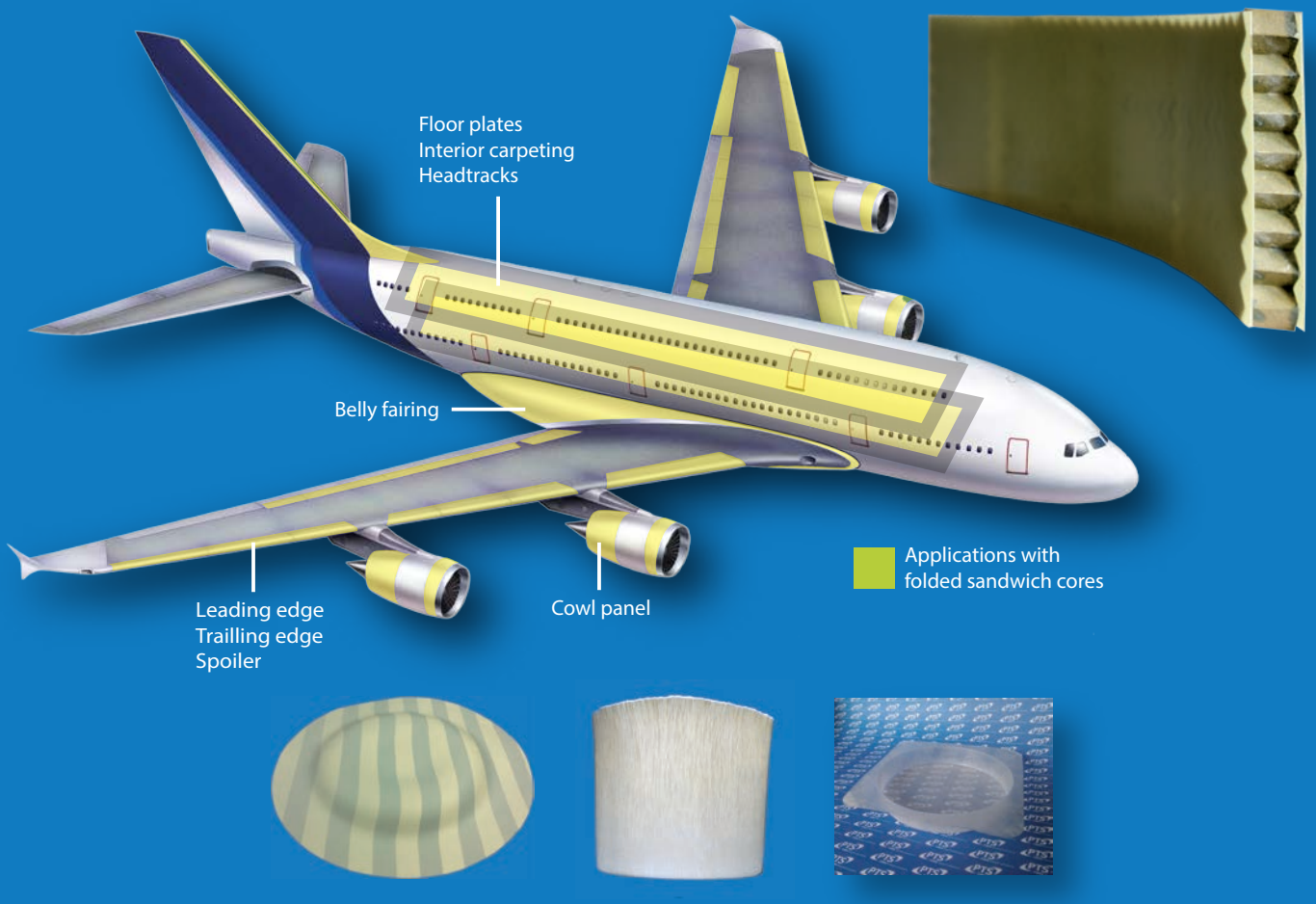
PTS NEWS
02/17
FIBRE based solutions for tomorrow‘s products

FOLDCORE SANDWICHES AND 3D FORMING FOR INNOVATIVE PAPER-BASED MATERIALS



- *3D forming of papers: Innovative new applications for paper products*
- *Adapted papery materials for lightweight structures with folded sandwich cores*
- *3D UHF antennas on paper and paperboard substrates for logistics applications*
- *Optical strain field analysis – an innovative test method to analyse the mechanical properties of fibre-based materials*
- *Substrate qualification for package labelling: PTS offers a Certificate of Encoding Suitability for folding boxboard*

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3D FORMING OF PAPERS

INNOVATIVE NEW APPLICATIONS FOR PAPER PRODUCTS

When designing B2C products, the package is becoming ever more important today. Because it acts as a highly efficient communication channel by itself, the image conveyed by the package is frequently the sole basis for the customer's buying decision. A sustainable packaging solution, for example, conveys the message that the product inside has been sustainably produced.

Paper and board materials are ideally suitable for these applications because they are recyclable and environment-friendly. For the growing trend towards individualised packages, however, they are suitable only within very narrow limits. The latter must be exceeded to realise unique geometries enabling the direct identification with a brand, for example, something that cannot be achieved with the methods available to date for the three-dimensional forming of papers.

Unlike primary forming processes such as pulp moulding, which are characterised by long cycle times and the limited quality of moulded parts, forming processes like thermo- or hydroforming and deep drawing work with two-dimensional semi-finished parts that can be manufactured at high quality. An upper die or working medium presses the material into a cavity to turn its flat shape into a three-dimensional hollow body. This step can be performed in two basic ways:

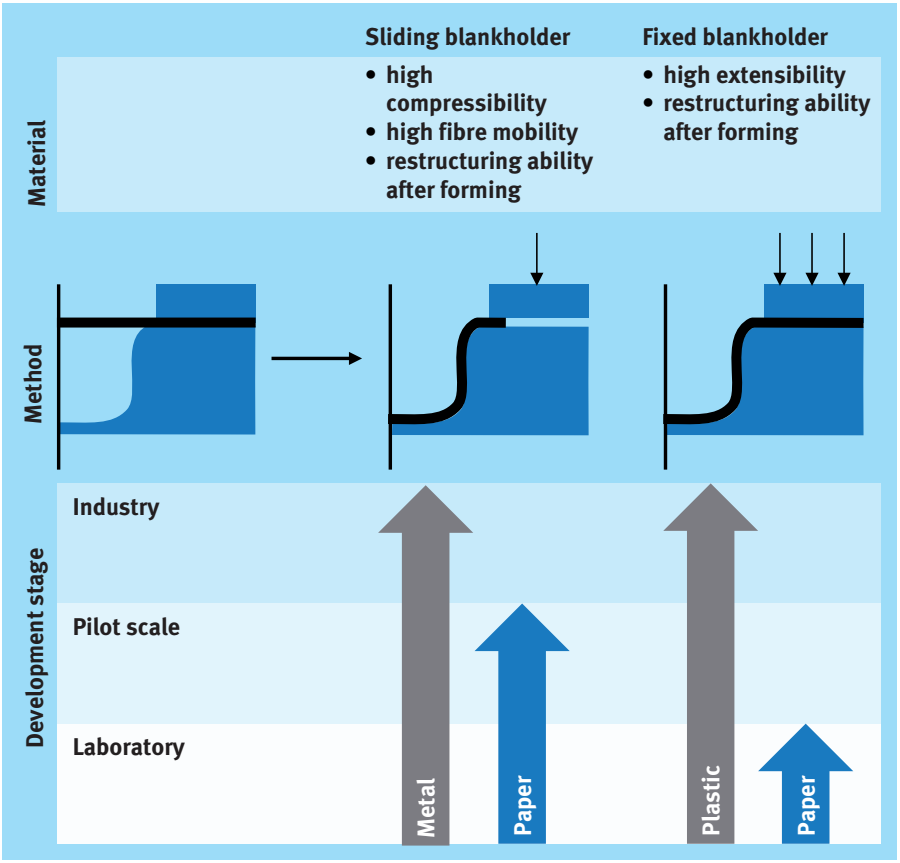


Fig. 1: Process principles of 3D forming with material requirements and development stages (Source: PTS)

In techniques with **fixed blankholder** (e.g. thermoforming), the edges of the flat starting material are firmly clamped in the blankholder. This forming principle is used in industry to produce trays, yoghurt cups or blister packages from plastic films. Papers have rarely been used for these applications so far because they do not meet many of their requirements – especially the extremely high extensibility needed for these products.

Fig. 2: Hydroforming test body with projected fringe pattern (Source: TU Darmstadt – PMV)

In forming processes with **sliding blankholder** (e.g. deep drawing, hydroforming), the two-dimensional semi-finished part is fixed by a pre-defined blankholder force that can be systematically controlled to allow the material to "flow". This principle is widely used in metal forming; its industrial use with paperboard materials has been limited to products with simple geometry and low quality requirements such as disposable plates, cheese boxes or snack trays so far. Products with a more complex geometry and higher quality demands can only be realised with paper or board materials offering high compressibility, fibre mobility and suitable restructuring mechanisms. Such papers are the subject of ongoing

research. Scientists from various institutions are cooperating to systematically develop suitable forming methods and materials.

In an IGF research project called "**Shear deformability**", scientists from PTS and TU Darmstadt (PMV) are investigating the three-dimensional forming of paperboard materials by hydroforming with sliding blankholders. An elastomer membrane incorporated in the forming die makes sure that the overall extensibility of the paper is optimally used. By introducing thermoplastic additives in a multilayer composite, the scientists have obtained materials allowing the production of moulded parts with challenging geometry, high surface quality and good dimensional stability. To quantify the height profiles of the three-dimensional parts, they have developed a topography analysis based on fringe projection. Samples having a diameter of 200 mm, for example, could be produced with forming depths of up to 12 mm.

A different forming method is the subject of "**FormPack**", another ongoing IGF project. Together with scientists from TU Dresden (VAT), PTS experts are working to improve the deep drawing process of paper. By adapting the formulation to the specific material requirements of the method and optimising the conditions of the forming process, they have obtained cylindrical beakers with a base diameter of 80 mm, draw depths of up to 80 mm and a high wall surface quality.

Further work focuses on increasing the extensibility of the material, which is necessary to obtain shapes with convex wall portions. In conventional methods, the paper web is compacted mechanically to achieve strain at break values in the two-digit percentage range in machine direction. To adapt this concept for paper machines without compacting unit, PTS scientists are currently investigating the use of various hydrogelling agents like gelatine, agar or gellan gum to increase the dry shrinkage and, thus, elongation potential of papers. On lab scale, they have already realised strain at break levels in the two-digit percentage range after unrestrained drying. Gelatine, which was found to be the most promising agent, was introduced in the paper by spray application in the pilot paper machine of PTS Heidenau. The resulting forming properties have yet to be investigated.

Fig. 3: Cylindrical body made from paper by deep drawing (Source: TU Dresden – VAT)

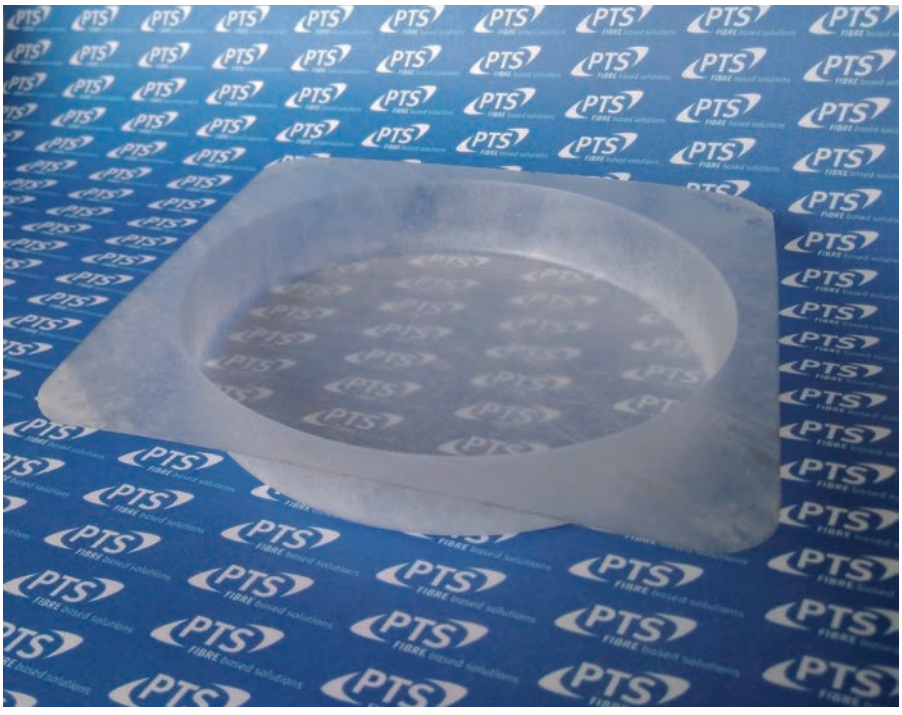


Fig. 4: Sample tray made of dialcohol cellulose paper (Source: PTS)

A completely different approach has been adopted in "**Actipoly**", an EU Cornet project focusing on the development of paper that is also suitable for established industrial methods with fixed blankholder. For this purpose, the paper material must be thermoplastic like plastic films without losing its recyclability.

To achieve this, the extensibility was further increased by a chemical dialcohol cellulose modification of pulp fibres. The resulting material softens when heated to a temperature above glass transition (around 80°C) and is rupture-resistant up to a strain at break of more than 35%.

It retains the shape obtained under heat also after cooling down, which makes it potentially suitable for the production of conventional food trays. The paper can currently only be produced in the laboratory, but the scientists are hoping to transfer the manufacturing concept to pilot scale within the next few years.

Dr. Martin Zahel
martin.zahel@ptspaper.de

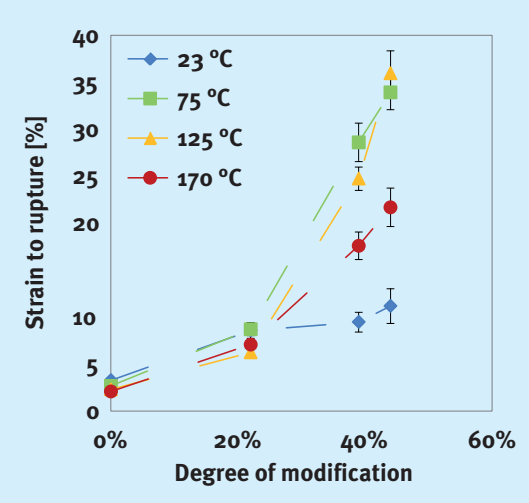
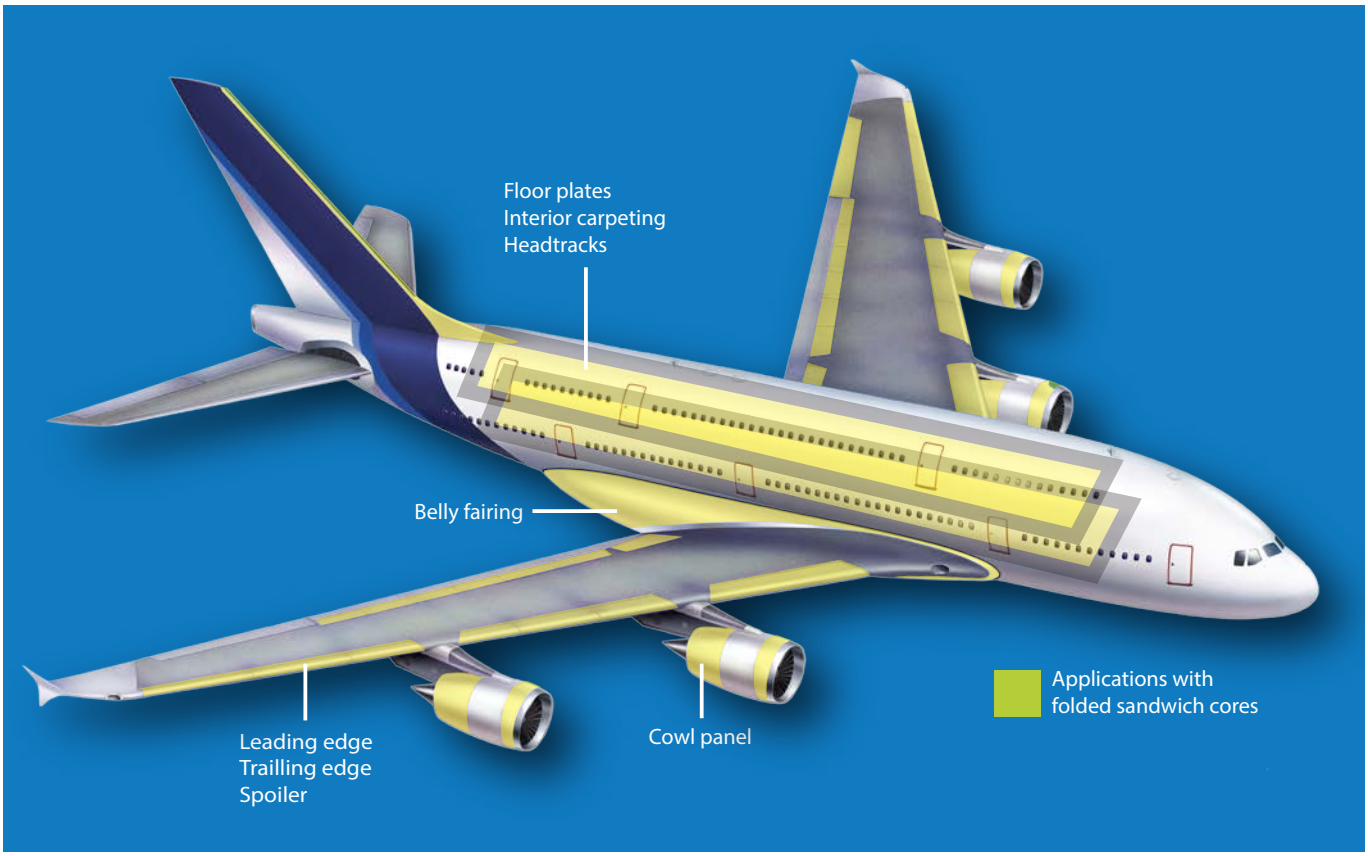


Fig. 5: Strain at break as a function of the degree of modification of dialcohol cellulose papers at different temperatures (Source: PTS)

ADAPTED PAPERY MATERIALS FOR LIGHTWEIGHT STRUCTURES WITH FOLDED SANDWICH CORES



The development of lightweight structures is an important task in the aerospace industry and other fields of transportation. The use of composite materials such as carbon or glass fibre reinforced plastics is a first step towards achieving this. Another step is the use of these composites in sandwich structures combining high bending stiffness with low weight.

Sandwich structures are comprised of two thin, stiff and high-strength skin layers surrounding a thicker, more lightweight and softer core. The core is made of phenolic-resin coated aramid paper to ensure low volume weight in combination with the stiffness and strength values needed to resist axial and compression loads acting vertically to the sandwich plane.

Sandwich structures are used for the floor plates, carpeting and fairing of airplanes or as supporting structures for rail vehicles today. To save even more weight and costs, it is planned to use them also for the belly structure of airplanes. Folded sandwich cores are particularly suitable for these applications because of their excellent weight-specific characteristics. Their main advantage over state-of-the-art honeycomb sandwich cores is their

drainability, which prevents them from retaining water.

Unfortunately, the aramid papers available today are not optimally suitable for these purposes: low-grammage grades lack the bending stiffness required for folded cores, the latter can only be achieved at high grammage levels.

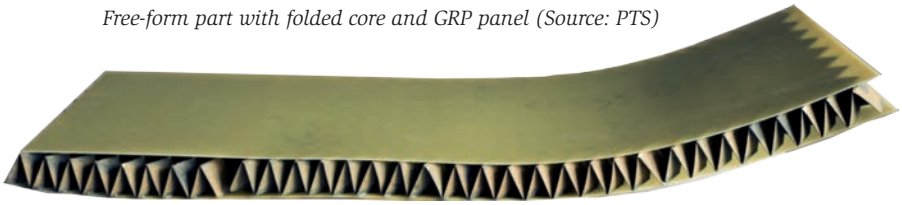
Against this background, scientists of Papiertechnische Stiftung and the Institute of Aerospace Engineering of TU Dresden have developed a new core material that offers much better weight-specific characteristics and is particularly suitable for high-tech components like sandwich plates in aircraft and other mobility applications.

It is comprised of a three-ply adapted papery material (APM) based on aramid/carbon fibres. The inner ply has a lightweight filling to increase its thickness and bending stiffness without affecting the grammage. The desired high strength is achieved by impregnating the material with phenolic resin. Compared to aluminium-based honeycomb structures, the APM is noncorrosive, and it offers much better weight-specific characteristics than steel or thermoplastic materials like polypropylene.

In the scope of their research project, the scientists have also developed new characterisation methods for the mechanical properties of thin, papery materials under in-plane compression and axial loads. For the first time ever, the new methods make it possible to determine all material characteristics relevant to simulation models. The data obtained allow the efficient structural-mechanical dimensioning of APM products, something that has not been possible before and is a key prerequisite for the use of paper as construction material. The material model developed will significantly enhance the accuracy of numerical simulation models for the behaviour of sandwich structures comprising innovative cores made of papery materials. The simulation models will enable their potential users to design new innovative structures and products much faster and more cost-effectively.

The project was nominated for the 2017 Otto-von-Guericke award of AiF, and has reached the final round together with only two other candidates.

Free-form part with folded core and GRP panel (Source: PTS)

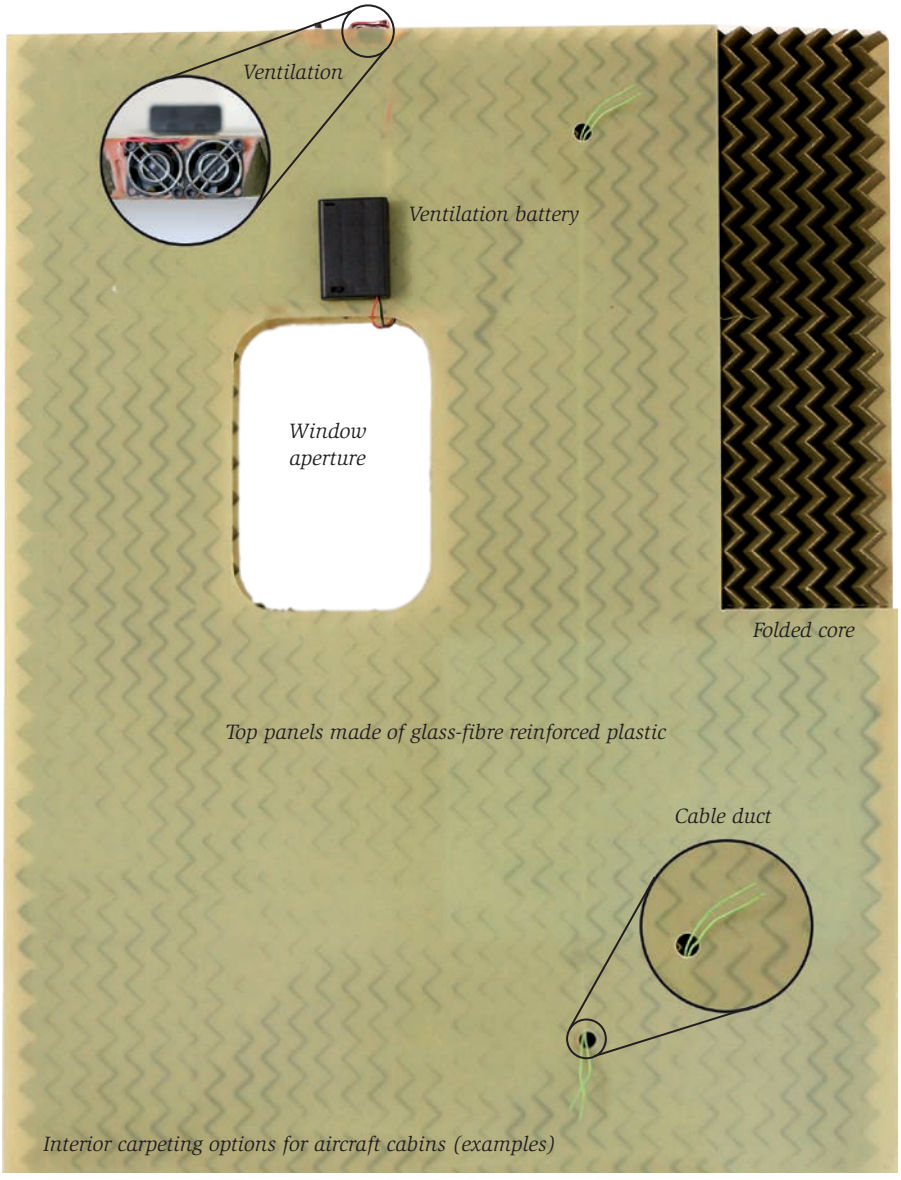


Significantly enhanced weight-specific core characteristics

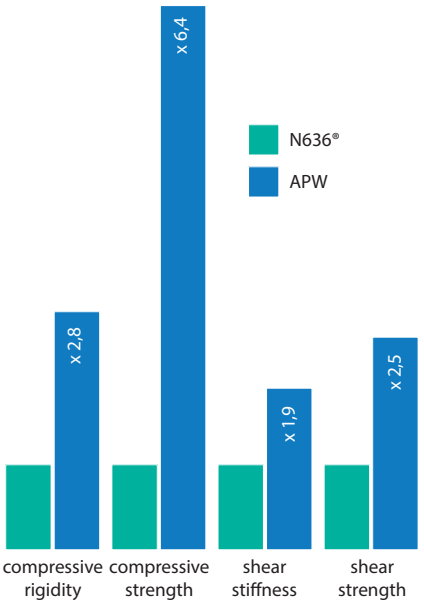
The folded APM cores were tested under pressure and axial loads, using cores made of the commercially available N636® material as reference. The APM cores showed a 2,8 times higher compressive rigidity, 6,4 times higher compressive strength, 1,9 times higher shear stiffness and 2,5 times higher shear strength at a weight that was 2,2 times higher than that of the N636® core.

Optimised folded cores made of APM thus have the potential to significantly improve the weight-specific mechanical properties of sandwich cores (see figure below).

Johann Strauß
johann.strauss@ptspaper.de



Interior carpeting options for aircraft cabins (examples)

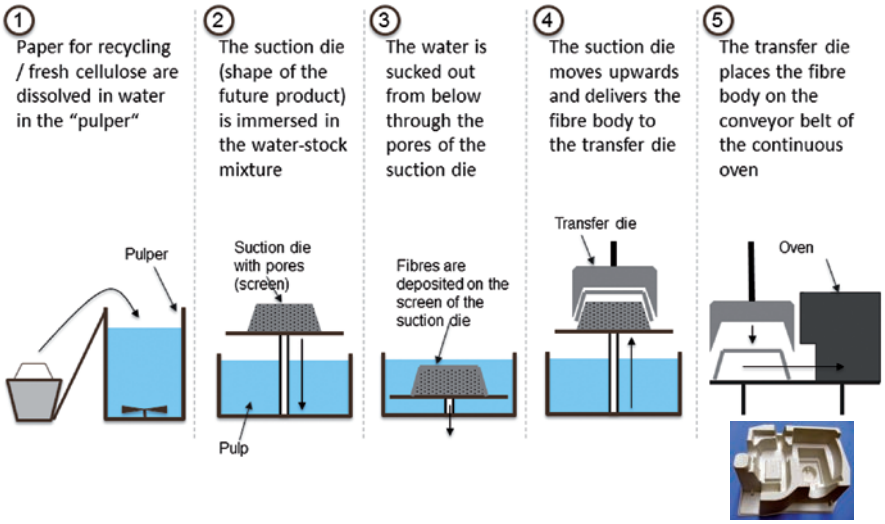


NEW FUNCTIONS FOR MOULDED PULP STRUCTURES

Gefördert durch:
Bundesministerium für Wirtschaft und Technologie
aufgrund eines Beschlusses des Deutschen Bundestages

In the research project IGF 18787 funded by the German Federal Ministry for Economic Affairs and Energy, PTS scientists are developing moulded pulps with new functions. Main aim is to enhance the odour and pollutant adsorption of moulded pulp structures to enable new applications in the automotive (vehicle interior), construction and furniture industries, for presentation media and filtration purposes. The scientists focus on application areas where filling is not possible and compact moulded parts provide advantages. Moreover, they are working to reduce the thermal load of moulded pulps to open up applications in the fields of lightweight construction, thermal insulation (e.g. in automotive engineering), for friction linings or specialty packaging.

A process concept for the high-grade incorporation of functional fillers in moulded pulps is being developed to realise the desired functions whilst ensuring a homogeneous material structure of the fibre-based moulded parts. Because the latter depends mainly on the dewatering of the pulp suspension – a process that is directly influenced by the fillers used - the scientists are working to adjust the stock system and process additives, and to improve the dewatering step during forming. Focal points are the chemical-physical conditions of the initial forming step, which are influenced by the fibre components, filler components and use of specific process additives.



Process principle of the vertical transfer moulding of pulps (Source: FGW Fasergusswerk Polenz GmbH)

Core element of the project work is the laboratory production of moulded pulp structures. For this purpose, a pilot-scale facility has been designed and built for the transfer moulding of pulps (custom product).

Johann Strauß
johann.strauss@ptspaper.de

PTS SCIENTIST RECEIVE THE BOYSEN ADVANCEMENT AWARD

Dr.-Ing. Tiemo Arndt, Business Unit Manager of Fibres and Composites at PTS in Heidenau, was presented the advancement award of the Friedrich and Elisabeth Boysen Foundation on 17th June 2017 at the Faculty of Mechanical Engineering Day at Dresden Technical University. That is one of the most prestigious awards to be given to Dresden Technical University graduates. The award is bestowed annually by Stuttgart University, Dresden Technical University and Karlsruhe Institute of Technology for the best dissertation at each venue.

The advancement award was conferred on a dissertation entitled "Hydrodynamic Cavitation for Pulp Treatment in Stock Preparation" for which the title "Summa cum laude" was conferred on Dr. Ing. Arndt. His ground-breaking results pave the way for a sustainable, energy-efficient technology for treating and deinking pulp in the paper technology industry. Thanks to his work, several stages in the treatment of paper for recycling can be economized whilst at the same time maintaining or even raising in some cases the strength and optical properties of paper products. Initial steps taken in scaling up the process towards its industrial application have revealed its great potential.

Recognised in particular was the fact that Dr Arndt successfully set up and managed a group of research scientists at PTS at the same time he was working on his doctorate. Moreover, he is active in several industrial associations and research clusters, formulating and mapping out their work to the benefit of the paper industry. The remarkable list of his publications bears witness to the high level and the academic productivity of Dr Arndt.

Dr. Tiemo Arndt (right) while receiving the Boysen Advancement Award (Source: TU Dresden

Erwin Polmann
erwin.polmann@ptspaper.de

MANY VISITORS TO THE PTS BOOTH AT THE BMWI/AIF INNOVATION DAY IN BERLIN

On 19 May, the Federal Ministry for Economic Affairs and Energy BMWi and German Federation of Industrial Cooperative Research Associations AIF invited small and medium-sized enterprises to their traditional Innovation Day in Berlin. The annual Technology Open Air, a show presenting new products, processes and services from many different technological areas, offers a public meeting platform for scientists, companies, politicians, journalists and anyone interested - including students and pupils. It is organised on the park-like premises of the company AiF Projekt GmbH, which manages – among other - cooperative projects, the most popular funding option of the ZIM central innovation programme for SMEs offered by BMWi.

PTS was again present with an own booth at the Innovation Day. This year's focus was on two projects: ACTIPOLY is an European research project that aims at developing fibre-based packaging materials suitable for deep drawing and with anti-bacterial and barrier properties to prolong the shelf-life of fresh foods. The research work was done in co-operation with partners from Belgium and Poland. The novel packaging material for trays will open up new markets for producers of packaging materials and also fresh food.

The second project funded by BMWi deals with the development of adapted paper-like materials for folded and honeycomb sandwich cores. The sandwich core material developed in the project has a much broader scope of application and can be used in manifold ways for innovative products in the field of lightweight sandwich structures. The improved weight-specific core properties achieved with the new material could be demonstrated numerically and by experiments. The research results open up new product and market segments for the paper industry and provide companies of the paper and aircraft sectors with new test and simulation methods. Project partner is the Institute of Aerospace Engineering of Dresden Technical University. The second project received particularly great attention because it had been chosen by the AiF jury as one of the three candidates for this year's Otto-von-Guericke award.

Dr. Martin Zahel (left) explains a fibre-based packaging material suitable for deep drawing and with anti-bacterial and barrier properties to prolong the shelf-life of fresh foods (Source: PTS)

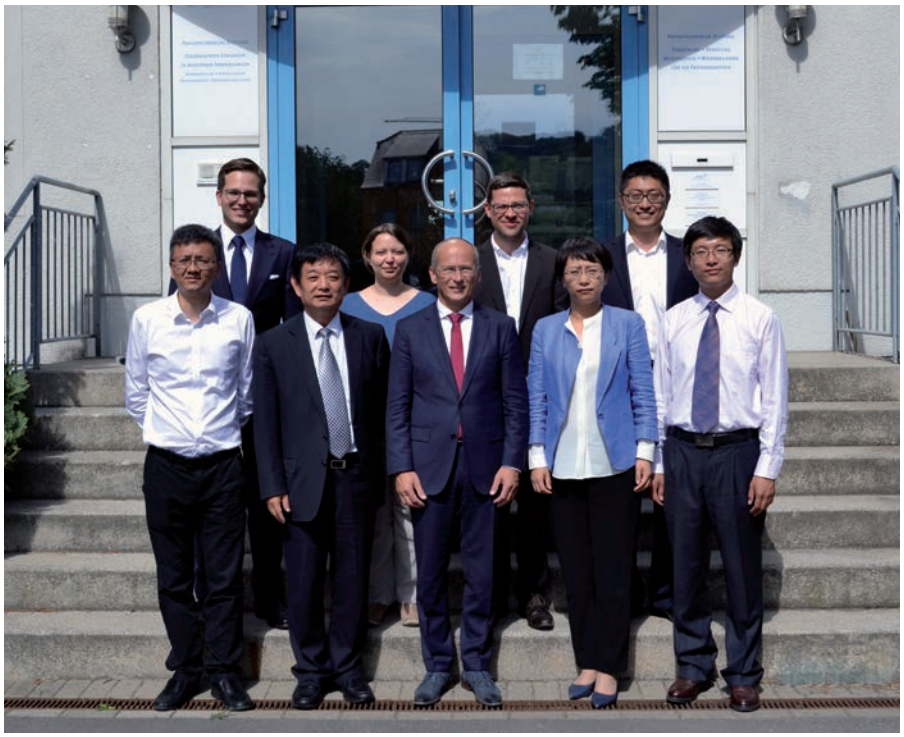
The research results of PTS received broad interest (Source: PTS)

Moreover, the PTS booth was visited by the members of the Bundestag and Laender parliaments on their tour of the exhibition. Tiemo Arndt and Martin Zahel, the two PTS employees manning the booth, seized the opportunity to talk about the innovative chances offered by the paper sector and to present the research services of PTS and its partners.

The project managers are now looking forward to the exhibition in Berlin on 6 December: They are working hard to win the Otto-von-Guericke award for PTS. ■

Erwin Polmann
erwin.polmann@ptspaper.de

HIGH-LEVEL VISITORS FROM CHINA: DELEGATIONS OF CNPPRI AND CTAPI VISIT PTS



Visit of the CNPPRI delegation at PTS in Heidenau (Source: PTS)

In past decades, China has developed more dynamically in economic terms than any other country in the world and might well become the world's largest economy for years to come, even ahead of the United States of America. In its "China Strategy 2015-2020", the German Federal Ministry of Education and Research (BMBF) has set the target of contributing to address global challenges together with Chinese partners and supporting a sustainable, resource-conserving, environmentally friendly development. The paper economy can also act as a multiplier with its resource-saving and innovative technologies.

Scientists among themselves: PTS welcomes CNPPRI managers

After PTS was received by the Chinese National Pulp & Paper Research Institute (CNPPRI) in Shanghai and Peking in 2016 (see PTS News 01/2017), a return visit in Germany was scheduled from 7 to 11 June 2017. The Chinese delegation was led by Mr Zhenlei Cao (PhD), Vice President of Sinolight Corporation and also Secretary General of CTAPI.

On 9 June, the guests visited the PTS institute in Heidenau. The delegation was very interested in gathering information about PTS activities in the areas of fibres & composites, quality monitoring of recovered paper, innovative measurement technology and inkjet codification. The Chinese scientists presented their expertise and demonstrated the manifold potentials of the Chinese paper market and related industries.

In the course of the visit, a strategic co-

Formal signing of the cooperation agreement between PTS (Prof. Dr. Frank Miletzky; left) and CNPPRI (Ms. Sun Bo; right) (Source: PTS)

The China National Pulp & Paper Research Institute (CNPPRI)

CNPPRI was founded in 1956, transformed into a high-technology enterprise in 1999 and is now a wholly-owned subsidiary of China Sinolight Corporation, a group with more than 300 employees and business activities in three sectors. During the past 60 years, CNPPRI has participated in numerous national research projects. 180 of its 1700 successfully completed research projects have received national awards. CNPPRI is authorized to grant master's degrees and has established a Postdoctoral Research Centre. It has developed into a state-of-the-art research institute with R&D department, innovation, consulting and technical services that offers engineering expertise for industrial scale-ups and plays a leading role in the Chinese paper industry.

Its activities focus on research into the highly efficient use of fibrous materials, "green" pulp and paper production, paper-based functional materials as well as new product and technology developments including scale-up and commercialisation.

operation agreement was formally signed between the Chinese National Pulp & Paper Research Institute and PTS. This agreement encompasses active cooperation in the areas of Industry 4.0, specialty paper, packaging materials and measurement technology. In addition, common efforts have been planned with respect to funding and public grand procurement, new business development, further education and the exchange of scientists.

The Chinese delegation then continued on to visit the Munich Institute of PTS on 10 June. In addition to a guided tour of the VESTRA pilot coater, the work in the coating laboratories and the possibilities of inkjet and laser codification of fibre-based materials were explained on the basis of practical examples.

There was also sufficient time to indulge in intercultural issues: the Chinese delegation had the possibility to participate in sightseeing walks through the cities of Dresden and Munich. PTS is looking forward to continuing the cooperation with the colleagues from China.

Concentrated power: Scientists, trade association and industry representatives visit Germany

It is not only the Chinese paper institutes who are seeking cooperation with German and European partners. Also companies from the Far East have become aware of the attractive and broad range of cooperation options available in Germany and Europe. For this reason, a delegation of 26 high-ranking Chinese representatives led by Professor Chunyu Cao, President of CNPPRI, went on an 11-day trip to Germany and Austria in order to establish contacts with companies and institutions in the European paper sector. Their trip had been organised by CTAPI, the China Technical Association of Paper Industry, whose 18,000 members make it the largest public agency of the Chinese paper industry today.

Official reception of the CTAPI delegation at the ZELLCHEMING Expo 2017 in Frankfurt/Main (Source: CTAPI))

What's going on in Europe? Visit to the ZELLCHEMING exhibition in Frankfurt/Main

First stop of their tour was the ZELLCHEMING Expo in Frankfurt/Main on 6 July. After receiving an official welcome from Ms Petra Hanke, Executive Director of ZELLCHEMING, and Ms Simone Pfisterer, Vice President of mesago, the delegates seized the opportunity to talk to national and international exhibitors.

Talks with exhibitors were part of the fixed programme of the Chinese delegates who showed great interest (Source: PTS)

They were particularly impressed by the great variety of exhibits: the exhibition covers the entire value chain from raw materials to paper production and converting, consumption and final disposal.

After the ZELLCHEMING exhibition, the Chinese guests visited the cities of Mainz, Heidelberg, Stuttgart, Bamberg and finally Dresden.

Professor Dr. André Wagenführ presenting TU Dresden (Source: PTS)

Visit to Dresden Technical University and PTS Heidenau

On 10 July, the Chinese delegates visited the Technical University of Dresden, and in particular the Institute of Natural Materials Technology where they were welcomed by Mr Professor Dr.-Ing. André Wagenführ and his colleagues. The institute pools competencies in the retrieval, processing and refining of natural materials along the entire value chain regarding e.g. food, biotechnological or wood- and fibre-based products and their packaging in the context of a circular flow economy.

PTS president Mr Professor Dr. Frank Miletzky holds a honorary professorship at

Professor Dr. Chunyu Cao explaining typical features and trends of the Chinese paper industry (Source: PTS)

Martin Drews from the German Pulp and Paper Association (VDP) presenting main features of the German paper sector (Source: PTS)

Dr. Georg Wiche presenting the activities of VOITH Paper in China (Source: PTS)

this institute.

After presenting the chair of wood and fibre material technology and its fields of work, the TU scientists talked about their current research on cellulose-based three-dimensional moulded parts and dry defibration. Further highlights were a tour of the laboratories and of the institute's continuous honeycomb core production unit.

Since the guests from China had been highly interested in information about the activities of PTS Heidenau, Professor Dr. Frank Miletzky welcomed them there in the afternoon of 10 July to present the highlights of the Saxon PTS location. He focused especially on the institute's activities in the field of paper for recycling because the Chinese industry has considerable demand for analytical solutions for the quality monitoring of paper for recycling. The visit was rounded off by a presentation and tour of the pulp and paper pilot plant and PTS laboratories, focusing on possibilities for the development and production of innovative fibre composites to access new markets. Another focal point of the meeting with CTAPI representatives was possible ways of cooperation.

Visit to PTS Munich

Final stop of the delegates' tour of Germany was the PTS institute in Munich, where the Chinese guests were first invited to have lunch with local Bavarian specialities. After this, Professor Dr. Chunyu Cao provided insights into the Chinese paper industry, which is characterised by currently more than 2,800 active paper producers, an annual production volume of 109 million tons and average annual growth of around 4.5%. With an impressive share of around 26% of the world's paper production, China is one of the major global players.

To give the Chinese guests insight into the German paper sector, Mr Martin Drews from the German Pulp and Paper Association (VDP) presented facts and figures about the country's production, export and import activities. His presentation was followed by lively discussions about recycling and certification issues. The exchange of views was a particularly important aspect of the visit as it deepens the understanding of the two countries' special characteristics to pave the way for joint efforts to meet future challenges.

Next on the agenda was an exciting contribution from the company Voith Paper. The lecture presented by Mr Dr. Gregor Wiche, Senior Vice President of Voith Paper and in charge of the company's activities in China, and his colleague Gerald Steiner, Vice President Digitalisation at Voith, provided some ideas how the Chinese paper industry could meet the global challenges of „Papermaking 4.0". Voith had also sponsored the visit to Munich, including an invitation to the Augustiner beer garden in the evening.

The visit of the two delegations shows that the Chinese paper sector is highly interested in a future cooperation with Germany: China can become a strategic partner of Germany in both economic and scientific terms. PTS therefore invites companies from all parts of the German paper sector to cooperate closely with partners from China in the fields of research, science, education and innovation.

CTAPI delegates in front of the PTS institute in Munich (Source: PTS)

Anatoli Davydov
anatoli.davydov@ptspaper.de

OPTICAL STRAIN FIELD ANALYSIS
AN INNOVATIVE TEST METHOD TO ANALYSE THE MECHANICAL PROPERTIES OF FIBRE-BASED MATERIALS

pported by:
Federal Ministry for Economic Affair and Energy
AiF Member
the basis of a decision

The mechanical properties of paper-based materials and resulting application options are usually assessed by standardised laboratory tests. Tensile tests with paper or compression tests like the Flat Crush Test (FCT) or Edge Crush Test (ECT) with corrugated board use defined testing speeds and sample geometries under standard climate conditions to determine stiffness (modulus of elasticity) and strength parameters, among other. The results provide information about the material's suitability for e.g. packaging applications requiring a specific strength category. For the majority of applications, this information is sufficient and requires no further research. In some cases, however, "global" material characteristics determined as average over the entire sample width are no longer sufficient because they provide no information about the local distribution of material parameters: Are there any regions that are more elongated than other? Where exactly does a crack or defect occur? Were there any signs of it before it actually occurred? And could it be prevented by suitable design measures or material reinforcements?

The local distribution of displacement or strain values in a material is of great importance to many applications and enables better assessments of basic mechanical properties. It can be determined by an optical strain field analysis (OSA): A universal testing machine is coupled with a camera system to acquire images of the deformation process. The displacement of a pre-defined two-dimensional measuring grid is identified by correlating the grey values of successive images in the sequence (cf. Figure 1).

The image sequence acquired by the camera system is superimposed on the force-time curve recorded by the testing machine to accurately relate the force values to local displacement values. Different camera and lens systems provide the resolution, number of images and magnification needed to investigate many different complex issues. Two examples illustrate the method and its use: the deformation of flutes in corrugated board caused by its compression in z-direction, and the creasing process of board materials.

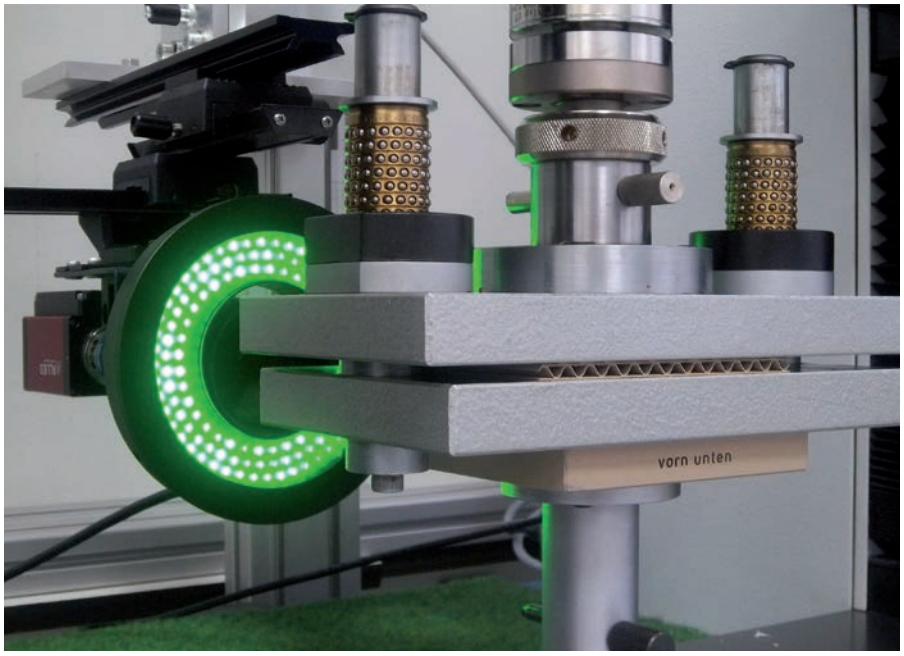


Figure 1: Example of an optically supported measurement set-up for mechanical flat crush tests with camera system, illumination and FCT installation for a universal testing machine (from left) (Source: PTS)

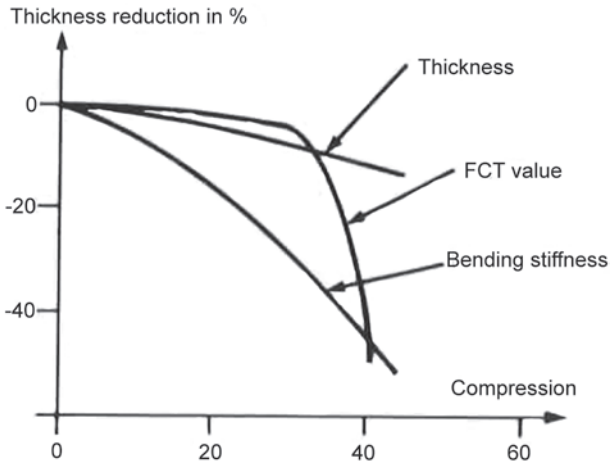


Figure 2: Material characteristics of corrugated board as a function of thickness reduction [Source: Markström, H.: Prüfmethoden und -geräte für Wellpappe, L&W. 1991]

Pre-compression of corrugated board – project: "Test method to determine the damage of corrugated board"

It is a well-known fact that the stiffness and strength values of corrugated board decrease when the material is pre-compressed in z-direction (cf. Figure 2). The loads applied in industrial manufacturing and converting processes (direct printing, die-cutting and gluing) or during transportation, reloading and storage (packing, climate influences etc.) cause the board material to be pre-compressed several times. This means that its stiffness and strength values are very likely to become increasingly smaller from manufacturing to recycling, an aspect that is not considered by most of the tests performed with "ideal", i.e. previously undamaged, specimens.

It is therefore necessary to more specifically determine the deformation behaviour of flutes as well as the changes in strength properties associated with it, and to investigate if and to what extent the deformation of single- or multi-wall corrugated board materials follows a pattern that can be systematically described. An OSA makes it possible to qualitatively

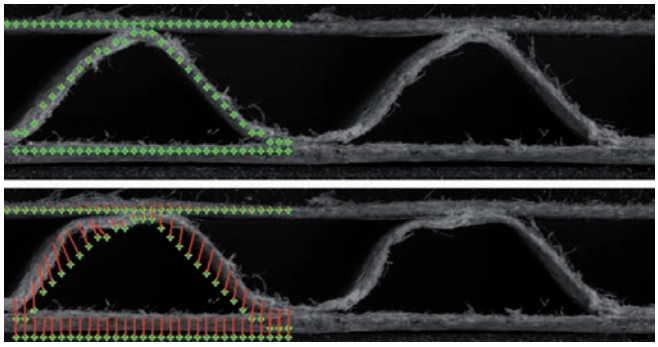


Figure 3: Unbiased sample (top) and deformed, non-ideal fluting with displacement vectors (bottom) (Source: PTS)

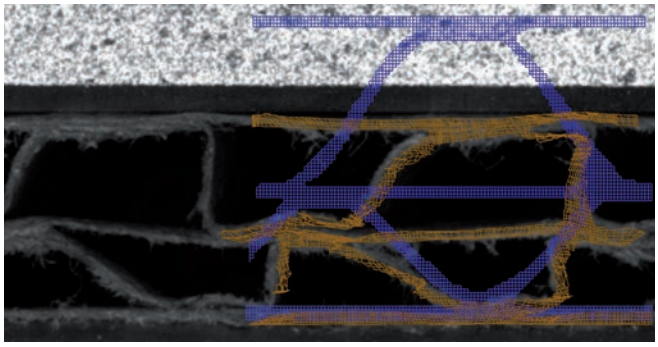


Figure 4: Complex deformation of a BC flute shortly before its (not very pronounced) FCT maximum (Source: PTS)

and quantitatively describe the precise deformation path of flutes (cf. Figure 3). It shows why some FCT curves have characteristic peaks (e.g. single-wall A flutes) and why no such peaks can be found in many of the more complex flute types increasingly used in practice (e.g. BC flute, cf. Figure 4) today.

The description of deformation processes of simple and complex flutes enables the better modelling of pre-compressed corrugated board materials as basis for analytical assessments, risk analyses and to define measuring uncertainties. The results can be used to derive measures to improve the handling of corrugated board in state-of-the-art manufacturing and application processes, and to open up new application options for the material.

Tensile and out-of-plane shear stresses during creasing – project: "Water-based coatings / defect-free creasing"

Creasing of paperboard is conducted to lower the bending stiffness of the material in a pre-defined way by local delamination between the plies without damaging the rest of the material. The material is subjected to complex mechanical loads during creasing: compression in z-direction, tensile loads in liners and out-of-plane shear loads across the cross-section (cf. Figure 5).

Typical creasing knives have a width in the range of 0,7 to 1,5 mm, which means they apply loads mainly locally. Measurement results related to the entire width of the sample (15 mm in the tensile test) are therefore not sufficient here. Moreover, the geometry of typical creasing processes suggests that they must cause local deformations that go far beyond

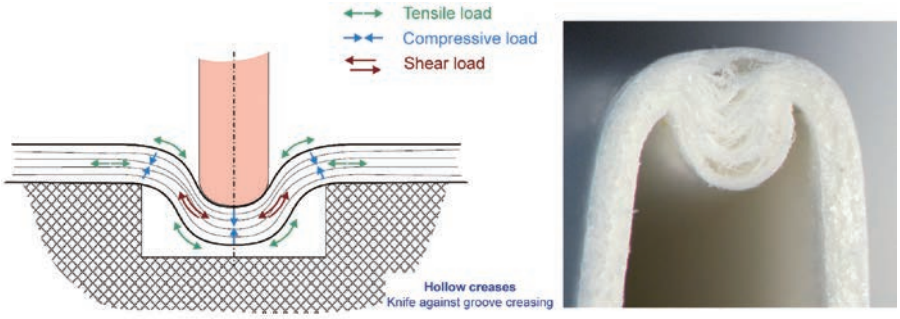


Figure 5: Schematic of a creasing process and relevant loads (left) [Herzau, E.: Untersuchung zum Einfluss der Rillung auf das Faltverhalten von Karton und Wellpappe. 4. Symposium „Wellpappe- und Faltschachtelverpackungen – Herausforderungen in der Praxis. Bei Zwick in Ulm. 2016] and one-sided bead formed by creasing and folding (right) (Source: PTS)

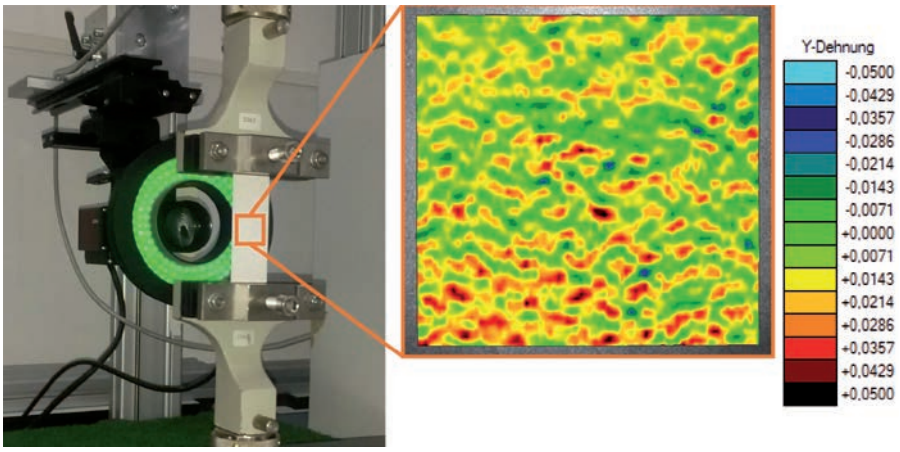


Figure 6: Measurement set-up, optical strain field analysis and key (from left to right) of a tensile test with board material (width of 30 mm, y-elongation in the range of -5 % to +5 %) (Source: PTS)

the maximally 4 or 5 % global strain to rupture under tensile load, which leads to the conclusion that almost every creasing process must result in major local damage or even rupture in the material. A combination of tensile test and OSA shows why this does not happen in practice and whether or not a material is suitable for creasing (cf. Figure 6).

The board material investigated here shows the well-known inhomogeneity of paper. The global elongation of the test strip amounts to ~ 2 %, but the OSA reveals great local differences: some regions have remained completely undeformed (green) whereas other (red) areas show local elongations of already > 5 % at 50 % strain to rupture. The OSA thus makes it possible to assess the local elasticity and uniformity of strain distributions in board materials and determine their suitability for creasing.

A parameter that is much more difficult to measure is the out-of-plane shear load in the cross-section of the material. To determine the shear modulus and shear strength of paperboard, PTS has developed a special test device for thickness levels between 0,2 and 2,2 mm. The specimen is fixed between two adapter plates by means of a two-component adhesive (epoxy resin), and intermediate

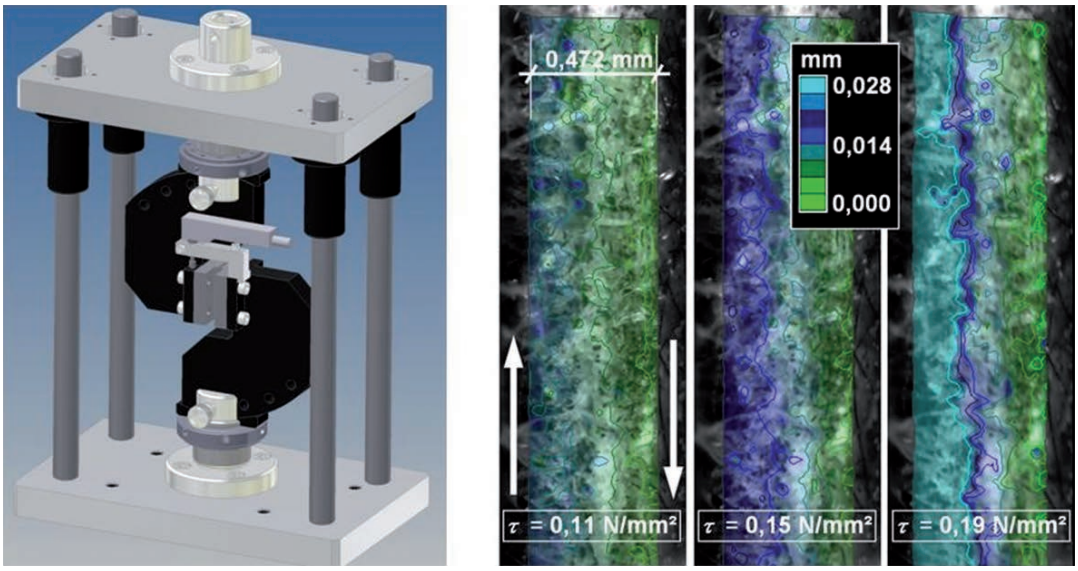


Figure 7: Test device used to determine the out-of-plane shear characteristics of paperboard (thickness between 0,2 and 2,2 mm, left) and analysis by means of OSA (right) (Source: PTS)

plates are used to compensate for thickness differences and ensure an accurate positioning in tensile direction. One side of the specimen is displaced by the traverse of the testing machine to cause the necessary stress in the material (cf. Figure 7), and the test stop is stopped when the sample breaks.

The displacements are assessed by means of an OSA because the shear modulus is calculated from very small displacements (approx. 10 - 15 µm) here and because it is not possible to use an extensometer. Further reasons why an OSA is indispensable are its high resolution and the fact that it can be performed directly on the material to avoid disturbing influences like deformations in the adhesive layer or variations caused by the measuring set-up.

Summary

An optical strain field analysis makes it possible to analyse displacements in nearly any image series, which makes it an ideal supplement to mechanical tests of fibre-based and composite materials. It can be combined with a universal testing machine to link the displacements in the images with a force curve and determine the distribution of material characteristics across the entire sample area. Another great advantage is that external effects on the measuring system such as the deformation of adhesive layers in out-of-plane shear tests play no part here because deformations are measured directly and exclusively in the test specimens. In addition to the above-described applications, optical strain field analyses can be combined with many other material or packaging tests such as the Short-Span Compression Test (SCT), Edge Crush Test (ECT), Box Compression Test (BCT) and other. ■

Benjamin Hiller
benjamin.hiller@ptspaper.de

PTS IS MEMBER OF THE ZIM NETWORK "DIGI4TT"

Individualisation, sustainability (e.g. Reach, reduced chemical use, prolonged product life cycles) and multi-functionality are present and enduring trends in the textile sector. Users of textile materials – whether from the protective clothing and equipment, automotive or medical technology sectors – are making ever increasing demands on their suppliers in this respect. Moreover, there are numerous new challenges resulting from Industry 4.0 and the growing digitalisation of many value creation processes.

To respond to these developments, Bayern Innovativ has founded the ZIM network "DIGI4TT - Functionalising technical textiles by digital printing". The network is intended to pool resources and competences in order to utilise digital printing as a new surface technology. Digital printing is to be developed into a flexible, sustainable surface technology for the production of functional technical textiles that meet the demands of individualisation and Industry 4.0.

The successful network has now entered its second funding phase (which will end on 31 October 2018) and is open to new partners.

DIGI4TT is looking for further partners to develop and process cross-disciplinary R&D projects, for example:

- Companies dealing with functional/technical textile applications
- Companies and technology suppliers of the textile chain
- Companies of the digital printing/surface functionalisation and mechanical engineering sectors
- Innovation generators from other sectors and fields of technology.

For further details, please visit:
http://www.digi4tt.de ■

Anatoli Davydov
anatoli.davydov@ptspaper.de

SUCCESSFULL PTS COATING SYMPOSIUM 2017

Coated – upgraded – smart was the motto of the traditional PTS Coating Symposium held at the Leonardo Royal Hotel in Munich on 5 -6 September 2017.

Transformation lay at the heart of this year's event, as became already evident in the opening speech delivered by Professor Miletzky. In particular the graphic paper segment has been hit hard by market changes in recent years. Fortunately, the subsequent papers on the present market situation also offered some encouragement, focusing on future chances and opportunities in the fields of folding boxboard and barrier papers and on the role of Industry 4.0.

Surface properties, printability, runnability and pre-wetting were main topics of the next lecture block on "Coating and upgrading technologies". The following session on "Components and concepts for coating colour formulation" presented the latest findings about the application of aqueous barrier coatings. The lectures on "Process technology" in session three focused on major improvements in Curtain Coating, the advantages of short dwell time coating and the dust-free dispersing of powdery coating colour components. The last session on "Innovative products" included a lecture on chromatogeny, a new technology whose development shows how long it can take from an invention to its first industrial application, but which also opens up entirely new product options to paper-based membranes the field of electro-mobility.

All in all, this year's PTS Coating Symposium offered a much broader range of subjects than the preceding events. Many participants said it was a real "eye opener" to them, showing which chances are lying ahead. Also the 11 exhibitors, whose brief contributions livened up the lecture programme, were highly pleased with the event. More than 30% of the attendees had been paper mill representatives.

PTS bid farewell to its 240 satisfied and inspired participants with an encouraging closing speech and the announcement that the next PTS Coating Symposium will again be held in Munich in 2019. ■

Ralf Gericke
ralf.gericke@ptspaper.de

Testimonials

„The recent PTS Coating Symposium has again confirmed: "This is the place to be" when you are looking for new findings and results about the surface finishing and new surface functions of paper and board. There is no other event providing more information on the latest trends and developments in both theory and practice."
Roland Rex, Moritz J. Weig GmbH & Co. KG

„The PTS Symposium has once again shown how important this conference is to the field of paper coating. This refers especially to the lectures, which have bridged the gap between fundamental science and new applications, but also to the social programme and conference location itself. All these factors have made the PTS Coating Symposium a special highlight of the paper sector in 2017."
Prof. Dr. Markus Biesalski, TU Darmstadt

„I am happy to see that the latest development needs and trends of our industry are well reflected in the program of this year's Coating Symposium. This shows that PTS continues to have a good grasp on what is going on both in academic and industrial research and development."
Leif Frilund, Walki Group

„The best with PTS Coating Symposium is the access to professionals working in the field of coating, which is fantastic for networking with the right people. You get a good overview of the actual and interesting topics that the industry is exploring at the moment, which gives a good base for making your own priorities. The knowledge level in the industry is presented in a very efficient way and the environment at the Conference is very enjoyable."
Per Emilsson, UMV Coating Systems AB

„An excellent Symposium. Very good lectures, even better networking, a very suitable venue and ambience. We have reached all our aims, started unexpected projects – there is no better event for suppliers wishing to prove their competence in the fields of specialty and fine papers. We are already planning our booth for 2019."
Wolf-Christoph Heilmann, wolf heilmann – produkte für die papiererzeugung

NEW PTS SERVICE: AUDITING OF PFR MANAGEMENT

An audit can reveal valuable potential for improvement, help assure the quality and increase the performance of your management of paper for recycling (PfR). We ascertain the present situation, develop first possible solutions and provide recommendations – neutrally and independently and taking into account the customer's goals.

Our audits are based on experience and the comparison with best practices because there is currently no standard available to comprehensively analyse and evaluate the management of paper for recycling. We use an interview guideline and joint inspection to establish the present situation on site. Our experience has shown that it is useful to include a representative of each process step of the customer's existing PfR management system and related areas to learn about the problems and goals of individual PfR management steps. After this, we discuss first possible solutions with the customer, covering also projects that are already in the planning stage. As a neutral and independent service provider, we offer transparent results and recommendations for action. ■

Main steps of an audit

- Analysing the situation as is (interview guideline, site inspection)
- Problems and goals, measures already taken
- First possible solutions and recommendations

Content of an audit

- Production, use of PfR, management of PfR
- Incoming goods inspection (steps, methods, sampling, documentation etc.)
- Storage yard logistics (management, labelling etc.)
- PfR use and purchase

Mike Schiefer, mike.schiefer@ptspaper.de
Lydia Tempel, lydia.tempel@ptspaper.de

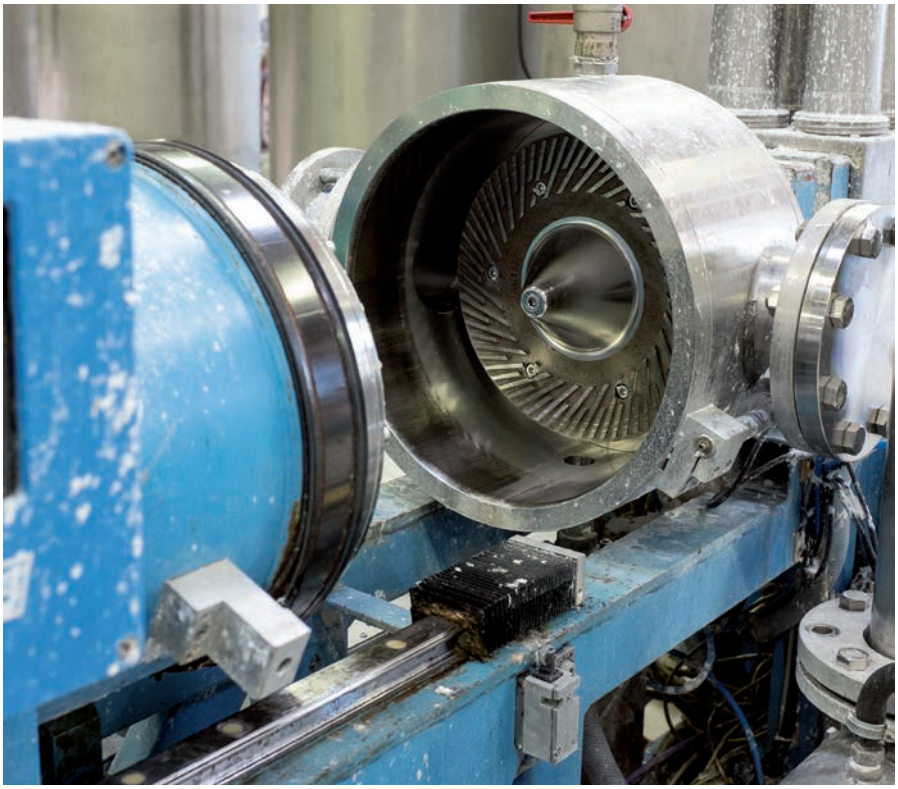
PTS LABORATORY REFINER PROVIDES REPRODUCIBLE RESULTS

Mercer International Group with its two German locations, the pulp mill in Stendal and the pulp and paper mill in Rosenthal, both members of the German Pulp and Paper Association VDP, and PTS in Heidenau have been working together as partners for many years.

PTS has frequently supported Mercer with internal projects, customer-specific and analytical tasks.

Pulp refining is a key process step for both papermaking and pulp production. The laboratory refiner of PTS is highly flexible, capable of providing reproducible results and makes it possible to simulate the industrial refining process. For Mercer, it is therefore a highly interesting alternative to their in-house analytical methods.

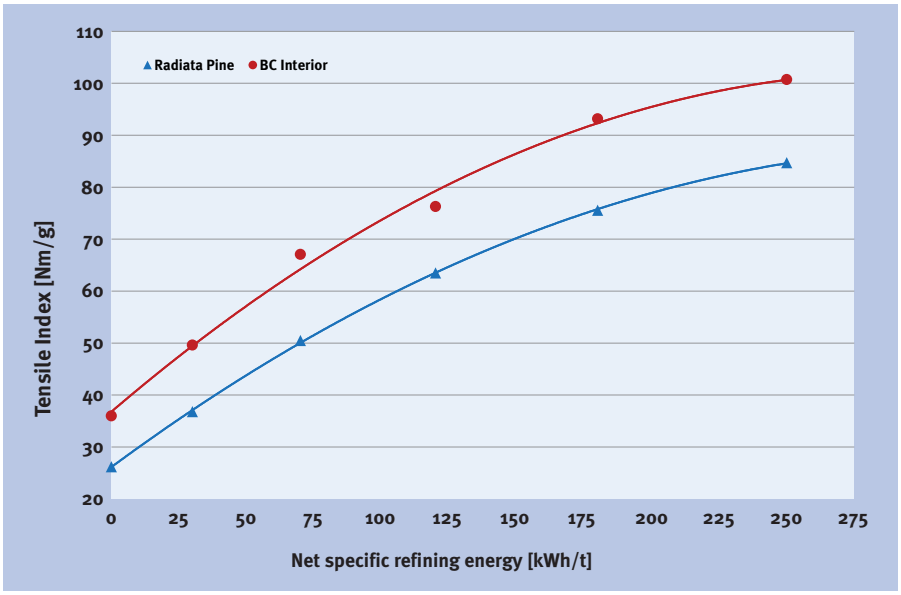
When Mercer was planning an extensive refiner benchmarking study to extend and update its data base at the end of last year,



they frequently consulted PTS about this. Special care was taken to define suitable process conditions and choose optimally designed refiner fillings.

One reason for the complex planning and preparatory work is that Mercer will commission a new Fibre Centre in Stendal at the end of 2017 whose centrepiece will be a laboratory refiner. The comparability and industrial transferability of the laboratory refining results achieved at PTS is therefore of great interest to them. Because of the helpful advice provided by PTS experts, their careful evaluation of laboratory results and timely completion of previous orders, Mercer awarded the refiner benchmarking study to PTS.

Steffen Schramm
steffen.schramm@ptspaper.de
Dr. Frank P. Meltzer
frank.meltzer@mercerint.de



Tensile index as a function of net specific refining energy (Source: PTS)

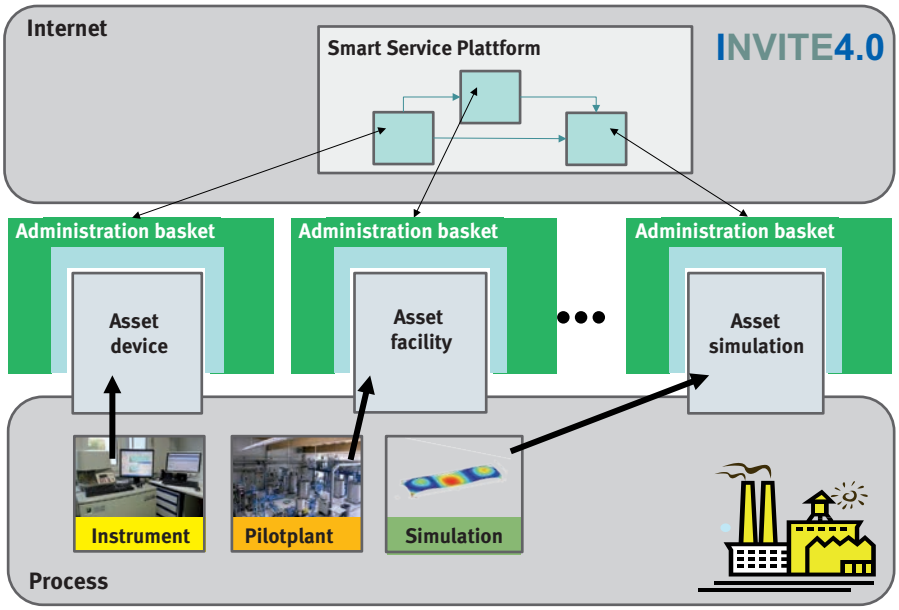
NEW RESEARCH PROJECT INVITE40

Engineering of technology-based services with Industry 4.0 technologies

The objective of the INVITE4.0 joint project is to develop a method for engineering technology-based services using Industry 4.0 technologies with a focus on the systems and process engineering as well as on the paper and fibre-based materials added value chain.

The project is thus dedicated to the topic of designing and constructing innovative digital development and service systems within the framework of Industry 4.0. The guiding principle is the technical creation of a RAMI4.0-compliant "Smart-Service-Ready-Platform architecture" as a prerequisite for the implementation of cyber-physical production systems on digital smart service platforms.

INVITE4.0 sees itself as a necessary complement to activities of large companies such as Siemens and VOITH with a focus on the special conditions of SMEs and industry-oriented research institutes. In the course of the project, the results of PTS basic research and studies from other consortia will be evaluated. Based on this methodology and on representative use cases, an adaptive solution will be compiled that is intended to make it possible for companies and institutes in the field of systems and process engineering and the paper and fibre-based materials added value chain to develop and operate materials and production processes, devices and equipment as well as simulation models on global Internet of Things (IoT) platforms.



Linkage of I4.0 components on the smart service platform (Source: PTS)

The image below illustrates the anticipated project results. The link of I4.0 components on a smart service platform will be implemented by the RAMI4.0-compliant generic administration baskets developed in the actual core of the project and the semantically adaptable assets with integrated interfaces. For this purpose, basic communications and data structures will be developed and a demonstrator will be built to show the integration of assets on a digital smart service platform in the

form of a prototype.
Ifak, the Institute of Automation and Communication, and PTS, both are research institutes organised under the umbrella of the Konrad Zuse Community, will be conducting research in the project. In line with their competences, the work of the joint partners will be focused on different subprojects: ifak will be working on developing middleware intended to integrate I4.0 components into the process environments (subproject "INVITE40-IFAK"), while PTS will be working out a method for developing I4.0 components in the paper sector (subproject "IN-VITE40-PTS").

Sven Altmann
sven.altmann@ptspaper.de

ZUSE-GEMEINSCHAFT ifak

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

3D UHF ANTENNAS ON PAPER AND PAPERBOARD SUBSTRATES FOR LOGISTICS APPLICATIONS

Source: Leibniz -Institut für neue Materialien – INM

PTS and INM (the Leibnitz Institute for New Materials) are undertaking a co-operative joint effort in the field of researching durable conductive tracks that can be applied to folding boxboard by inkjet-printing of sinter-free and conductive hybrid inks. This aim is to be demonstrated on foldable 3D UHF antennas (IFG Project BG 05393-17).
The results are intended to enable small to medium-sized packaging manufacturers to print conductive structures for "smart packaging" directly onto cardboard. For this purpose, novel, flexible hybrid printing inks based on fibrous substrates are being developed that will be suitable for use with folding boxboard. This combination is intended to bring about the following benefits:

- flexibility: printed structures will stand up to sector-typical converting procedures
- sintering unnecessary: conductive structures can be used immediately after printing
- simplification: simple and easy printing of printing inks using standard inkjet printers

The printing ink and substrate will be optimally tailored to each other. The porosity and wettability of the paperboard will be modified to ensure optimum ink adhesion. Cleverly designing the layer structure will enhance adhesion, maintain conductivity and reduce any mechanical stress on the conductive structures. The printing inks will be examined with respect to their viscosity, wetting properties and failure mechanisms and then adapted to the substrate. Finally, conductivity and percolation curves will be investigated as a function of the mechanical stress and layer structure of the substrate.
There is still a long way to go until a stable practical application will have been successfully achieved. However, the researchers are optimistic that the newly discovered properties of the extensively researched ink system will open up new possibilities based on the selectively applied research of packaging logistics.
The growing market of "smart packaging" in conjunction with the simplification and flexibility of such packaging that is offered to boxboard manufacturers and print shops promises to develop additional fields of business. It is possible to envision, for example, protection from product counterfeiting, improved track & trace functions or even packaging solutions that provide information about the conditions of the packaging contents by means of sensors (e.g. colour change). In summary, this combination of an improved substrate together with an optimised printing ink will create a material composite (or an innovative substrate) that has as yet not been available and will therefore make new products possible, considerably expand existing business sectors and lay the foundation for a modern, "smart" type of packaging.

Ralf Gericke
ralf.gericke@ptspaper.de

SUBSTRATE QUALIFICATION FOR PACKAGE LABELLING

Within the framework of more stringent requirements for serial encoding of package labelling, the user base has expanded from prescription drugs to embrace the packaging of pharmaceuticals, food, cosmetics and agrochemicals. Package codification is being boldly pressed forward at the international level. This means that package labelling will be the prime impetus on the packaging market in the coming years. It is to be expected that, as a result of the implementation of Regulation (EU) 2016/161 for the pharmaceutical sector, additional sectors will be forced either by law or by an industrial standard to encode their products.

The development of pharmaceutical packaging is showing a rise in packaging units as well as the significant influence of converters. The many different solutions for package labelling are primarily affecting the sectors of folding boxes and labels. Due to the expansion in the fields of application, paper is being used to an ever greater extent in the fields of Flexpack and blister as well as polymeric systems such as Tyvek®. The suitability of these grades in package codification, however, is by no means a foregone conclusion.

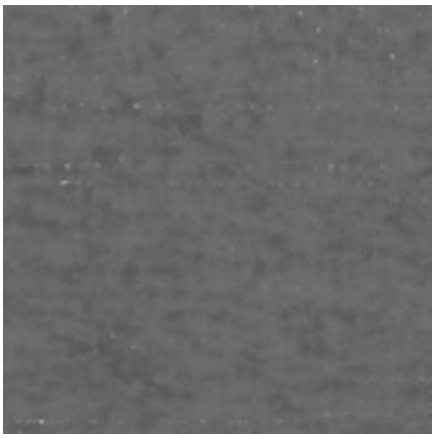
Both the FFPI (Research Grouping of Folding Boxes for the Pharmaceutical Industry) and PTS have been pushing the evaluation of the substrates forward for years. In addition to the established tests, PTS also offers a Certificate of Encoding Suitability for folding boxboard.

Substrate qualification is also gaining in importance because the value added is clearly enhanced as a result of the packaging encoding. The combination of a digital code with the packaged contents achieves a total value that easily corresponds to 100 times the packaging costs. The technical realities for code verification are still very complex nowadays; for instance, the results of a Round Robin Test with verifiers involving 35 units of measure revealed significant differences of up to 1.5 points. Despite the definition of measuring equipment in accordance with DIN 15415, a reliable measured value is still far from being sufficiently met. PTS and FFPI are conducting in-depth studies on stabilising the measured values. These studies have established that the following supplementary measurements would be worthwhile as well:

- Evaluation of the evenness of print, i.e. how great is the variation in the degree of blackness within a defined printed area?
- The arithmetic averaging of the black value in the fields is included in the evaluation. Initial results indicate that the evenness of print correlates clearly with the results of encoding.

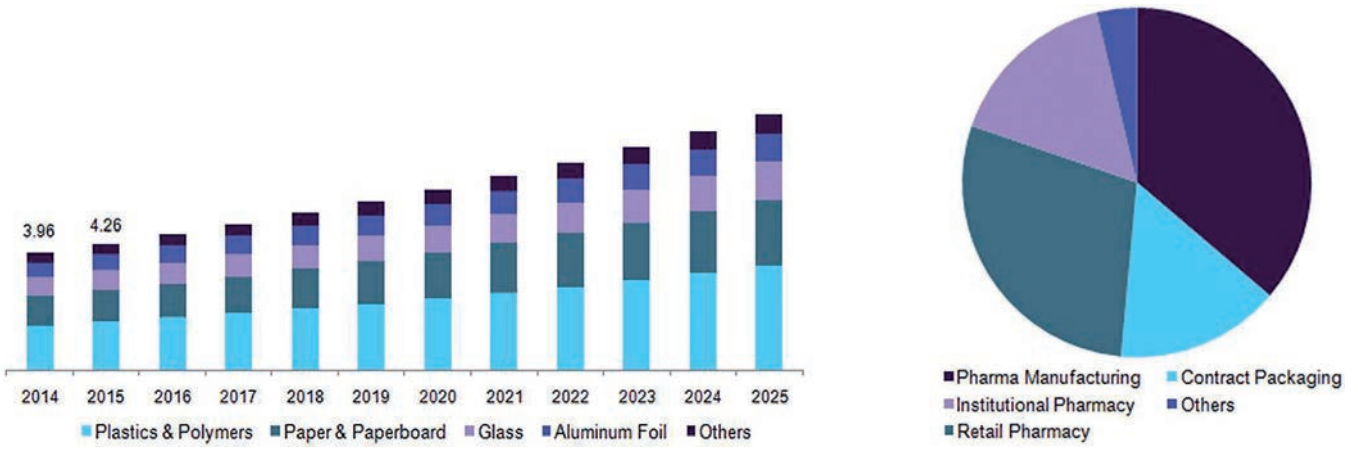
As a consequence of the experience gathered until now, PTS will develop a standard for evenness of print in order to achieve a reproducible result.

An important evaluation relates to chemical constancy, i.e. how long and under what conditions the printable surface can be encoded with high quality. The migration of a variety of substances out of the paperboard changes the surface tension of the board such that high-quality encoding is no longer possible under certain circumstances. Extending the workability time of the encoding to about 12 months makes the reliability of chemical constancy all the more important. PTS is conducting research in this field in order to define a new industrial standard.



The variation in the degree of blackness within a defined printed area (Source: PTS)

Additional questions that must be clarified include: what ink/substrate combination provides the most efficient result? Can a high-quality printing ink still achieve reliable results when the amount of it is reduced? A print density of 300 dpi can be reduced to 200 dpi using modern printing inks. This yields an improvement and stabilisation of smudge proofness by reducing the amount of water involved. In addition to the cost savings of the printing ink, the machine speed can also be increased by such a measure. A machine output of 650 boxes/min can be achieved merely by reducing the print density to 240 dpi. In some cases, modern printing inks are capable of achieving a b3 codification ranking with a print



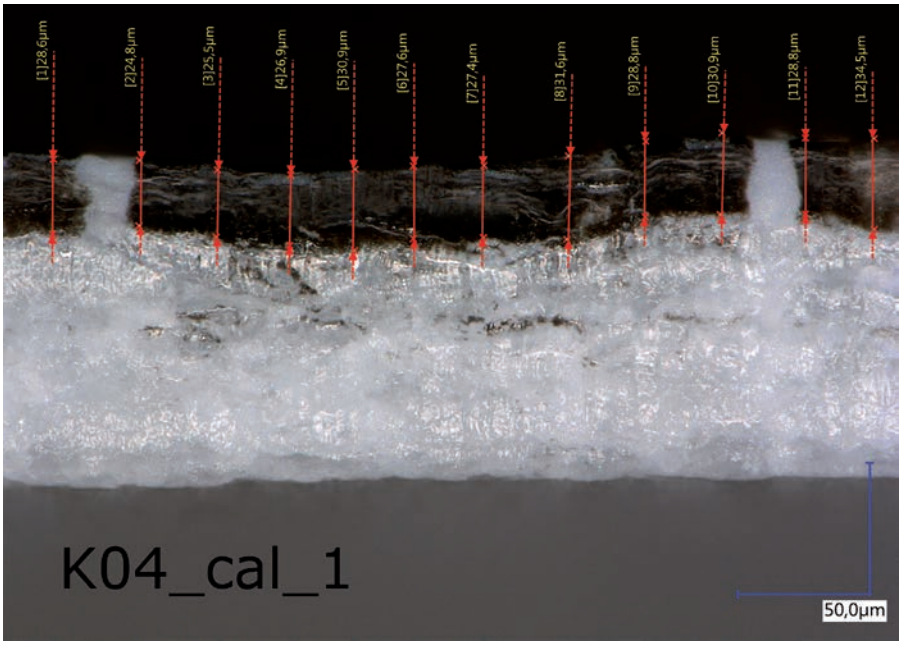
German (left) and worldwide markets for pharma packaging (right) in 2016, each in % (Source: Grand view research)

density of only 150 dpi. This means in turn that even high-gloss sealed paper can be printed, since the drying time drops significantly. The combination of substrate and printing ink results in a much longer stable work window.

Measurement of ink penetration depth complements optical inspection. Expanding the existing certificates to additional printing inks and substrates will yield a greater area of work for package codification. Procedures will be developed especially for labels and packaging paper and board that are analogous to folding boxboard in order to spin off of it a product certification in 2018. The studies of the material combinations that converters use have resulted in good correlations to the industrial process. They can be used to define and develop specific substrates for the user.

In particular, the qualification of individual systems can be simulated very efficiently in the metrology facility. Process optimisations in the "substrate-ink" material combination can be achieved by evaluating print quality, smudge proofness and abrasion. The three print units of the PTS test bench can print more than 35 standard printing inks in cartridges. Additional printing inks can be applied in the laboratory and at least the basic properties can be evaluated.

PTS utilises the results when encoding with substrate studies in order to define wettability, penetration and topography. More extensive studies allow the problem definition to be correlated with the material combinations. This in turn can reveal process optimisations and potential for economies of scale in packaging manufacture.



Measurement of ink penetration depth complements optical inspection (Source: PTS)

Problems encountered are characterized, differentiated and assigned to various causes. The combination of scientific studies with technical testing facilities provides a good overall picture for examining problems and selecting products. The stability of the value added at the converter can be improved by way of issuing a certification of substrates.

In practice, the expansion of the test procedures mentioned above makes it possible to clarify the relationships and thus enhance production reliability. The operation of packaging lines will become more complex due to the increasing demands of the logistics chains. On the other hand, troubleshooting problems and improving specifications provides the user with the tools necessary for process optimisation. ■

Dr. Arne Krolle
arne.krolle@ptspaper.de

NEW FINDINGS ABOUT PULP REFINING

The laboratory refiner of PTS can be used for beating tests or to prepare stocks for subsequent paper machine trials. It has a minimum pulp input of 6 kg o.d. and may be equipped with disk or conical fillings. The 12 inch (30 cm) knives are procured from a special steel foundry, which manufactures them by request with the desired cutting angle, knife number, knife width, groove width and material. They prepare a casting pattern of each filling, which makes it possible to reproduce it repeatedly in several sets.

Recent studies on refining have investigated the forces acting in pulp refiners and their effects on fibre shortening. First trials with industrial refiners have shown that narrow knives tend to cause particularly high forces. It is therefore necessary to reduce their specific edge load to avoid fibre shortening. To eliminate or reduce the effects of other parameters and determine the effect of knife width more accurately, specialists have conducted further tests under controlled conditions in the PTS laboratory refiner. They used fillings whose design differed only in the parameter knife width. Figure 2 shows an example filling with 1 mm knife width. All trials were done with the same pulp type.

The force related to knife length turned out to be a useful parameter for defining the force threshold that should not be exceeded to avoid fibre shortening. It can easily be calculated from the specific edge load (SEL).

The test results will be presented in detail by Mr Kerekes (University of British Columbia) and Frank P. Meltzer (Mercer International) at the PTS Pulp Symposium in Dresden on 28-29 November.

Steffen Schramm
steffen.schramm@ptspaper.de
Dr. Frank P. Meltzer
frank.meltzer@mercerint.de

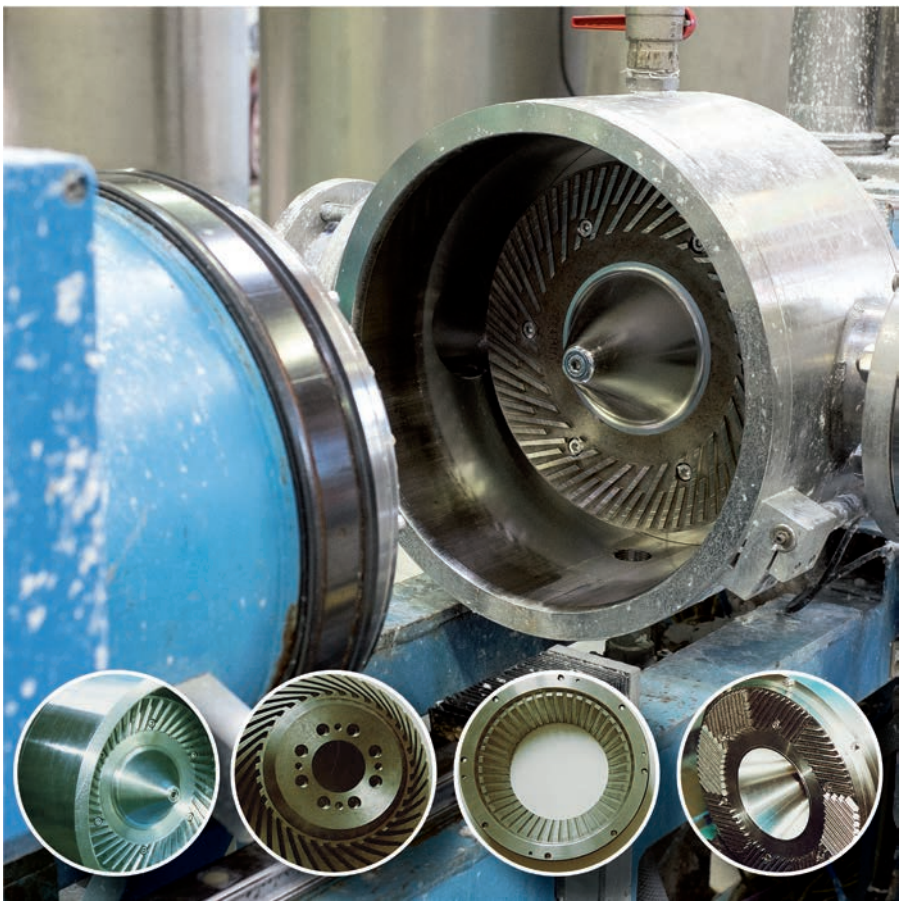


Figure 1: Conical and disk fillings with delicate, 1mm-wide knives are manufactured by milling (source: PTS)

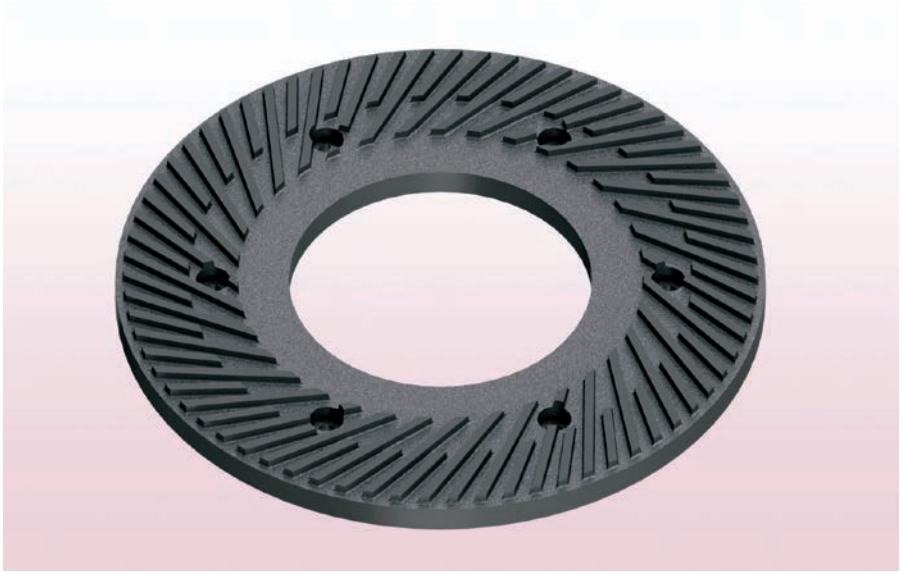


Figure 2: Test filling with 1 mm knife width (source: PTS)

PTS FIBRE based solutions

Papiertechnische Stiftung
Hess-Strasse 134 · 80797 Munich/Germany · Phone +49 (0)89-12146-0 · Fax +49 (0)89-12146-36
Pirnaer Strasse 37 · 01809 Heidenau/Germany · Phone +49 (0)3529-551-60 · Fax +49 (0)3529-551-899
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