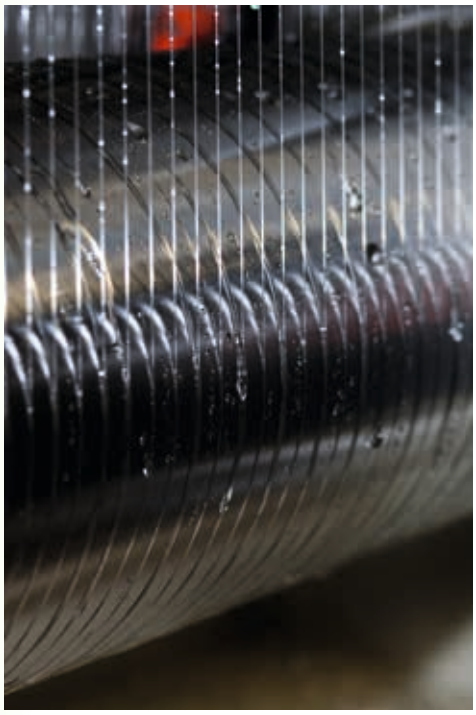
Wound onto a spool, the viscose filament yarn was spun from recycled cotton provided in form of cellulose sheets. Researchers at the Fraunhofer IAP have found a way to turn cotton clothes such as jeans into new high-quality garments rather than lowly cleaning rags.

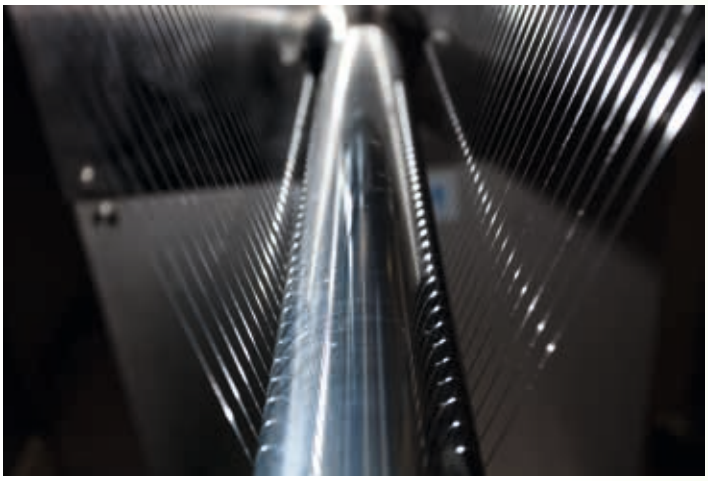
Countless closets are overflowing with clothes, yet their owners wear many of those trousers, skirts and tops rarely or not at all, as a Greenpeace survey of shopping habits recently found. People sort out even perfectly intact garb, relegating it to a garbage can or clothing bank. That is hardly ecofriendly given the vast amounts of resources, chemicals and water devoted to making apparel. Although Germany does recycle old clothes, they end up as inferior products such as cleaning cloths rather than new garments. This is because trousers, shirts and the like are often made of blends rather than a single type of fabric. To date, it has been impossible to separate these intertwined fibers. "Textiles rarely consist of pure cotton. Jeans, for example, always contain a certain amount of chemical fibers such as polyester or elastane," says André Lehmann, a researcher at the Fraunhofer IAP in Potsdam. Working on behalf of the Swedish company re:newcell, this chemist and his team succeeded in converting the pulp from recycled cotton into viscose rayon fibers made of pure cellulose.

As good as wood-based cellulose fibers – the new viscose filament yarn

The textile industry usually uses pulp as the starter material for producing regenerated

Photos: Fraunhofer IAP / Alexander Krause





Viscose fibers are made from recycled cotton at the Fraunhofer IAP. A wide variety of customer-specific requirements can also be met with the modular wet spinning system.

cellulosic fibers such as viscose rayon, modal and lyocell. This pulp does not melt, so it has to be dissolved into a solution and passed through a spinneret to be spun into cellulosic fibers. The feedstock for this pulp is usually wood. "However, re:newcell sent us cellulose sheets made of recycled cotton and asked us to find out if they could be converted into viscose rayon fibers. "We were able to extract the foreign fibers from the pulp by setting the right parameters for both the dissolving and spinning processes, for example, with effective filtration stages," says the researcher. This yielded a filament yarn – that is, a continuous strand of fiber several kilometers long consisting of 100 percent cellulose, the quality of which is comparable to that of wood-based regenerated cellulosic fiber. Compatible with the standard industrial process for making viscose rayon, the new fibers spun from this cotton pulp are suitable for mass manufacturing. "We were able to meet re:newcell's high purity standards for the new fiber," says Lehmann, who calls this filament yarn a cotton-based regenerated cellulosic fiber. It holds up well in comparison to commercially available viscose rayon fibers and exhibits the same properties.

This was no easy task. Producing viscose rayon is a complex process: The pulp is first activated with lye and then chemically derivatized. This yields a very pure alkaline viscose solution. Spinnerets riddled with several thousand 55 µm diameter holes then spin this solution in an acidic bath. The thousands of liquid jets emerging from the polymeric solution enable the derivatized cellulose to regenerate and continuously precipitate in the spinning bath to form a filament. The next step is to steadily reverse the chemical derivatization, and then wash and dry the filament for it to be wound onto a spool. Made of pure cellulose, this filament is ecofriendly. Rather than adding to the mountains of microplastics that pollute the oceans, it readily decomposes. This is a huge advantage over petroleum-based polyester fibers, which still predominate on the global market with a share of some 60 percent.

More sustainable fashionwear

"Cotton clothing is usually incinerated or it ends up in the landfill. Now it can be recycled several times to contribute to greater sustainability in fashion," says Lehmann. This will also broaden the base of raw source materials for pulp production in the textile industry. "The starter material for viscose rayon fibers has been wood-based cellulose. By optimizing the separating processes and intensifying the filtration of foreign fibers in the spinning process, we will eventually be able to establish recycled natural cotton fiber as a serious alternative source of cellulose and base raw material." •

Interview

“Major Challenges Offer Huge Opportunities”

Bringing together the effects and disruptions of COVID-19, cost pressure and resource handling to form a maintainable and successful stategic concept is not the easiest of tasks for any management board. We talked to Andreas Endters, President & CEO of Voith Paper, about their evaluation and subsequent solutions.

The year 2020 will most likely go down in history books and economic journals as the “corona year”. Disrupted supply chains, short-time working and slashed budgets are just some of its wide-ranging impacts. Is Voith also feeling the effects of the pandemic?
The last few months have been very challenging for all market participants. Since the beginning of the year, we at Voith have been doing our utmost to continue to provide our customers with the best possible support in order to secure their production with our products and services. Naturally, the health of our workforce and our customers has always been our main focus. Governments worldwide have classified the paper industry and its suppliers, in some cases at a very early stage, as “necessary to maintain critical infrastructure”. We were therefore able to keep production at our sites up and running continuously with only few exceptions as well as processing and implementing existing and new projects – while complying with the necessary hygiene measures and regional regulations. Particularly challenging was the fact that our experts

Photos: VOITH

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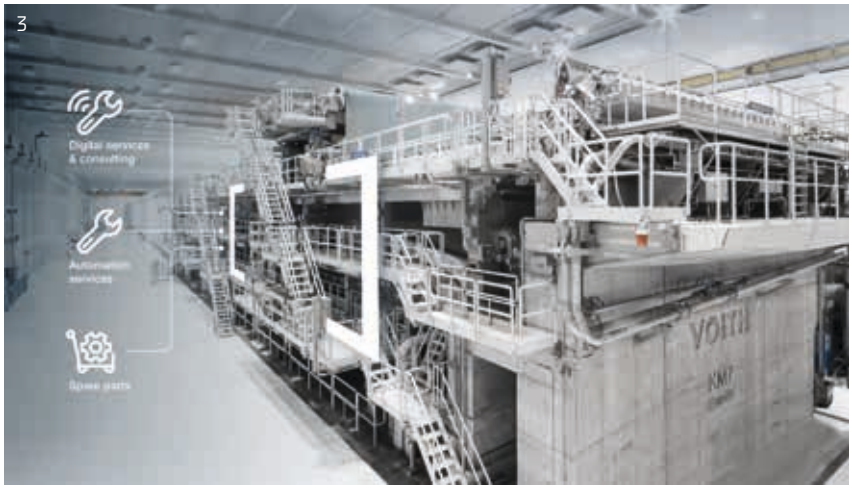

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and service technicians could not carry out their assignments on site in the usual way due to travel restrictions. Scheduled service deployments were postponed at many locations. This is why we have increasingly been supporting our customers worldwide with our remote solutions. We are now reaping the benefits of having invested early in digital solutions like augmented and virtual reality with our Papermaking 4.0 portfolio.

What impacts do you see COVID-19 having on the industry and what lessons can we learn from the last few months?
Basically, after an upturn for packaging and tissue paper in the first phase of the pandemic, we are witnessing a normalization of demand in the second phase. There is a significant decline in demand for graphic paper and some specialty paper grades. The last few months have also shown that the use of digital applications for maintenance work and customer support is working very well. Moreover, the pandemic raises awareness of the importance of paper in our society, which is good news for all manufacturers. Only very few raw materials are as sustainable, and paper is becoming even more climate-friendly. That is why paper-based products are set to grow in importance, and we will see numerous new areas of application for paper in the future.

Is the coronavirus having an economic impact on Voith's Industry 4.0 timetable?
Within Papermaking 4.0, we have been using automation and digitalization solutions for years to increase availability and efficiency for our customers. At Voith, we will continue to expand our competencies and our range of solutions in the area of digitalization in the future.

It's too soon to tell how the major trade fairs for the paper and printing industry are going to evolve. Do you see industry meetings and expos as absolutely essential, or will Voith also increasingly go the route of hosting its own digital initiatives like virtual in-house fairs?
I highly appreciate personal contact. While the last few months have shown us that many conversations and meetings can be shifted to the digital space, they have also made clear how important personal exchange is. We will continue to participate in events that are relevant to us as soon as this is possible for all participants in a secure environment.

In addition to the currently predominant topic of the coronavirus pandemic, the paper industry faces further challenges. What are the biggest unresolved issues in the sector?
Currently, I see two major challenges that at the same time offer huge opportunities. Paper pro-

1 Andreas Endters, President & CEO Voith Paper, focuses on sustainable papermaking and the digital transformation.

2 Voith follows the path to an automated stock preparation in order to save energy and reduce fiber consumption.

3 Thanks to the large degree of component interconnectedness and extensive monitoring of all process data, the BM 7 of BillerudKorsnäs in Gruvön is pointing the way to the digital future of the paper industry.

1

1 OnCall.Video for video remote support allows for a fast and worldwide access to Voith's expert knowledge via an internet-based video collaboration platform.

2 The OnPerformance.Lab will allow Voith to offer data-based remote services to significantly improve the performance of papermakers.

ducers are under considerable cost pressure, especially in a strained market environment. In addition, responsible handling of the resources available to us is more important than ever. It is precisely these challenges that we help our customers to master.

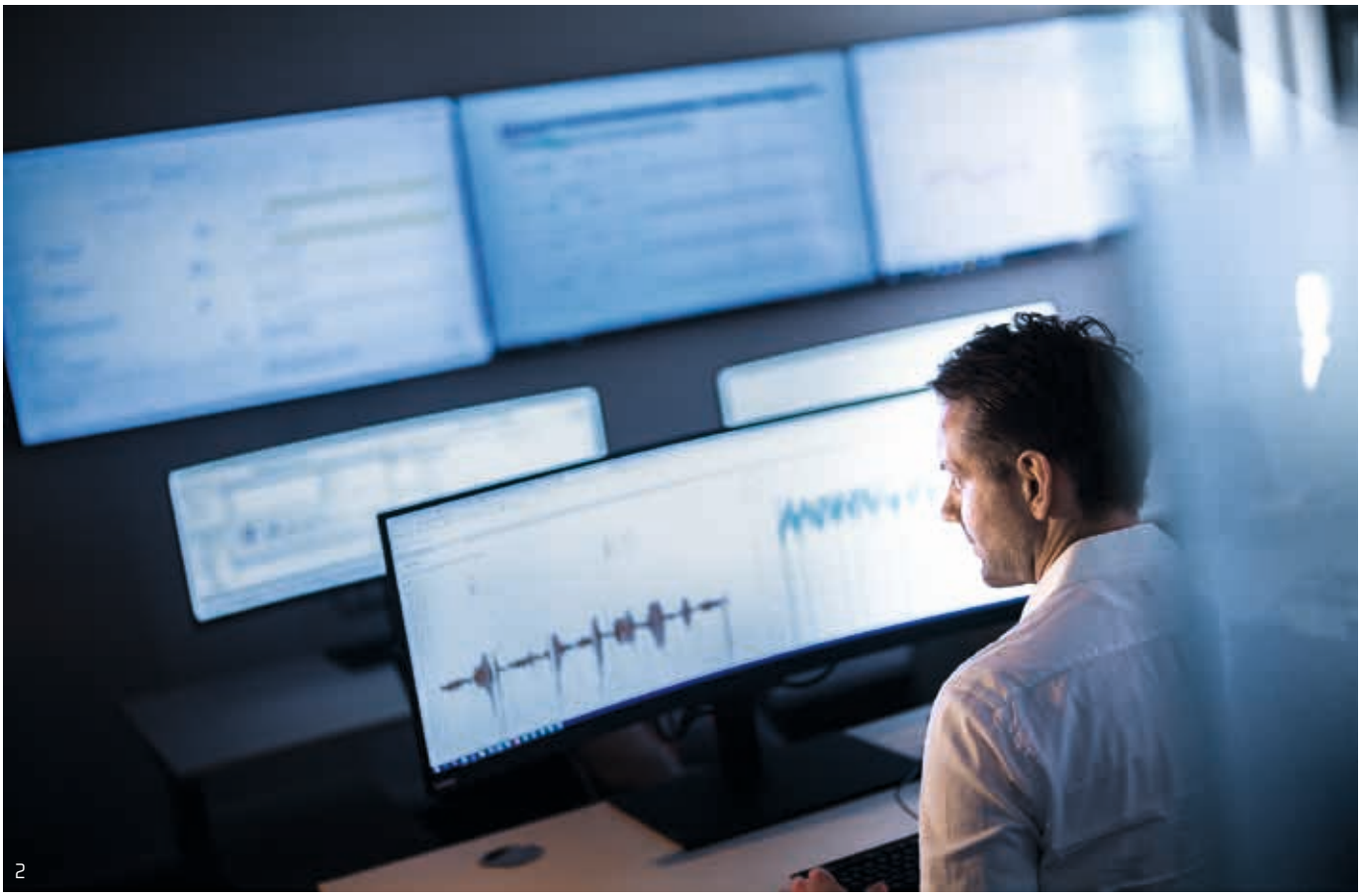
What does this support look like?
Voith is the full-line supplier offering the most sustainable solutions in the industry. At the same time we are pioneers in digital transformation. Because we offer a very wide range of products and services, we can combine these on an application-specific basis and as a result help our customers to appreciably reduce their production costs. Our intelligent solutions allow better monitoring and optimization of all processes. This results in higher efficiency and improved availabilities, and in cost savings for our customers.

Can you give specific examples?
In the field of artificial intelligence, we have developed a new solution that can protect our customers from sheet breaks. The Voith Sheet Break Prevention detects early signs that, without countermeasures, would lead to sheet breaks. The artificial intelligence recognizes patterns and provides the operator with an early sheet break warning as well as the causes leading to a sheet break. In this way, countermeasures can be quickly defined to prevent the break and increase the plant's efficiency. In addition, we are pursuing the vision of an automated stock preparation, in which processes are digitally optimized and automated, not just to save energy but also to reduce fiber consumption. In collaboration with a long-standing customer, we have already been able to achieve significant increases in efficiency and quality improvements in the stock preparation process.

You mentioned the conservation of resources as a second major challenge. What consequences do you identify from this issue?
Our solutions are also setting benchmarks in terms of sustainability. Paper is one of the most exciting materials of our time. It is based on renewable, CO_2-binding raw materials, and it is recyclable and biodegradable. At the same time, the manufacturing process is still very energy-consuming and water-intensive. As a full-line supplier, we bear the responsibility of ensuring the lowest possible resource consumption. Our innovations focus on helping our customers minimize their carbon footprint and reduce water and fiber consumption. For a European customer, for example, we installed a closed water loop and modern process technology for wastewater treatment on a new production line for packaging. This means that all the process water occurring in the paper manufacturing process is treated in the company's own wastewater treatment facility on site and then returned to the production process. Another example is our BlueLine OCC process for efficient recovered paper pulping and screening, which is already the most resource-conserving process concept on the market worldwide. The more productive and high quality the processing of recovered paper fibers is, the higher the paper quality – even without purchasing virgin fibers. This protects the environment and reduces production costs.

How are you aligning Voith Paper strategically against the backdrop of economic and ecological challenges?

Photos: VOITH



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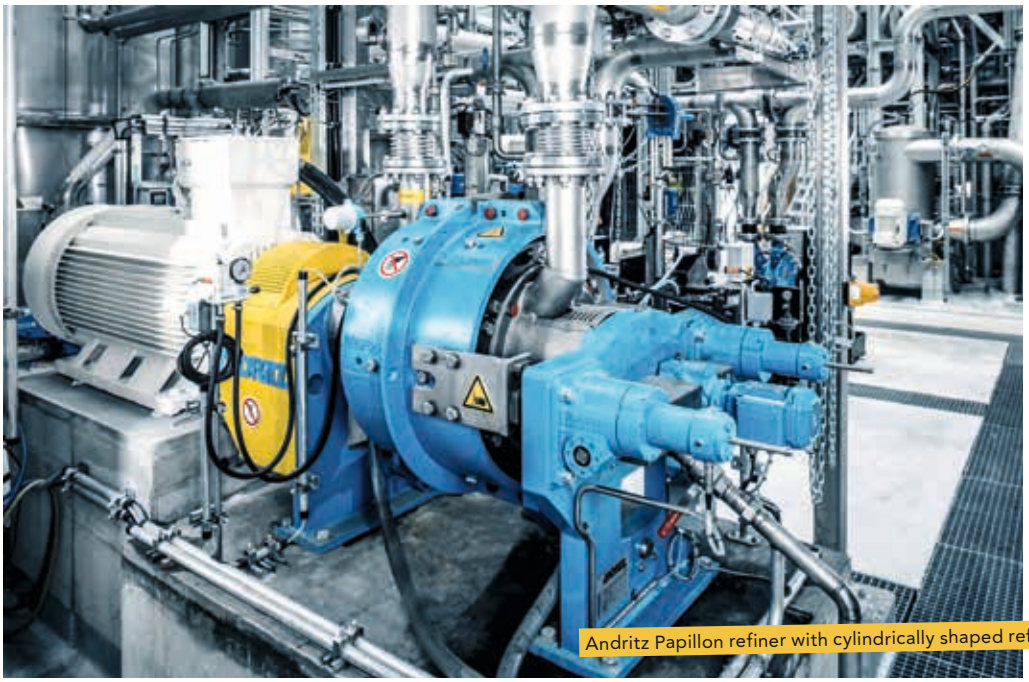
We will continue to expand our leading position as a full-line supplier. Voith offers a unique product portfolio from stock preparation to paper machine and winder. In doing so, we not only cover our customers' needs for new lines and rebuilds, but we also supply the necessary spare and wear parts, services and entire automation and digitalization solutions required for efficient operation. Orders covering the entire production line – like those at Koehler Paper Group and SCA – confirm our strategic approach. For SCA, for example, we are supplying as a full-line supplier a so-called process line package assuming the overall responsibility for the project. In addition to the BlueLine stock preparation and XcelLine paper machine, our scope of supply also includes the detailed engineering, all subsystems and components for the process line. This reduces the number of interfaces and points of contact for the customer and simplifies and increases the efficiency of the entire handling of the project.

In recent months you have made two acquisitions. What goals are you pursuing with your M&A strategy?
The takeovers of BTG and Toscotec contribute to the systematic expansion of our position as a full-line supplier. BTG's portfolio ideally complements our products and services. Its solutions in the field of data analysis, automation and software make it a key partner for the digital transformation of the pulp and paper industry. With Toscotec, we are further expanding our growth strategy and strengthening our position in the important segment of tissue paper.

And what plans do you have for the coming financial year?
We will further expand our range of products and services and will also commission some very important new lines. In addition, we will focus on the digital transformation of existing processes to facilitate efficiency increases. At this point, I can announce that we will bring together our digital expertise even more efficiently to the benefit of our customers and open our remote service center, the OnPerformance.Lab, in fall. This facility will allow us to offer data-based remote services to significantly improve the performance of our customers. We are also introducing a new machine and equipment design that will improve the safety of operating personnel and simplify maintenance work. And last but not least, we will continue to work on behalf of our customers to make the paper production process even more sustainable and efficient with our innovative technologies and to make our world better with paper.

Many thanks for your time! •



Andritz Papillon refiner with cylindrically shaped refining zone.

Interview

Innovative Solutions for Tissue Production

The global tissue market continues to grow, and is a dynamic sector within the paper industry. Andritz is a major supplier across the industry, from stock preparation to reel, and from conventional tissue machines through to the latest technology for premium quality products.

Andritz offerings to the tissue industry continue to go from strength to strength as innovations developed at the *Prime*LineTIAC R&D center come into operation: the Papillon refiner for stock preparation, the *Prime*LineTEX tissue machine for textured products, and Metris Digital Solutions which are set to optimize production efficiencies at tissue mills. We spoke to Klaus Blechinger, Vice President Tissue, Günter Offenbacher, Director Sales Tissue and Drying, Peter Clewes, Vice President Fiber Preparation, Recycled Fiber and PMA Systems and Harald Kraschowetz, Senior Sales Manager Fiber Preparation, Recycled Fiber and PMA Systems.

Can you comment on the tissue market as a whole from Andritz's point of view? For instance, what regions are the most dynamic?
The world tissue market is still growing in line with the forecasts. China is active, however there is a clear direction change towards the installation of smaller and thus more flexible production units rather than the big machines as installed over the last years. We also expect the tissue market in South America to grow as well as strong development in Eastern Europe. In total the investment dynamics have slowed down in comparison to recent years, but there is still potential for almost all market areas.

In North America, and a little more reluctant in Europe, the trend towards premium products continues, and we expect that to remain into the future. Interestingly we see in South America and China tendencies to consider the production of higher quality grades as well. This demand for higher quality is being satisfied with new technologies, which, from the energy usage point of view, are reasonably close to conventional tissue.

Andritz has had some success in China, what do you put this down to?

Photos: Andritz

Andritz offers complete solutions and key equipment for all kinds of tissue.

The Innovation and Application Center (*Prime*LineTIAC) features a tissue pilot plant for the production of dry-crepe, structured, and textured tissue.

Andritz was one of the first European suppliers to bring advanced tissue machine technology to China, for example with new machines for Hengan and APP. Secondly, Andritz has extensive local capabilities in our workshop in Foshan which have been strongly enhanced over the last years in order to fulfill the request for local manufacturing and backed up by Andritz global quality management. Moreover, key components can now also be manufactured successfully in China according to highest Andritz quality standards for the global market, for example Yankee cylinders can be made at the Yankee manufacturing and Service center in Foshan. Last, but not least, having a strong local service organization in China is a decisive factor for the majority of our customers in this region.

What are customers demanding now in terms of raw material savings? How is Andritz responding to those demands?

There is a clear trend for reducing the use of long fibers and increasing the percentage of short fibers used for tissue production. In some regions, short fibers are used for the complete product range. It is important that refining processes are optimized, for instance by the use of the Andritz Papillon refiner, which definitely provides for the lowest energy consumption when compared with other refiner types. Further energy saving potential is given by the Andritz ShortFlowConcept by reducing the number and volume of tanks, which results in less agitating and pumping energy requirements as well as lower investment costs.

Andritz Novimpianti – the specialist for air and energy systems for the tissue industry.

Can you comment on the different types of fiber Andritz tissue lines are suited for?
Stock preparation lines are suitable for all kind of fibers. Beside the typical wood fibers, Andritz has good operational experience on some of our commercial machines with bagasse pulp and bamboo fiber, both bleached and unbleached. Further to this our stock preparation research center in Graz/Austria, as well as our commercial size mechanical pulping pilot facility "R&D Center Springfield", Ohio, USA, have vast knowledge and extensive data for almost all existing fibers, including almost all annual fibers. Finally all these fibers can be tested in our Tissue Innovation and Application Center (TIAC) on a full scale pilot tissue machine, in order to identify the impact on operational efficiency, product data and paper quality.

Can you describe what Andritz can supply in terms of complete lines? And for what products?
Andritz can supply complete turn-key production lines from bale handling to reel, and, if needed, also rewinding and roll handling. We offer all technologies including complementary air and energy systems, sophisticated automation and electrification solutions, complete life-cycle services as well as best-in class tissue machine clothings. Our equipment such as pulpers, refiners, screens, cleaners, headboxes, shoe presses, Yankees and hoods are manufactured in Andritz own workshops.

Additonally to our turnkey solutions we offer also an advanced Metris Portfolio helping our customers in the digital transformation of their tissue production line. This inlcudes the Metris UX platform, Metris OPP and much more.

Can you also describe what Andritz provides in terms of back up and service to customers?
Apart from commissioning and start up assistance as well as optimization after start-up on site, Andritz can provide dedicated remote support. From our Metris Performance Center in Graz we can fully support the operators on site, optimize the customers' plant, adjust and change settings. The Metris Performance center can take over all functions of the customers control room and can remotely operate all equipment if needed. Our Metris OPP (Optimization of Process Performance) services represent a clear advantage for tissue producers to maximize efficiencies across their mills. These services are accompanied and secured by cyber security solutions, artificial intelligence, preventive and predictive maintenance services, as well as many other services.

What sets Andritz apart from other tissue line and machine suppliers?
Andritz serves the tissue industry with a complete product range from conventional tissue, across intermediate technology right through to the high-end premium TAD machines.

For all these technologies we can offer extensive R&D work and specific product development for certain market areas, furnish, etc. in our *Prime*LineTIAC.

Various technologies are also available for energy saving solutions, for example our ShortFlow system, double dilution approach flow, shoe press for post press dryness increase, steel Yankees for efficient drying, steam generator heat recovery systems, re-evaporation and co-gene-

Photos: Andritz

Andritz' latest innovation, the *Prime*LineTEX tissue machine for the production of textured tissue, was extensively tested at the Andritz pilot plant.

ration plants. We offer complete support throughout all projects, right up to full production and beyond.

Can you talk about the acquisitions Andritz has made in recent times, Novimpianti and Xerium in particular? Can you tell us what advantages those two companies bring to your customers?

With the acquisition of Novimpianti Andritz has completed its product range for air and energy systems and brought in additional expertise and service/optimization support for our customers. Also R&D work in this area now has a strong focus.

Xerium is one of the best known providers of consumables in the paper industry, including roll covers, forming fabrics, felts and shoe press belts. Xerium also has a comprehensive network and excellent customer support solutions.

What are the key innovations and R&D have you been working on at the *Prime*LineTIAC that your customers would be keen to know about?
*Prime*LineTEX has been the main focus recently. With this intermediate technology Andritz has developed a competitive tissue machine for premium grades that enables a lower fiber input – particularly when compared to dry crepe – and less energy consumption in comparison to TAD.

In your experience is IIoT and the use of Big Data via Metris technologies making a difference to production efficiencies? Will Metris applications be important for tissue producers in the future?
Metris technologies are our answer to support the digital transformation. Metris OPP for example has been successfully used in many pulp productions plants since over a decade now. The implementation of Metris OPP provides remarkable results in terms of savings and operational improvements. We expect the same excellent results for paper and tissue machines in the very near future.

A strong service and customer support is of utmost importance. The Metris Performance Center features various applications for a perfect global customer service and support by providing remote solutions, real-time communication and data analytics. This means Andritz is able to expand the service activities for papermakers around the world by putting an expert virtually in the mill's control room whenever needed.

What does the future hold for tissue producers when it comes to the very best in technology from Andritz?

Besides optimizing and increasing the efficiency of dry crepe installations and on the new technology of the textured tissue, ANDRITZ will still focus strongly on premium technology. In order to make this technology feasible for a broader market area, our focus will be to reduce the energy input significantly. The ideas and innovations are already in place, and our pilot plant offers the great possibility to test them extensively. •

Stora Enso

Market Pulp Line Conversion to Fluff Pulp Line with Bellmer

Stora Enso converted one of its bale-based market pulp lines into a softwood fluff pulp line and increased its fluff pulp capacity at Skutskär Mill in Sweden. Bellmer was selected as their technology partner.

At the middle Lasse Aspelin, StoraEnso Skutskär, right Frank Schorzmann and Ahti Peiponen from Bellmer.

The 26 million euro investment enhanced Skutskär Mill's profitability and long-term competitiveness by increasing fluff production by 160,000 tonnes annually. The mill's total fluff pulp capacity after the investment is 415,000 tonnes.

"Both hygiene and non-woven products are a fast-growing market. This investment has enabled us to support the growth of our customers and further develop this business together with them," states Stora Enso's Biomaterials Division.

Stora Enso's Skutskär Mill in eastern Sweden is a modern pulp mill that primarily produces fluff pulp for diapers, other hygiene products and non-wovens, but also pulp for liquid packaging board and speciality papers. The mill's total annual capacity is 540,000 tonnes of NBSK pulp, softwood fluff pulp and bleached hardwood (birch) pulp.

Fluff Pulp – "NaturaFluff by Stora Enso"

According to the company, ‚NaturaFluff by Stora Enso' is the widest range of fluff pulp grades on the market, including a completely chlorine-free bleached fluff pulp. After the investment, Skutskär Mill now produces 415,000 tons of fluff pulp per year.

"Skutskär Mill started manufacturing fluff pulp in 1969. We have long been the largest manufacturer of this pulp in Europe. In the last couple of years, we have only strengthened our position. Demand for fluff pulp is growing by 4 per cent a year globally," says Henrik Holm, Director of Stora Enso Skutskär Mill.

Stora Enso studied the transformation work for four years with various equipment suppliers before deciding to carry out the project with Bellmer. The modernization was large and included a new dilution controlled headbox, water removal improvements at the wire section, a new reel and a winder, including complete automation and controls. The reel delivery also included an automatic return system for bringing empty spools back to the reel spool storage. As this is a swing dryer machine that can produce both sheets and rolls from pulp, the project included a fly-over section to pass the web over the cutter lay-boy to the new reel at the dry end.

Photos: Stora Enso / Bellmer

Winder/unwinder section with new parent reel feeding and empty spool lifting.

Fly over to pass web over cutter lay-boy to reel section, when producing fluff pulp.

TURBOWinder™ by Bellmer

Bellmer's scope of the turnkey delivery was very detailed. It included:

- Automatic set change with 28 tape applicators to fasten shipping roll tails to the roll body.
- A traversing cutting device.
- Web holders to maintain tension during set change.
- Effective and reliable web separation after the slitters, with two spreader rolls mounted in an adjustable frame.
- An automatic core feeding table and pivoting device to load new cores between the drums.
- Fast and accurate automatic slitter positioning for 15 pairs of bottom and top slitters.
- Separation "fingers" after the slitting to force the webs to separate.
- Web feeding with vacuum and driven belts.
- A parent roll transporting system, TURBO-Transporter™ from reel to unwinder. An automatic empty reel spool return system was also included.

"The formation of the fluff pulp must be good and the quality must be just right, since the pulp

Superior finished fluff pulp roll quality with precise dimensions.

Start up of the new Bellmer reeling, transporter and winding section.

is used directly in the converter's end products. That is why we needed to make significant improvements also to the production line's wet end. We replaced the wire section and installed a new headbox," says Henrik Holm.

"A key part of the conversion was, however, the new winder, which Bellmer supplied seamlessly in co-operation with us. Bellmer was flexible, as when we had an idea, they were quick to develop it. Solutions emerged smoothly," says Holm.

Customer-focussed product development

"Effective threading through the winder is crucial for a fluff web due to its thickness (> 750 g/m^2). We improved the web threading to wind-up section by installing driven belts instead of air blows," says Bellmer's sales manager Ahti Peiponen.

"Fluff pulp, winded to the desired customer reel dimensions at the automatic winder, is delivered directly to the converting plants manufacturing hygienic products; therefore, Stora Enso only needs to apply medical tape used in hospitals to bind the tails of the customer reels, instead of the typically used hot-melt glue. R&D was required to invent this medical-tape solution, which was successful, and the outcome is that 28 tape dispenser units units do the job required during the automatic set change" says Peiponen.

"Occupational Safety and Healthy requirements were fulfilled by taking the necessary measures to avoid excessive noise levels and improve ergonomics," he adds.

"A perfect match"

"Our main criteria were that Bellmer fulfilled our technical specifications and guarantees, had the right delivery time – and price, of course," says production manager Lasse Aspelin.

"The targets were to reach several scheduled points, such as the start-up time, rolling test fluff pulp the first time and mixing between fluff and bale pulp. When the line was ready, we started regular fluff pulp production and periodically in bales in order to fine-tune the winder/packing line," says Aspelin.

"As this was Bellmer's first modern, new-generation reel and winder delivery to a Scandinavian customer, the project was important to us. At the same time, we are pleased to be Stora Enso's partner in Skutskär as a leading headbox manufacturer," says Jyrki Strengell, CEO of Bellmer Finland Oy.

Stora Enso

Stora Enso says its strategy is to support customers to meet consumers' demand for sustainable products based on renewable materials. Part of the bioeconomy, Stora Enso is a global provider of renewable solutions in packaging, biomaterials, wooden constructions and paper. Stora Enso's business divisions are Consumer Board, Packaging Solutions, Wood Products and Biomaterials. The Biomaterials Division offers a wide variety of pulp grades to meet the demands of paper, board, tissue, textile, and hygiene product producers. • **Leif Lindberg, author for a Finnish paper magazine; Ahti Peiponen, Winder specialist, Bellmer GmbH**

Photos: Stora Enso / Bellmer

maik brummundt.de

design + illustration

[what goes around comes around]

PTS Research

Preparation of Thermoplastic Cellulose Based Fibre Materials and Their Application in the Manufacturing of Thermoformable Papers

One of the current key research topics at Papiertechnische Stiftung (PTS) is the chemical transformation of commercially available cellulose pulp into added-value fibre materials such as thermoplastic pulp. As shown in Figure 1 the obtained cellulose derivatives were used to manufacture papers with maximum thermosensitive material elongation up to 50% that can be thermoformed, too.

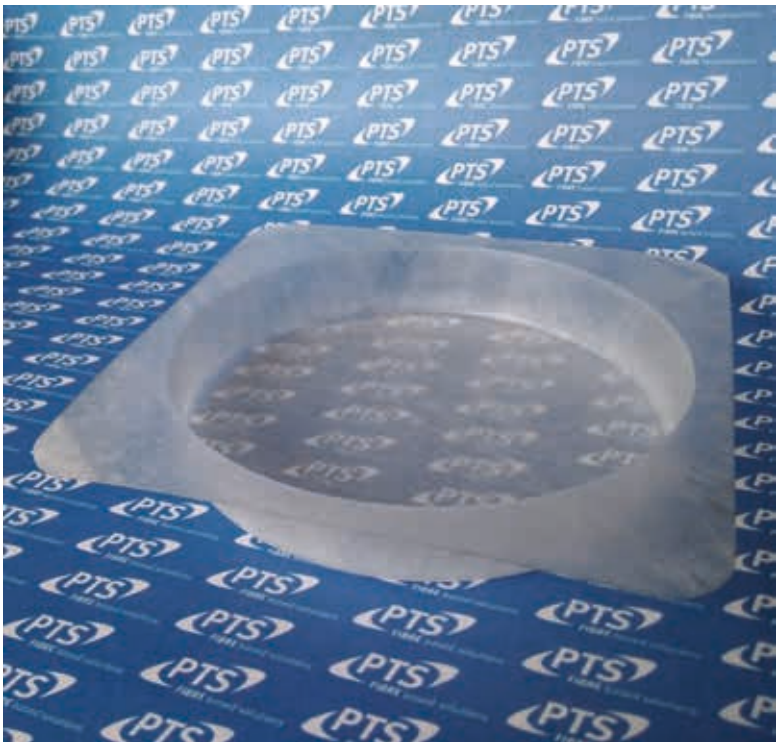


Figure 1: Thermoformed dialcohol cellulose tray.

According to "Statistisches Bundesamt" in Germany, 63.3 % of packaging material used in transport and packaging sector in 2017 was paper, cardboard and board, measured in terms of the volume of waste collected. [1] In the area of used sales packaging for private consumers only 21.1 % were paper-like products, while nearly half of the material was light weight packaging (plastic, composite and metal). [2] This may be attributed in particular to a high level of plastic formability, which is required for the production of large quantities of packaging products with individual and functional geometries by thermoforming and press forming techniques. Unfortunately paper materials are not suitable for those processing techniques due to their lack of thermoplasticity.

However, cellulose pulp can be modified chemically in a partial manner to provide thermoplastic papers. Therefore a simple aqueous glycol cleavage oxidation reaction with sodium periodate ($NaIO_4$) to a ring-opened cellulose derivative named dialdehyde cellulose (roC-CHO) can be performed followed by a subsequent aqueous reduction by sodium borohydride ($NaBH_4$) to dialcohol cellulose (roC-OH) (Figure 2). [3]–[5]

Optimization of reaction protocol

According to the state of the art 4.1 equivalents of $NaIO_4$ are required for the oxidation of cellulose to roC-CHO within a reaction at room temperature at a stock consistency of 0.4% (all values based on dry cellulose). [4] Since the theoretical necessary amount for a 100% degree of oxidation (DO) is 1 equivalent, a large excess of chemicals is applied which makes the overall process inefficient and expensive. In addition to this $NaIO_4$ is a hazardous chemical and its reduction would make the overall process more safely. In order to make the process more efficient, we focused on three target directions: The excess of reagents should be decreased, the stock consistency of the reaction mixture increased and the

Images: PTS

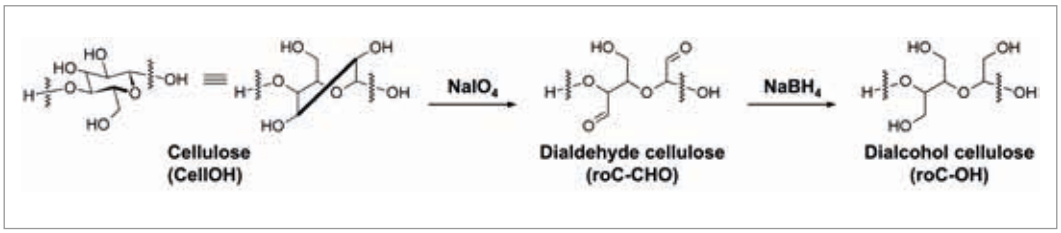


Figure 2: 2-step derivatization of cellulose to dialcohol cellulose (roC-OH).

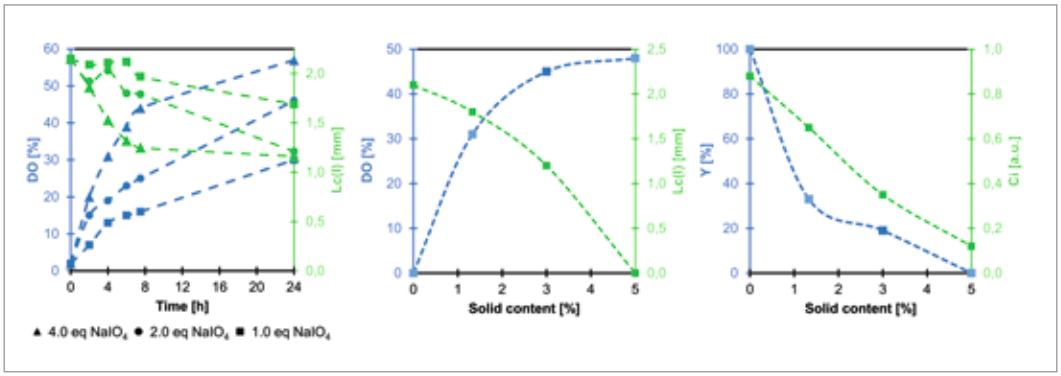


Figure 3: Optimization of oxidation reaction at 25 °C: influence of used sodium periodate amount as oxidizing agent at 1.5 % stock consistency (left) and influence of stock consistencies (based on dry fibrous material) during reaction with 1 eq NaIO4 after 24 h oxidation time (middle and right). Ci: crystallinity index; DO: degree of oxidation, proportion of modified cellulose anhydroglucose units; Lc(l): fibre contour length (length weighted); Y: reaction yield after NaBH4 reduction.

reaction times should be shortened to the maximum possible extent.

On the basis of the optimization it was determined that reduction of the periodate to the theoretically necessary amount leads to about half the oxidation extent of CellOH to roC-CHO compared to the literature (Figure 3 left). However, it was possible to improve the degree of oxidation obtained in relation to the amount of periodate required and thus the efficiency of the reaction. From previous investigations it was known that the total thermosensitive material elongation is based on the elongation of the individual fibres, for which reason fibre degradation by the oxidation reaction shall be avoided. [5] From this point of view the reactions with reduced periodate amount and thus less possibilities for side reactions, but particularly with 1 equivalent NaIO4, are advantageous.

Based on this, an optimization towards higher stock consistencies during the reaction was carried out. The optimum was found to be about 1.3 wt% (based on cellulose). For higher stock consistencies, a decreased crystallinity within the fibre structure of the respective fibres was observed, which collects with deteriorating yields after the reduction of roC-CHO to roC-OH (Figure 3 right). The explanation for this observation can be given by several reasons. Although chemical modification at cellulose start in amorphous fibre regions, crystalline parts are also modified and become amorphous. This reduces the overall crystallinity. However the aldehyde groups of roC-CHO stabilize the fibrous structure by intra- and intermolecular hemiacetal formation [6], [7] leading to a pulp with only minor visual changes in appearance and rather no yield loss. By subsequent reduction of the roC-CHO to roC-OH, the aldehyde groups are converted into hydroxyl groups, thus the possibility of hemiacetal formation is lost making strongly modified and amorphized fiber components water-soluble and reduces the yield of roC-OH pulp. [8], [9]

Next to the oxidation the reduction roC-CHO to roC-OH was investigated and optimized, too. Sodium borohydride has been proven in literature to work well in an aqueous phosphate buffer system with the chemicals and excesses listed in entry 1 of Table 1. [4]

By adjusting the amount of borohydride, it was found that the theoretically necessary equivalents of borohydride were not sufficient for

Entry	eq $NaBH_4$ (AGU)	eq $NaBH_4$ (CHO)	c NaH_2PO_4 [mol/l]	Residual DO [%]	Yield [%]
1	2.10	22.7	0.38	3	66
2	**1.00**	**10.8**	**0.00**	**< 1**	**64**
3	0.37	4.0	0.00	6	66
4	0.19	2.0	0.00	9	62
5	0.19	2.0	0.38	26	86

AGU: anhydroglucose unit, CHO: aldehyde groups, DO: degree of oxidation

Table 1: Optimization of reduction reaction at 25° C applying roC-CHO with DO = 37 %.

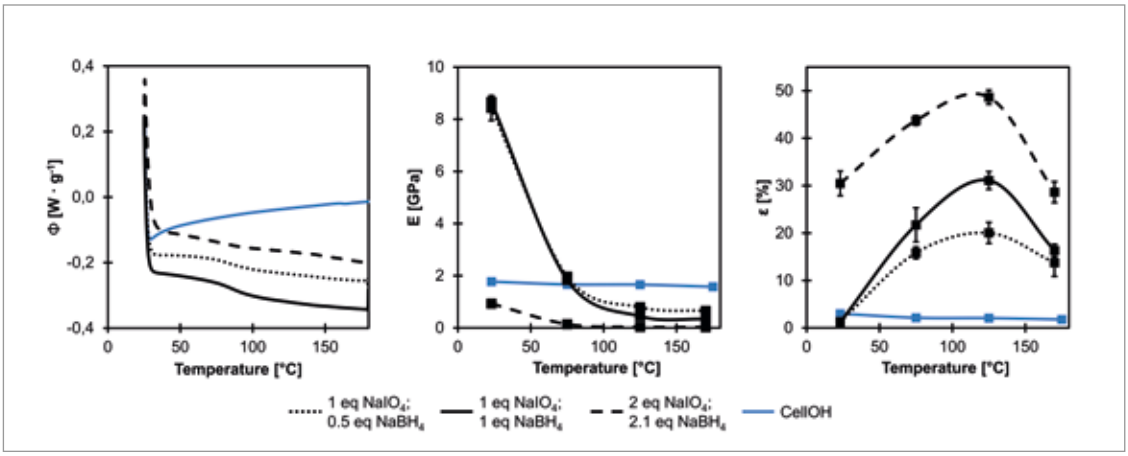


Figure 4: Influence of reaction conditions during two step roC-OH synthesis on thermomechanical properties of corresponding papers: Differentials Scanning Calorimetry (DSC) (left) and temperature assisted tensile testing: Young's modulus (E) (middle) and elongation at break (ε) (right), Φ: heat flow.

complete reduction (entry 4). In addition, it was observed that the buffer system had a negative effect on the reduction (entry 5). We were surprised by this result, but an explanation can be given as follows: A borohydride solution has its highest stability at high pH values and decomposes in acidic and neutral pH under hydrogen evolution and metaborate formation. This increases pH and therefore borohydride stability. In case of the buffered reaction the borohydride is decomposed until the buffering system is depleted, which decreases the reduction efficiency and results in higher residual DO. The reduction rate is increased by higher pH values, too. [8]

Overall, it was found that the use of 1 equivalent NaBH4 (related to AGU) leads to a complete reduction within the reaction time of 1 hour (entry 2).

Thermomechanical Properties

For characterization of the thermomechanical properties, the pulps were transferred into sheets by Rapid-Koethen process and analyzed by DSC for their glass transition or melting behavior as well as temperature assisted tensile testing for their temperature dependent softening behavior. The results from DSC measurements are shown in Figure 4 (left). On the basis of these investigations a glass transition in the range of 85–100° C was determined for sheets prepared from roC-OH pulps.

To characterize the temperature depending softening behavior and mechanical material characteristics, the temperature range 23–175° C was investigated by temperature assisted tensile testing (Figure 3) with respect to Young's moduli (middle) and elongation at break (right).

Images: PTS

The maximum elongation at break for all samples prepared was observed in the range of 75–125° C, which correlates well with glass transition range. Above these temperatures the elongation at break decreases, assumably due to the evaporation of material's moisture.

In addition to the amount of periodate used for oxidation, which significantly influences the degree of oxidation, it is necessary to completely reduce the samples in order to obtain a high elongation at break. The sample which was oxidized by 1 eq NaIO4 and reduced by 0.5 eq NaBH4 shows residual aldehyde groups that form hemiacetals and hence decrease thermal elongation as well as temperature induced material's softening. Futhermore it was found out that by application of the lowest amount of 1 equivalent of periodate during oxidation, materials with the highest stiffness at ambient temperature among the investigated samples are obtainable.

Conclusion

The possibility of 2-step reaction optimization from cellulose pulps to roC-OH pulps and the thermomechanical properties of dialcohol cellulose papers was investigated. It was found out that an increase of stock consistencies in combination with reduction of applied periodate amounts during oxidation is possible. This observation as well as the opportunity to safe borohydride during reduction by non-utilization of phosphate buffering makes the overall process more effective. The obtained dialcohol cellulose papers showed temperature induced softening and maximal elongations up to 50 % in their glass transition range of 85–100° C.

Outlook

Deeper investigations into the subjects of impacting parameters to thermoplastic properties, fibre retention and flocculation as well as the optimization of drainage are currently being carried out at PTS. In addition, pathways for making the reactions more economically e. g. by reoxidizing the periodate/iodate liquor electrochemically [11] are under development. • **Stefan Möckel, Dr. rer. nat. Martin Zahel, Dr.-Ing. Tiemo Arndt**

Acknowledgement

The presented results were observed in public funded scientific research projects CORNET 142 EGB „ACTIPOLY" and IGF 19726 BR „FibrePlast". Therefore we want to gratefully acknowledge the „Bundesministerium für Wirtschaft und Energie" (BMWi) for financial funding.

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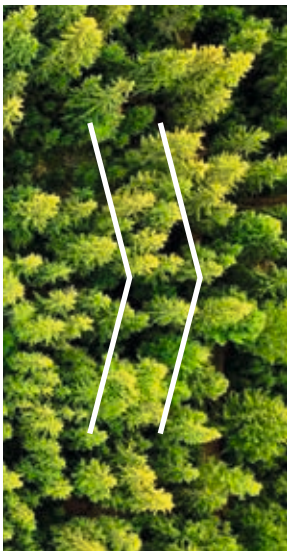


Green Claims vs Green Washing

Cepi Launches an LCA Tool for Paper Products

In December 2019, the European Commission presented its ambitious Green Deal roadmap, a comprehensive strategy aimed at putting Europe on the right track for climate neutrality in 2050 while encouraging sustainable economic growth.

In this strategy, the role of consumers is clearly recognized: this transition won't happen without them. However, green washing is a threat to their involvement: they won't be able to make more sustainable choices if they don't receive reliable, comparable and verifiable information.

For that reason, the European Commission has decided to leverage the Product Environmental Footprint (PEF) method to distinguish between valid green claims and green washing.

We are proud to announce that Cepi together with its member companies developed an LCA tool fully based on the Intermediate Paper Product PEF Category Rules (PEFCR).

The PEF tool enables any Cepi member company to calculate product LCAs and validate their green claims within the Green Deal context. The tool has been designed for both LCA experts as well as users less familiar with the LCA methodologies. Having access to an LCA tool makes it significantly easier for small and medium size enterprises to compute complex Product Environmental Footprints for their products.

The foundations of the PEF work were established in 2013, the idea was to develop a harmonized method to evaluate the environmental friendliness of products, focusing on their carbon footprint and related GHG emissions.

The initiative gave way to two projects: Product Environmental Footprint (PEF) and Organisation Environmental Footprint (OEF) with the objective of developing a harmonized environmental footprinting methodology that can accommodate a broader suite of relevant environmental performance criteria.

The European Paper Industry participated to the EU PEF Pilot project in 2011 and again in 2013–2018: we were one of the 15 sectors that delivered PEF Category Rules. The Intermediate Paper Product PEFCR is the most complete of any EU PEF Pilot Category Rules allowing in-depth primary production data be used for the results and enabling understanding of improvements in time as well as improvement areas. The Intermediate Paper Product PEFCR is a detailed LCA calculation method for paper that will be converted into finalised products such as packaging, print and tissue.

The tool that Cepi is launching today has been developed in collaboration with Green Delta, the partner with whom the Intermediate Paper Product PEFCR Development Group tested the remodeling of the Category Rules. The tool strictly follows the PEFCR and uses the secondary datasets dedicated for PEF while being the only available tool to deliver EU PEFCR compliant results. The tool has been developed to be of use for small and mid-size enterprises in mind and is available to all Cepi members free of charge.

There are still areas of improvement for both the industry and the PEF methodology. These include:

- Improved and up-to-date datasets for all paper products
- Further development of the land use impact methodology that reflects sustainable forest management realistically
- Further develop the circularity formula
- Developing rules on how intermediate product footprint results will be linked to the final product calculations.

The EU PEF Project continues in 2021 with lessons learned from the 2018-2020 transition period. Cepi together with its sister associations is committed to work further with the EU institutions on the development of the PEF and OEF. •

Photos: Cepi

1 For indoors and outdoors: The playhouse made of corrugated board.

2 Eero Aarnio with "his" toy.

Eero Aarnio

Eco-Playhouse Made With Corrugated Board

Eero Aarnio, an artist worldwide famous for furniture designs, such as the iconic Ball Chair, has designed an eco-playhouse made with corrugated board. Aarnio has always been interested in different materials and the opportunities they create. Corrugated board has a particular fascination for him due to its light weight and environmental credentials.

Thanks to its design and the lightweight board construction the playhouse can be conveniently moved from place to place. The playhouse can be set up indoors or outdoors, if the weather permits. It can also be folded up for easy storage. "During this exceptional period people have spent more time at home with their families. Assembling a playhouse is a nice thing to do together and gives enjoyment to the whole family," commented Eero Aarnio. "In the past, my own children have built huts out of empty corrugated boxes," Aarnio recalls.

The sustainable white kraftliner materials provided for the production of the playhouse are made by Metsä Board, part of Metsä Group. Metsä Board's white kraftliners were used for the surfaces: MetsäBoard Pro WKL 160 g/m^2 was chosen for the outside due to its smooth printing surface and MetsäBoard Natural WKL Bright 160 g/m^2 for the inner surface. The used kraftliner type is B-flute.

"Screen printing technology gives the liner surface a uniform, beautiful colour tone. MetsäBoard Pro WKL provides fast drying of the printed ink. Thanks to its high printability and excellent production efficiency, it was an ideal material for this project," comments Ilkka Harju, Packaging Services Director EMEA and APAC Metsä Board.

The playhouse has been produced by the Finnish companies Futupack and Capertum. •

Photos: Metsä Board

The new investment for its state-of-the-art pulp mill at Värö will allow the mill to increase capacity in steps towards 850,000 tpy.

Värö: Supplying the World

The Foundations Securing Paper's Future

Södra is making plans to ensure there will be enough fiber to go around now and for the decade to come.

Södra's last major capacity project was the addition of 275,000 tpy of softwood at Värö in 2016. At the time, the new line in Sweden helped put to rest concerns about the long-term security of long-fiber pulp supply in Europe.

The time required to build new capacity means softwood pulp investment decisions must anticipate demand. The overall growth in paper demand, fuelled particularly by tissue and packaging, necessitates regular top ups in pulp supply: it doesn't take much for a balanced market to tip into shortage.

It is in this context that Södra announced a further expansion of Värö earlier this year. The new investment for its state-of-the-art pulp mill at Värö will allow the mill to increase capacity in steps towards 850,000 tpy.

When Värö was completely rebuilt in 2016, it became one of the world's most modern and largest softwood pulp mills with a capacity of 700,000 tpy, but, Marcus Åsgärde, Mill Manager for Södra Cell Värö explains: "It was soon apparent that the new line had even greater potential than we had anticipated. We now see a possibility to further increase production in a cost-efficient way by the end of 2022. This is a major first step toward the 850,000 tpy that is within the framework of the existing environmental permit."

A secure fiber base for the additional capacity is guaranteed as Södra will source the wood needed from the forest estates of its 53,000 members. The project is scheduled to start up in April 2022 and will ramp up until the end of the same year.

"Our control of the value chain, from seedling to value-added products and services, makes Södra a unique business partner," says Magnus Björkman, Business Area President for Södra Cell. "We invest in growing our industrial operations, but only in parallel with ambitious sustainability targets to increase the growth of our members' forest estates. This investment also facilitates future investments in optimizing pulp quality – that's important because we know our customers' expectations will only increase in the future."

"We are a leading player in a global market and Värö is ideally placed to supply nearby European markets as well as the rest of the world", adds Henrik Wettergren, Vice President Södra Cell International.

Photos: Södra

Magnus Björkman: "We invest in growing our industrial operations, but only in parallel with ambitious sustainability targets."

Marcus Åsgärde, Södra Cell Värö Mill Manager: "It was soon apparent that the new line had even greater potential than we had anticipated."

This announcement has brought into focus the role of softwood pulp in papermaking. Taking tissue as an example, consumers increasingly value the quality of the product they buy, while at the same time tissue producers place ever-higher demands on runnability in order to maximise output. The characteristics of the wood fiber used are therefore more important than ever.

The crucial role of softwood

Substitution with hardwood from fast-growing plantations in South America means the proportion of softwood in the tissue fiber mix has fallen this century. The result is that the remaining softwood fibers bear a much heavier responsibility – they really need to perform. The tensile properties which softwood delivers cannot be left to chance in a world which is not only demanding more tissue, but better tissue and high productive efficiency.

In Southern Sweden, where Södra's three pulp mills are located, the tree growth characteristics are between the two extremes of constant, steady growth in southern Europe and short, sharp periods of growth in the northern Nordic region. This results in a fiber-wall thickness which produces the ideal combination of strength and softness for tissue. Södra has tended to harvest the younger spruce wood from forest thinnings, which have thinner fiber walls and so produce softer tissue. At a certain growth stage of a plantation, the forest needs to be thinned out to allow it to thrive, but the resultant thinnings are unsuitable for use in construction. So almost as a by-product of good forest management, Södra has been able to procure an ideal raw material.

A more diverse fiber input

Despite advanced forest-management practices in Sweden which mean the volume of standing timber in the country increases year on year, thinnings remain a finite resource. An important aspect of Södra's investment at Värö, with consequent benefits for its Mörrum and Mönsterås mills, has been to deliver the pulp characteristics required by the most demanding papermakers from a more diverse fiber input.

Two examples: The enhanced ability to regulate chip size into the digester and manipulate post-digester kappa number have proved to be important tools for Södra to influence quality and characteristics within the process.

Södra's aim has always been to minimise the post-pulping refining necessary by maximising tensile within the process: the less refining that is necessary to boost tensile, the softer the tissue which can be produced with the pulp, for example. This optimisation process will continue. Refining should always be viewed in context however – if a papermaker refines at a relatively high level anyway as part of its process, then specifying a pulp with the ability to withstand refining and still deliver premium performance will be a priority.

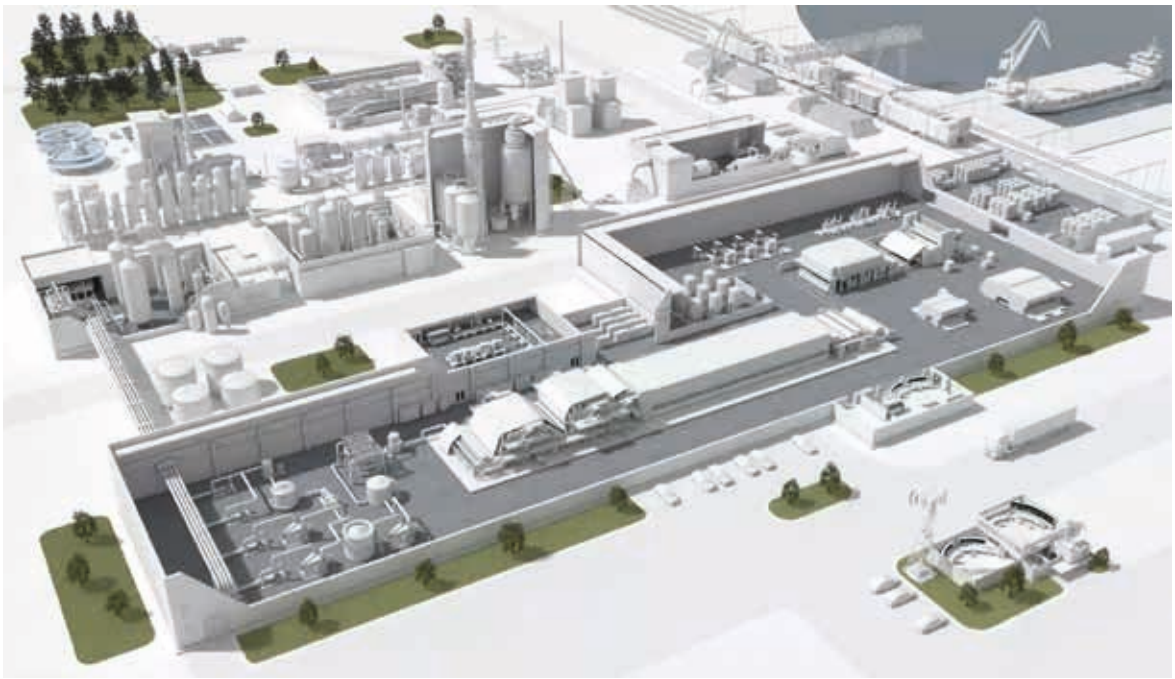
Paper makers in Europe and beyond have come to rely on Scandinavian pulp to meet their reinforcement needs and to balance this with the required softness for the modern tissue consumer. Totally chlorine-free (TCF) and elemental chlorine-free (ECF) bleaching are now both considered Best Available Technology (BAT). The key environmental parameter from the customer perspective is certification - Södra's production is mostly dual certified to PEFC and FSC.

Markets and consumer requirements evolve in their environmental priorities and in the paper they seek. But what is sure is that the strong bond between the papermakers and fiber suppliers will underpin paper's future. •

Process Data Management

The Foundation of Digital Success

A robust digital strategy that starts with effective management of process data is crucial to the success of any pulp and paper business. But making sure it is used, and used correctly, starts with the right platform and expertise – making them the critical first steps on your path to digital transformation, as Jukka Kostiainen, Enterprise Solution Architect at ABB, explains.



Pulp and paper manufacturers need to extend corporate data management and data governance from enterprise level systems through to manufacturing operations management and automation systems.

The promises of the digitalization revolution are significant: as a 2019 McKinsey report estimates, digital technologies could offer pulp and paper producers a 15% reduction in total cost and provide a five percentage point improvement in overall equipment effectiveness.[1]

While the industry is certainly embracing digitalization – particularly in terms of an enhanced ability to collect data – knowing how best to utilize it is key. Gartner estimates that 85% of big data projects fail[2] – so how do you make sure yours isn't one of them?

Using data effectively

While most mills use some sort of process data management system, simply having data is not the same as understanding how to utilize it effectively. IBM Research estimates that up to 88% of Industrial Internet of Things (IIoT) data goes unused; The Economist suggests that 99% of the value of manufacturing data is lost, with only 3% tagged and analyzed. Other pitfalls include legacy systems that are inaccessible or not digitalized; not labeling data logically across the enterprise; a lack of real-time data; and the failure to communicate data-derived conclusions effectively.

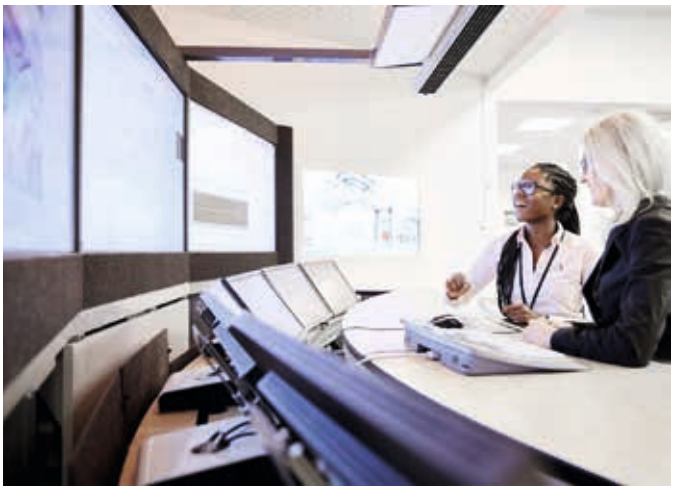
The first steps of any digitalization journey are therefore understanding the foundations of process data management and managing the collected data so that it adds value. The ultimate goal must be to create a fully integrated digital infrastructure that allows asset and operational data to be accessed, visualized and analyzed for improved performance.

Where to start?

A good place to start is by ensuring that your data strategy is closely aligned to your business strategy. It is encouraging to see that our customers are increasingly recognizing the value of a holistic view of their data assets throughout the business, but this is by no means yet the industry norm.

Traditionally, process data has been stored as an extension to automation systems at a production line level. In many cases, there has also been no harmonization over production lines in technology and naming

Photos: ABB



Bringing structure to all levels of organizational data is vital in transforming it into a significant business asset.

Visualization of KPIs at an equipment, site, and company-wide level ensures effective decision making.

conventions. This has resulted in fragmented, unstructured data that makes it difficult to do anything on an application level or across multiple production lines. Meanwhile, the flat structures in many process information systems (PIMS) don't make life any easier when integrating to site and enterprise level.

Bringing structure and standardization to data, which may have been collected (and unused) for decades, is a vital step in transforming data into something of significant business importance. One example could be ensuring data tags are tied to a specific production phase or piece of equipment in a standard way. These can then be grouped together into units that align with a particular strategic business or process function – e.g. all data that is needed to analyze the equipment health of electric drives. We also spend a lot of time ensuring the integrity and consistency of our data models. This is vital work, as the models are then used throughout the customer organization to harmonize the data and interface, and as the basis for providing useable insights for smarter decision making.

The aim here is to extend corporate data management and data governance from ISA-95 level 4 enterprise level systems, right through to Level 3 manufacturing operations management and Level 2 automation systems.

The benefits of good data management

All good so far, but how does effective process data management contribute in practice to the improvement of a pulp and paper manufacturer's operations? This is the key question and comes in three different areas:

1. Improved productivity: Properly stored and labeled data allows mills to take advantage of advanced digitalization solutions, such as advanced process control (APC). Our ABB Ability™ APC applications, such as the recently launched Wet End Control, leverage data to build predictive models and implement control strategies that stabilize and improve process conditions in a cost-efficient way. The benefits include reduced energy consumption and optimized raw material use.

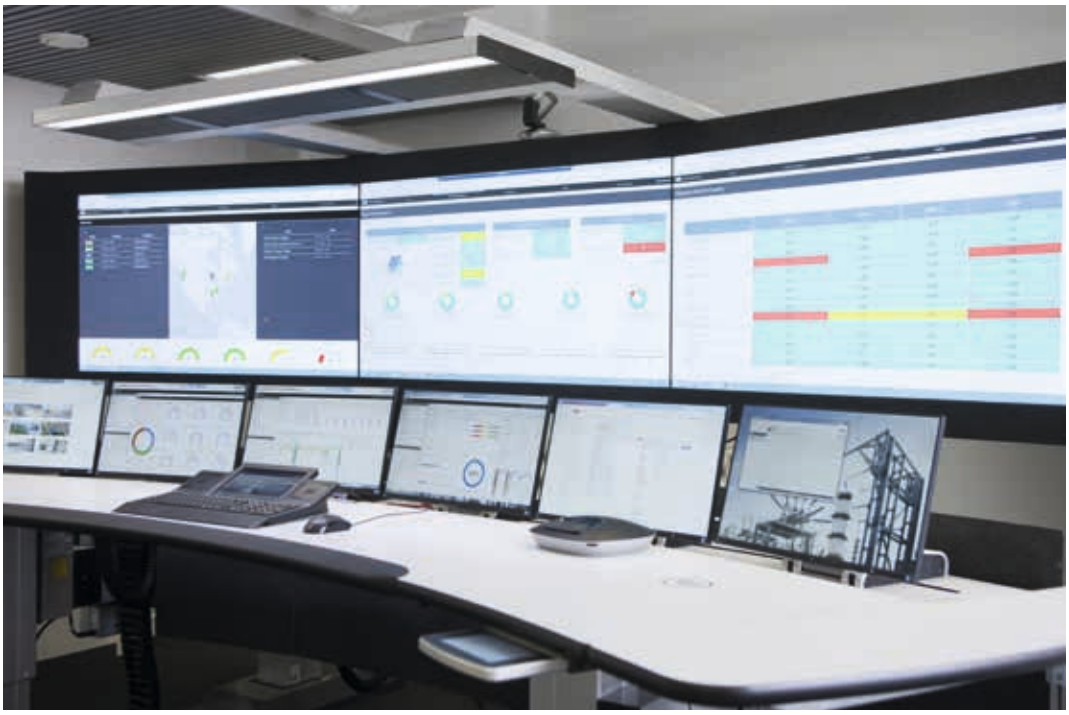
2. Smarter decision making: Visualization of performance against KPIs at an equipment, site, and company-wide level ensures broad situational awareness that supports effective decision making throughout an organization. But visualization is only possible through the effective management of data from a range of different sources.

3. Enhanced data security: Without a comprehensive and consistent approach to data management, there can be no comprehensive and consistent approach to data security, leaving valuable assets vulnerable to attack. Strong data management structures that work at all levels of the business are required as the basis for the advanced data governance and security that is required in today's interconnected industrial environment.

Selecting an expert guide...

The importance of process data management makes the choice not only of platform, but also of implementation partner vital, and businesses must be able to answer some key questions confidently.

First and foremost, does a potential partner have the right combination of domain-



Effective Process Data Management leads to improved productivity, smarter decision making and enhanced data security.

Kotkamills Oy located in Kotka, Finland, benefited from Process Data Management to help integrate systems and cut costs.

specific expertise and knowledge of both IT and OT infrastructure to ensure their solutions offer real value? A partner with deep industry experience, will – at a minimum – save you a lot of time (for example, by being able to adapt 'off-the-shelf' systems rather than custom build from scratch), and can quite easily be the difference between a solution that works and one that is unusable.

Another question to ask is whether a potential partner appreciates the challenges of collecting data in the real-world conditions of a mill. Do they recognize the need for robust and reliable sensors that can

Process Data Management first step to help cut costs for Kotkamills OY

When Kotkamills Oy wanted to implement ABB Ability™ Manufacturing Execution System to ensure a smooth order-production-delivery process, the first module they needed to implement was ABB's Process Data Management. This was to help increase the integrability of the individual systems on site after Kotkamills was acquired by a private company.

"System integration has not only brought us new technology but also enabled us to build a system that matches our needs perfectly," said Petri Hirvonen, CFO of Kotkamills Oy.

The single integrated system has produced savings in both the cost of managing the order-production-delivery process and the cost of maintaining the hardware and updates. "We have realized considerable savings in our system costs," said Hirvonen.

Photos: ABB

withstand the rough-and-tumble of the mill environment? Do they understand how to integrate the different legacy systems common in brownfield sites - often systems that were typically not designed to support modern, open, or standard connectivity protocols – with the process data management platform?

We've found decades of experience in the industry not only provides knowledge of a customers' business and operations but when combined with vertical expertise – from sensors to automation to IT systems – it enables the collection, analysis, management and deployment of data-driven models and insights that create value specifically for pulp and paper. Otherwise, the lack of domain expertise leads to impractical solutions built on data that isn't understood, managed or leveraged properly.

...and the right platform

Turning to the process data management platform itself, it is important that this should be secure, high-performance, scalable and able to integrate third-party applications that can bring additional functionality to your digital environment. With established players and start-ups all competing for a piece of the pie, it is important to avoid being locked into a limited digital ecosystem that will prevent you from leveraging the full range of solutions.

Ideally, it should be possible to set up your selected process data management platform hierarchically, i.e. at a control system, site and enterprise level. This means the same data structure and data models are shared across data levels, ensuring transfer between levels is straightforward, secure and controllable to the finest degree. This saves significantly on time and implementation costs as the platform expands: for example, if you have to move applications between levels, you don't need to re-write the interface as it is already harmonized. The right platform should also support a range of open interfaces and application programming interfaces (APIs) for streaming and pulling data, including REST API, .Net SDK, ODATA, ODBC, OPC UA, OPC DA, making the data available to use as new use cases emerge on your digital journey.

Data streaming – both between levels, and to and from the Cloud – should be available in real time and in both directions in order to maximize the advantages of digitalization: if an application calculates the optimal set values for a process, it must be able to communicate those values to the process or there is no benefit! When using the Cloud, it is also important to consider the cost efficiency not only of the data storage but also the cost of data transfer, which can be expensive as data is constantly being transferred back and forth.

Of course, in any process data management platform, strong data modelling features should be present, allowing data to be used and harmonized throughout your organization. For example, an ABB customer wishing to transfer a sensor application between two mills found that they had measured values for the sensors they were following in one mill but lacked set values for the other mill, resulting in no targets for their process data algorithms to optimize. This is where robust data modelling comes in, enabling you to implement process data powered applications on multiple sites to maximize benefits.

Only by considering all the above can a business create a cost-efficient architecture upon which to build their digital future and applications.

Conclusion

How well a company manages its digitalization journey will determine its future. It is therefore vital to ensure that the fuel for that journey – the vast amounts of data that are now available through the IIoT – is as strategically managed as possible. A process data management system from a partner with deep sector knowledge, such as ABB, is key to this. This partner will help navigate the challenging digital road with the goal of interpreting the wealth of data with a pulp and paper leans to maximize the business value delivered, and providing the trust businesses need to act on the analysis and insights that is unlocks. •

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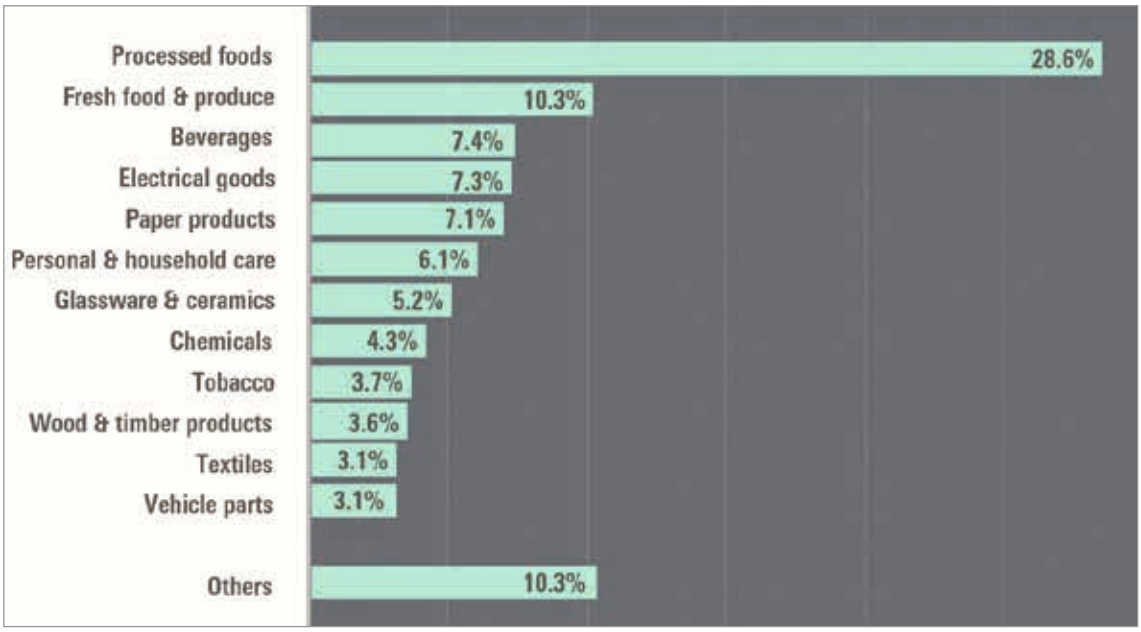

Consumption of corrugated board, 2019, by end-use application.

Smithers

Four defining trends for corrugated packaging in the 2020s

The latest research from Smithers shows that almost $101 billion worth of containerboard was manufactured in 2019. This equated to nearly 171 million tonnes of materials.

The in-depth analysis in The Future of Global Corrugated to 2025 (www.smithers.com/en-gb/services/market-reports/packaging/corrugated-packaging-to-2025) – shows this material was converted into over 155 million tonnes of corrugated packaging with a value of $165 billion of converter sales.

Expanding market

The market has seen growth of about 3% on 2018 volumes, although total market value showed only a 2,2% increase due to softening raw material prices, with average prices moving downwards from $595/tonne in 2018 to $589/tonne in 2019.

From a regional perspective Asia-Pacific is already the largest world region market, with a 51% share by volume in 2019. This is up form up 47% in 2015. In 2019, North America was the second largest world region with a 20% share of corrugated, followed by Western Europe with a 14% share.

Containerboard

The top five containerboard producers in 2019 were International Paper, Nine Dragons, WestRock, Smurfit Kappa, and Lee & Man. Combined these accounted for just under a quarter of total world production in 2019, with one third concentrated across the ten largest suppliers. The landscape changed significantly in January 2019 with DS Smith's purchase of Europac, which saw around 1 million tonnes of capacity change hands.

Net capacity changes between 2018 and 2019 amounted to almost 3 million tonnes of additional containerboard capacity coming onto the market. China accounts for nearly 40% of the anticipated total changes over 2018–2020, with the US making up almost a fifth and Germany a further 16%.

Most additional containerboard capacity increases across this period was due to changes in the paper grades produced

Image: Smithers

on existing machine assets. Over the next five years new paper machines for containerboard are forecast to account for the majority of additional capacity however, although grade switches will continue to be important.

Industry drivers

More than half of the total consumption of corrugated board packaging materials emanates from non-food applications, covering markets as diverse as personal care products and automotive parts.

Food and beverages made up about 46% of the volume demand in 2019, with processed foods accounting for the single biggest share of total consumption at almost 30%. As in almost every sector the scale and the depth of economic disruption caused by the COVID-19 outbreak will impact corrugated converters. As an industry however packaging is fairly resilient to downturns, especially in developed markets. Some areas in particular e-commerce packaging are even benefitting in the short-term, as shops across the US and Europe are closed and online purchases rise accordingly.

As, and when, the world economy returns to something approaching normalcy, there are several trends that will shape the choice and use of corrugated packaging into the 2020s.

Microflute

Flute sizes have been driven down for many years, with the development of ever finer flutes providing greater opportunities for micro-flute corrugated to compete with folding carton packaging. Micro-flute board can now be found in a wide range of end-use applications from confectionery to cosmetics, and jewellery to household chemicals.

Typically, microflute corrugated consists of an outer liner of cartonboard with a high-end print finish. Developments in digital printing are now allowing for standard white-top linerboard to fulfil this role in some applications. In premium applications that require high-gloss finishes, coated varnished cartonboard is still necessary to provide the desired effect, however.

Online delivery

Even before the shuttering of conventional retail outlets in Q1 2020, e-commerce packaging was expected to grow over three times faster than the market average.

Responding to this, there is a push to develop more high-quality printable white linerboard that is suitable for omni-channel format packaging – that can be use both in conventional retail and for e-commerce delivery.

There is also scope to develop bespoke corrugated formats for e-commerce trade, combining convenience and extra protection. Several corrugated forms now have dedicated service lines and design teams to deliver premium solutions for online businesses.

Corrugated firms are also exploiting the desire for more fit-to-product packaging in e-commerce trade, including developing their own systems; examples include DS Smith's Made2Fit concept and Box on Demand (BoD) from WestRock.

Barrier coatings

Barrier coatings on corrugated board can enhance and extend many functional and protective properties, and many companies are innovating in this space enabling board makers to use existing equipment to create product differentiation. Many of these are being positioned by marketing departments as greener alternatives for plastic packaging.

A key consideration is not compromising the existing strong environmental credentials of paperboard by adding a polymer coating that compromises pulp recovery at end-of-life. This is pushing R&D to way from conventional solutions towards more naturally derived coatings that are fully recyclable and/or biodegradable.

The environmental agenda

Sustainability in packaging is a leading concern for many major brand owners and supports the wider use of corrugated formats, which are easy to recycle both in consumer and industrial channels. This has been exacerbated – in North America in particular – by China's restrictions on imports of low-quality paper waste.

In response, major paper mills are increasing their capacity for recycled liner and fluting. Pratt Industries, for example, opened a new 425,000 tonne 100% recycled containerboard mill at Wapakoneta, Ohio in 2019, and has plans for two further mills in the next six years. Norpac meanwhile has repurposed its former newsprint PM1 at Longview, Washington, to run 100% recycled fibre. • **John Nelson**

"The Future of Global Corrugated Packaging to 2025" is available to purchase from the Smithers website.

IPR propagates a new awareness in dealing with paper.

Digitalisation

Digitalisation Raises Awareness of Sustainable Paper

Megatrends like digitalisation and sustainability shape ecomony and society. This leads to a new awareness in regards to the use of paper.

An article by IPR – Initiative Pro Recyclingpapier

Digitalisation is rapidly changing the world. The past months have made this especially clear: office jobs done at the kitchen table and schooling via live streaming are the new normal for many people. However, even during such strange times, resource and climate protection are at the center of discussions around a future-oriented sustainable development. Digitalisation and sustainability – two megatrends that shape the present. This also has its effects on how paper is used: the merits as well as the question of an ecological footprint are at the center.

Photo: DragonImages/stock.adobe.com / Video and Papierpodcast: Initiative Pro Recyclingpapier (IPR)

The promise of a paperless office, which was already made in the 1970s, remains a vision instead of reality. While there is less use of printing paper (e. g. office and magazine paper) for some years now, the volumes used are still at a high level. Paper remains an established medium of communication in many people's lives.

There are many reasons why paper will also play an essential role in communication in the future. Studies show: Those who read on paper can concentrate better and are able to understand longer text passages more easily compared to reading on-screen. Information is gathered more easily if the reading experience is also tactile. This difference in quality is even growing corresponding to increasing digitalisation. More than 130 scientists from all over Europe therefore speak out in support of intensive reading on paper in the Stavanger Declaration. According to them, digital media should not replace paper but rather enhance it.

Paper also scores in regards to security. Cyber attacks in the recent past which halt whole universities and metropolises remind of the risks that come along with increasing digitalisation. Paper is less prone to manipulation compared to digital media. This gains more and more importance for the democratic process. Not only fake news and filter bubbles are a danger to factual arguments, also voting on paper is safer compared to the digital version.

Paradoxically, this means that increasing digitalisation leads to a new awareness in regards to the use of paper. Therefore, it is even more important to look for a sustainable way to handle paper. The life cycle assessment of printing paper speaks for itself: recycled paper awarded with the Blue Angel saves a minimum of 60% water and energy during production and causes distinctively less CO_2 emissions than fresh fibre paper. New studies by the Technical University of Darmstadt show that paper can be recycled much more often than thought of so far. Recycled paper is therefore exhibit A for a successful circular economy that contributes to forest preservation and bio diversity at the same time.

Prof. Dirk Messner, President of the German Environment Agency, therefore demands joint efforts by companies and public institutions to use more recycled paper awarded with the Blue Angel. This is of even more importance, since a paperless office also does not come with zero ecological consequences: digitalisation is already responsible for four percent of the greenhouse gas emissions worldwide … and counting.•

What does sustainability mean in paper?

The initiative Pro Recyclingpapier (IPR) answers that in 100 seconds in their new short video: https://vimeo.com/417504739.

Curious to find out more?

In the "PaperPodcast", Prof. Anne Mangen explains the background to the Stavanger Declaration she initiated. And the President of the Federal Environment Agency, Prof. Dirk Messner, calls for a paper turnaround. The "Paper Podcast" provides facts, background information and positions on paper in the 21st century and is available on all common platforms.

Klaus Peter Fischer

Congratulations

Happy 80th Birthday, Klaus Peter Fischer!

The chemist Klaus Peter Fischer is part of a generation which worked from the ground up towards their desired professional position in the Pulp and Paper industry of East Germany.

After studying at the Engineering School in Koethen in Saxony/Anhalt, he received a degree as Engineer for Chemical Technology and worked at the VEB Zellstoffwerke and Zellwollewerke Wittenberge/Brandenburg for 27 years until 1990. During this time, he used the opportunity to get a degree as a Certified Chemist at the Institute of Technology in Merseburg. He started as Production Engineer and finalized his career with the position of Research Director. After the German reunification, his company was closed by the German "Treuhandanstalt". Until his retirement in 2002, he worked in five different companies, at the end as a leader in a new Technology Centre at Wittenberge. Fischer is married since 1960 and has two children, four grandchildren and three great-grandchildren. He is a passionate gardener.

Mr. Fischer, Happy 80th Birthday! When reflecting on your life what would be your résumé?
Thanks. I can today look back on a satisfiable professional life, as I have worked for 40 years in the same factory called "VEB Zellstoff- und Zellwollewerk Wittenberge". I call it, same as many other employees after such a long time, "my company". My career was successful. Unfortunately, I could not realize my favorite project which would have been the construction of a new pulp factory in Wittenberge, however the designed factory was later erected nearby in Stendal. It was a commercial decision to go to Stendal instead, as the land prices were lower there.

You are German, born in Osterburg in Brandenburg, and you grew up there. After finishing elementary and secondary school, you were an apprentice at Messr. AGFA Wolfen with a further education as a chemist, specialised in the research of synthetic fibres. What was the reason for this?
I was born there, approx. 25 km south of Wittenberge. The idea to become a chemist was already born at the time of my elementary school days and I have consequently worked on realizing my dream, starting with the apprenticeship until the day when I became a certified chemist.

After you finished your education and you served in the National People's Army, you studied at the Engineering School at Koethen in Saxony/Anhalt to get a degree as Engineer for Chemical Technology from 1960 until 1963. After this time, you worked at the VEB Zellstoffwerke and Zellwollewerke Wittenberge/Brandenburg until 1990. During this period, you also received a degree as a Certified Chemist from the Institute of Technology in Merseburg. You started in the mill as Production Engineer in the department of Rayon Staple. Five years later, you worked there as Shift Supervisor Production and another year later you were Research Manager for Pulp of the Paper industry. This was the basis for the job as Project Manager, in which you realized the investment for a tall oil distillation of resin soap from sulfate pulp. Lastly, you were Research Director. An impressive career! How do reflect on this period today?
I could realize most of my goals. I am particularly proud of my participation in the erection of the tall oil distillation plant in Wittenberge. This project was realized together with Messrs. ENSO Finland and the plant was erected from 1980 to 1983, when commissioning took place. The plant is still in operation, even though the product range has changed from tall oil production to processing of vegetable fatty acids.

After the German reunification, you worked up until your retirement in 2002 in five different companies within a period of 12 years. What was the reason for this?
My company was shut down at the beginning of 1991 on demand of the "Treuhandanstalt Berlin", which was the central privatization agency appointed by the German government. Our idea to construct a new pulp production at Wittenberge was further developed and finally received positive feedback at a company from Peine, which set up subsidiaries in Wittenberge that time. In 1992, I started my employment at that company, but this unfortunately ended unsuccessfully already in 1993. Following that, I was offered to work as a chemist in a local company focused on environmental protection and disposal of industrial waste. I stayed there until 1997. The last step in my professional life was the leadership in a new Technology Centre at Wittenberge. Thus, the reason why I worked later in a number of different small companies was just to stay employed at Wittenberge, where I found my home approx. 60 years ago.

Industry 4.0 offers new ways for the paper industry, some of which are already used quite successfully in an improved production process. However, there still is a huge potential in the chain from the supplier to end-user. How do you see those benefits?
Digitalization offers a wide range of ad-

Photo: private

> "In the paper industry, we see now the crucial importance of the conversion from synthetic packaging materials to products made from renewable raw materials."

vantages for the whole industry. In the paper industry, we see now the crucial importance of the conversion from synthetic packaging materials to products made from renewable raw materials. This may go along with growth in production.

In your opinion, what are the main topics in the paper industry of today and what are the opportunities?
As a chemist I would regard the cooperation between the paper industry and the chemical industry to develop chemical additives being of utmost importance.

What are your recommendations to our young engineers?
Following the apprenticeship, I needed approx. 10 years to realize my professional dreams to become a Certified Chemist. This was a long and hard time, as I had to do my studies mainly while I was also employed. Thus, I would recommend to young chemists to concentrate on their desired field as early as possible.

Mr. Fischer, many thanks for this interview! • WHAS

The Sofidel Headquarters, Porcari, Italy.

Photo: Sofidel

Italy

Sofidel Employees Donate Ultrasound Scanners and an Electrocardiograph to Hospitals

In the context of the health emergency linked to the Covid-19 coronavirus pandemic, the tissue paper manufacturer Group, particularly well-known for its Regina brand, continues its activities to support the local communities where it operates in Italy, Europe and the United States.

In the context of the health emergency linked to the Covid-19 coronavirus pandemic, the Sofidel Group continues its activities to support the local communities where it operates in Italy, Europe and the United States.

In Italy, the Group has donated two ultrasound scanner machines (for an overall value of approximately 70,000 euros) to the San Luca Hospital in Lucca, to be installed in the Pediatrics Department and in the Surgery Unit. The donation is the result of a voluntary collection – the economic equivalent in hours of work, leave or holidays – activated by Sofidel people in the Lucca province, then doubled by the Company.

A similar initiative was carried out by Sofidel people in Monfalcone, Italy, in favour of the Hospital of Gorizia for a donation of an ultrasound scanner machine and an electrocardiograph (for an overall collection of approximately 17,000 euros).

Sofidel also keeps on supporting the local communities where it operates abroad, with donations to public bodies and non-governmental organizations (NGOs) committed to providing support to people in need. A total of 300 tonnes of products have been donated – 200 in Europe and 100 in the United States – equivalent to 3 million and 730 thousand rolls of toilet paper, able to meet the monthly needs of 375,000 people. In detail, Sofidel donated 23 tonnes of tissue products for each country in France, Benelux, United Kingdom, Spain, Germany and Poland and 15 tonnes for each country in Sweden, Hungary, Romania and Greece.

These initiatives add to others already in place. Among these, the donation to Caritas Italiana of toilet paper, kitchen towels, napkins, handkerchiefs/tissues and placemats, the equivalent in volume of about 1 million and 680 thousand rolls of toilet paper – a quantity of paper that can meet the monthly needs of about 160,000 people, and the support offered through the #RotoloniReginaChallenge (10,000 euros donated to four Italian hospitals) and #ElRetodeRegina initiatives (20,000 euros donated to two Spanish hospitals). •

Dr. Josef Hafellner

Congratulations

Happy 70th Birthday, Dr. Josef Hafellner!

Dr. Josef Hafellner has shown his strength of coordination and organization in big, worldwide operating companies during his professional life.

Another focus in his work was – and still is – working with young people. Retired since 2015, he is using his experience to work as a freelance trainer nowadays, mainly for the Austrian paper school at Steyrermühl.

Dr. Hafellner, happy 70th birthday! When reflecting your life, what would be your resumé?
I am full of humility and gratitude.

You were born in Niklasdorf in Styria, Austria. Did you also grow up there?
Yes, I grew up in Niklasdorf nearby Leoben.

What was the reason you started your career in the paper industry?
I was recommended to do it by a vocational guidance counselor. Therefore, I decided to study Paper and Fibre Technology at the Graz University of Technology. Then, I worked with Prof. Stark as an assistant in the Research and Development department of our institute and finally did my PhD at TU Graz.

Did you work as an apprentice in the sector before you started to study at TU Graz?
I was an apprentice at the pulp mill Brigl & Bergmeister in 1966. This was also due to a recommendation by occupational guidance counselling.

You finished your studies in Paper Engineering at the TU with your doctorate, presumably under the direction of Prof. Stark. What was the topic of your doctorate?
My thesis was "Optimizing the refining process of chemical pulp using online dewatering equipment". I finished my dissertation with honors.

Before you started your first job in the paper industry, you were an assistant in the Research and Development department of the institute at your university. Was this helpful for your career?
Yes, I learned a lot about the organization of trials, working with young people (students) and independent research. I was also able to get insight into how to make connections in the paper industry and how to get an overall experience.

In 1984, you started to work at the mill at Steyrermühl, which still belonged to the family company Haindl at that time. When did you leave Steyrermühl and what was the reason for this?
I left Steyrermühl in May 1993 because I was looking for new career opportunities.

In which year did you join the family company Holtzmann, which would later on become part of the Stora Enso Group? As Coordinator Technics and Technology, you were responsible for the whole company. When did you leave the company and what was the reason for this?
In June 1993, I joined E. Holtzmann & Cie AG located in Weisenbach/Murgtal in Germany. There, I was responsible for mill coordination and therefore technical, technological and strategic tasks for the whole Holtzmann group. I was involved in a cooperation with Norske Skog, assisted in the project Golbey 2 and handled the ISO 9003 project. However, I left Holtzmann in June 1995 to join SCA Laakirchen.

After this, you left Germany. You found a new challenge in your home country by joining SCA Laakirchen.
I started at SCA Laakirchen and worked as Production Manager of Paper machine 3 and Paper machine 11, (technology and start-up responsibilities of Paper Machine 11), and also in management coordination/ comparison of Laakirchen and the Swedish mill in Ortviken. 2010 I took over responsibility of Paper Machine 11 at the British mill of SCA in Aylesford as Operation Director.

With the take-over of the Laakirchen mill by Heinzel, I started as Coordinator for the start-up of Paper Machine 2 in Pöls. After this job I worked on a feasibility study for switching Laakirchen from the former Paper Machine 10 with SCA grade to packaging grade. My retirement was in July 2015.

You are retired, however, you still share your expertise and experience today. What is it you are doing?
I am a freelance trainer mainly for the Austrian papermaking school at Steyrermühl.

For some time now, Industry 4.0 has shaped the paper industry. New ways are already used quite successfully in an improved production process. However, there is still a huge potential from the supplier to the end-user. How do you see this for the future?
I think that Papermaking 4.0 is a very important step for the development of the papermaking industry. There is no difference in the technology of papermaking since Tsai-Lune, only the speed, the width and efficiency is growing. So, it is necessary to implement sensors and computer technology in the process to be able to follow the process and that's Papermaking 4.0.

Some experts believe there is still a long way to go until a successful implementation. One bottleneck is human behavior.

Photo: private

> "Human behavior was always one of the most important parts of the process in our industry."

How do you see this?
Human behavior was always one of the most important parts of the process in our industry.

What do you consider the main topics in the paper industry of today?
Technology improvement, research, demands of our customers, process optimization and people's motivation.

Our industry has problems to win young people over to study paper engineering at universities. One reason is the limited PR work. What would you recommend to improve the situation?
Showing people how diverse the papermaking industry is. This includes Papermaking 4.0, the mechanical and technological aspects of the sector and what exactly are people's responsibilities in papermaking. Also, apart from technological knowledge, human interaction is a large part of paper engineering: there are international connections that can take you to different parts of the world and shape your career decisively, and networking can also play a big part in the personal development of individuals.

We haven't spoken yet about the private aspects of your life. Are you married? Did your family follow your movements during your changing jobs and did you have time for your hobbies? Or is the paper industry besides your career also your hobby?
I am married for 30 years, have a wonderful wife and one son. My family luckily followed me in my business decisions, which brought me to different countries and cities. In my part-time, I like hiking in the mountains, reading books, coaching people, traveling to foreign countries and getting to know different cultures. Also, the papermaking museum Steyrermühl is one of my main hobbies.

Dr. Hafellner, many thanks for this interview! • WHAS

Cortec

Recyclable Moisture Barrier Coating for Food Packaging

Retail and consumer food packaging often relies on polyethylene or "wax" coated paper and cardboard to resist moisture and seal out contaminants.

Photo: Cortec

An alternative to polyethylene and wax paper coatings: Cortec EcoShield®.

The problem is that these packaging materials are much more difficult to re-pulp than regular uncoated paper and corrugated board and typically cannot be recycled through normal channels. To replace these environmentally problematic materials, Cortec® Corporation has pioneered EcoShield® Barrier Coating, an environmentally friendly alternative to polyethylene and wax paper coatings for the manufacture of moisture resistant paper and corrugated boxes.

EcoShield® Barrier Coating is a water-borne barrier coating that is recyclable and 100% repulpable, effectively eliminating the need to use traditional wax and polyethylene coatings. The coating can be used on kraft and recycled paper, as well as on liners for corrugated boxes, providing a waterproof moisture barrier with excellent oil and grease resistance. When tested according to ASTM E-96, paper coated with EcoShield® Barrier Coating showed very good water vapor barrier properties compared to a polyethylene coated paper and better than commercial waxed paper.

Papers coated with EcoShield® Barrier Coating also have better physical properties such as burst, tear, and tensile strength; elongation, folding endurance, coefficient of friction, and smoothness.

EcoShield® Barrier Coating is formulated in compliance with FDA Code of Federal Regulations Title 21:
– §176.170 – Components of paper and paperboard in contact with aqueous and fatty foods
– §176.180 – Components of paper and paperboard in contact with dry food

It can be applied by most common paper roll coaters, including gravure, flex, air-knife, reverse-roll, etc. Drying temperature is 180–200 °F (82–93° C), and suggested paper weights are 8–11 lb/ream (3,000 ft²) (13–18 g/m²).

EcoShield® Barrier Coating is a coating for the food industry and other sectors that need a recyclable moisture barrier to replace polyethylene coatings. States Cortec: "Thanks to our groundbreaking innovation of a repulpable coating that seals contaminants and moisture out of paper/corrugated materials, package manufacturers are now set to transform the industry and make moisture barrier packaging easier on recyclers and the environment!" •

ipw The magazine for the international pulp and paper industry

ISSN 1615-1720
ipw formerly dpw: www.ipwonline.de | www.paperazzo.de

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Rates as of 1.1.2020: Rate Card applicable from January 1st 2020

Annual Subscription: Germany: € 150.–, Abroad: € 170.–, Single Copy: € 16.–
All Prices include postage and VAT. Student discount: 50%
The minimum duration of the subscription is one year. This period is automatically extended by a further year, unless the contract is terminated in writing with three months' prior notice to the end of a subscription year.

No. of Issues: 4 printed issues including bio-fibre magazine + bi-weekly newsletter + online access to all articles from our magazines.

Bank Account: Commerzbank AG, Bank Code / BLZ: 500 400 00
Account No. / Konto: 712 701 200

Registered seat: 60325 Frankfurt am Main, HR A. 45636
General Partner: KEPPLER & Cie GmbH
Reg. Seat: Frankfurt am Main HRA 87 456

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Upcoming Issue

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- → Market Analysis by Smithers
- → Design & Haptics: Art with Paper

Advertising/Editorial Deadline Nov 09

Material Deadline Nov 19

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Waste Disposal for the Paper, Printing and Corrugated Board Industry