VIPP VALUES CREATED IN
FIBRE-BASED PROCESSES
AND PRODUCTS

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LARS JÄRNSTRÖM IS RETIRING

Lars Järnström, professor of coating technology, came to Karlstad University in 1999 and has been involved in building the current strong research environment for fibre-based processes and products. Now retirement is approaching but he will continue working at the university as senior professor.

Lars Järnström's research centres mainly on environment-friendly surface treatment of fibre-based packaging materials. His aim is to contribute to reducing carbon dioxide emissions, plastic waste, food waste as well as to making production processes more efficient. Lars Järnström is also the head and co-founder of the industrial graduate school VIPP, which is short for Values Created in Fibre- Based Processes and Products. VIPP is a unique investment in the Swedish university landscape aiming to strengthen the research environment at the university and upskill industry employees participating in the research school. This multi-disciplinary partnership involves most forest industrial companies in Sweden and Finland.

"I came to Karlstad University in 1999 and then professor Lars-Arne Sjöberg and I started the surface treatment programme," says Lars Järnström. "It was active until 2007 and a total of 47 researchers at Karlstad University, including doctoral students, were involved in the programme."

The surface treatment programme was jointly funded by the Forest Industry Research Foundation (SkFs), the Knowledge Foundation and Nutek/Vinnova. All researchers concerned worked purposefully to ensure further external research funding for this field at Karlstad University. The strategy ultimately aimed to ensure continued research funding after the closing of the study programme.

Sustainpack
The application that was to be most significant for the continuing existence of research was the Sustainpack project, funded by EU's 6th frame programme. The origin of Sustainpack was quite a coincidence: the Karlstad research group and two other research groups had, unaware of each other's intention, submitted a pre-application to the EU for a so-called Large-Scale Integrated Project in the field of environment-friendly surface treatment of cellulose fibre-based packaging. The European paper industry took the initiative through CEPI to ask the submitting organisations to coordinate their projects and submit a joint final application.

"This project lasted for four years in 2004-2008 and paved the way for research collaboration between Karlstad University and leading companies, universities and institutes in Europe," says Lars Järnström. "This was a take-off for our bioeconomy and nanomaterials research We were pioneers and our research made us known in Europe."

Sustainpack was a springboard for international partnerships and a great number of European and Nordic funded projects.

VIPP Industrial Graduate School
The industrial graduate school VIPP started in 2011, supported by the Knowledge Foundation and partnership companies, and will continue till 2020. A total of 19 doctoral students have been enrolled and many have completed a degree and many more will. The VIPP establishment meant that the research group shouldered a greater responsibility for creating a unified environment in this research field.

"There was a need to create a unit and a joint forum for researchers on the energy and environmental aspects of the forest industry, and researchers on pulp manufacturing and paper machines, as well as researchers on the role of packaging in food waste from a service perspective, and so on", says Lars Järnström.

"Through his commitment and expertise Lars Järnström has contributed to shaping and developing research environments and new industrial contacts using VIPP as a natural platform," says Louise Törnefalk Svanqvist, chairperson of VIPP.

Other spin-offs are FoSBE, Research environment for circular forest-based bioeconomy, and Multi-barr, Multilayer barrier coatings technology for fibre-based packaging. FoSBE has funding from Tillväxtverket and the European regional development fund for building a research environment in forest-based bioeconomy with links to regional testbed environments. The Multi-barr project on multi-layer paper coatings was recently granted funding by the KK Foundation.

Prestigious award in 2018
Lars Järnström was the recipient of the 2018 TAPPI Coating and Graphic Arts Technical Award and the Charles W Engelhard Prize, which is regarded as the most prestigious award in the field of surface treatment of paper. Every year, the committee for the TAPPI Coating & Graphic Arts Awards nominates an awardee based on the following criteria: " The Division Technical Award is intended to recognize outstanding accomplishments or contributions, which have advanced the industry's technology in the awarding division's field of interest."

"I'm looking forward to continuing as senior professor to complete ongoing projects and other commitments, and also to contribute to the departmental research, for example, through the networks and contacts I have established over the years," says Lars Järnström. "Retirement certainly offers more leisure – my wife and I can, for instance, spend more time at our summer cottage. With the new appointment as senior professor it will be an attractive mix of leisure and research for the years to come."

ASIF JAVED
DOCTORAL THESIS MAY 16 2018

EFFECTS OF PLASTICIZING AND CROSSLINKING ON COATINGS BASED ON BLENDS OF STARCH-PVOH AND STARCH-LIGNIN

A barrier material is usually needed on a fiber-based food package to protect the packed food from gases and moisture and thus maintain its quality. Barrier materials presently used in food packaging applications are mostly petroleum-based polymers. Over the last few decades, efforts have been made to replace petroleum-based materials with bio-based materials. The present work has focused on the possibility of using a natural barrier material on a fiber-based food package and the effects of plasticizing and cross-linking on the mechanical and barrier properties, and the stability in water of coatings based on starch-poly(vinyl alcohol) (PVOH) and starch-lignin blends.
The flexibility of the starch films was increased by adding PVOH further by adding a plasticizer. It was shown that citric acid can act as a compatibilizer and cross-linker for starch and PVOH, and the use of citric acid may slow down the diffusion of both oxygen and water vapor if a multilayer coating strategy is used. The addition of polyethylene glycol to the pre-coating recipe resulted in a lower oxygen transmission rate through polyethylene-extruded board than when citric acid was added to the pre-coating. The flexibility of the barrier coatings and the properties of the base substrate affect the cracking tendency of the barrier coatings during the creasing and folding of a barrier-coated board.
The addition of lignin to the starch reduced the migration of starch from the starch-lignin films and the addition of ammonium zirconium carbonate as a cross-linker reduced the migration of both starch and lignin from the films. The addition of starch to the lignin solution increased the solubility of lignin at low pH, and the pilot-coated board showed a significant decrease in migration of lignin from the coatings containing ammonium zirconium carbonate when the pH of the coating solution was decreased.

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ARON TYSÉN
DOCTORAL THESIS MAY 22 2018

THROUGH AIR DRYING –

THERMOGRAPHIC STUDIES OF DRYING RATES, DRYING NON-UNIFORMITY AND INFRARED ASSISTED DRYING

The objective of this thesis was to investigate parameters concerning the drying rate and the non-uniformity in the through air drying process. Parameters considered were grammage, pulp type, formation, web-fabric interaction and infrared radiation. A piece of equipment was therefore developed which allowed the paper samples to be dried by air being drawn through them, with the option to supply additional drying energy through infrared radiation. The time-dependent local surface temperature of a drying sample was recorded using an infrared camera. In addition, the air flow through the samples was measured.
Samples with grammages ranging from 15 to 60 g/m² were made on a laboratory sheet former from a range of different commercial chemical pulps. The pulps comprised both hardwoods and softwoods. Samples with both good and bad formation were made. The measurements showed that the air flow through the sample varied with grammage and pulp type. The air permeability, i.e. the specific air flow, was constant at higher grammages, as could be expected. In contrast to that, at lower grammages, the air permeability was higher, and also a function of grammage. The permeability was also highly influenced by the fibre morphology, with softwood samples being much more permeable.
The non-uniformity in drying increased with bad formation and was influenced by the web-fabric interaction. Local drying time maps quantified the spatial non-uniformity of drying. Formation had little or no impact on the total drying time, but the non-uniformity of drying increased with worse formation. For commercial through air drying fabrics, the effect of web-fabric interaction was observed for hardwood samples, where the web areas in contact with the knuckles of the fabric weave had longer drying times. However, virtually no non-uniformity could be measured for the softwood samples.
The average drying rate was mainly influenced by pulp type, and was increased by the addition of infrared radiation. Interestingly, even though the permeability differed significantly between pulps, the drying rate was independent of the varying permeability at lower grammages. Thus, a higher air flow did not increase the drying rate. Adding additional drying energy by using an infrared radiator allowed for an increase in the drying rate. However, as the radiator power was increased, the corresponding increase in the drying rate was less than proportional.

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CAROLINE WILKE
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THE IMPACT OF DISSOLVED MATTER ON FIBERLINE PROCESSES

The impact of dissolved matter on the performance of four fiberline process stages was investigated: oxygen delignification, hot acid treatment, chlorine dioxide bleaching, and hydrogen peroxide reinforced alkaline extraction. In particular the impact on delignification due to dissolved lignin was studied.
The impact of unoxidized and oxidized dissolved matter on lignin and carbohydrate degradation was investigated in a laboratory oxygen delignification stage. It was concluded that the delignification was decreased by the presence of unoxidized dissolved matter but increased in the case of oxidized dissolved matter. Both types of dissolved matter comparably increased the carbohydrate degradation. Thus, the presence of unoxidized dissolved matter impaired the selectivity. In the case of oxidized dissolved matter, the selectivity was affected in the same way as when using a higher sodium hydroxide charge.
The presence of dissolved matter reduced the efficiency of a laboratory hot acid stage, and subsequently further affected the chemical demand in a following chlorine dioxide stage. In a laboratory chlorine dioxide stage, the presence of dissolved matter reduced the delignification. The additional chemical demand required to compensate for this reduction was proportional to the content of dissolved matter. Moreover, the total chemical demand was found proportional to the total kappa number of the pulp, that is the sum of the fiber and filtrate kappa numbers. Finally, the presence of dissolved matter in a laboratory hydrogen peroxide reinforced alkaline extraction stage reduced both the delignification and the brightness.
Furthermore, mill studies showed that the content of dissolved lignin varied significantly, and often more than the fiber-bound lignin, in a bleaching stage. For chlorine dioxide stages, it was proposed that the chemical consumption could be reduced by controlling the chemical charge based on the sum of the fiber-bound lignin and the dissolved lignin.

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SOFIA THORMAN
DOCTORAL THESIS DECEMBER 18 2018

WHERE DID THE INK GO?

THE EFFECT OF LIQUID ABSORPTION ON INK DISTRIBUTION IN FLEXOGRAPHY

The appearance of a print is affected by the individual ink layers. If the ink is unevenly distributed on the substrate it lowers the quality. This thesis puts focus on how the liquid absorbency of a coated substrate impacts on the ink distribution in flexographic printing. It is well known that a smooth surface increases the chances of a uniform print, whereas the influence from an uneven absorption is not established and has even been difficult to measure. If the ink is applied directly onto the substrate, or as an overprint onto already present ink layers, the outcome is even more complex. Ink trapping behaviour affects the uniformity of overprint layers. As of yet, this been largely overlooked in flexography.
The work includes several trials, from monochrome laboratory printing at 0.5 ms^{-1} to multicolour printing at 10 ms^{-1} in production-scale. These studies showed that ink absorption interacted directly with monochrome ink layers and that pore-structures with larger pores and greater liquid uptake generated more uniform prints. The tolerance of uneven pore-structure, and thereby absorption, varied between samples.
In multicolour printing, the overprint layer interacted directly with the preceding ink and indirectly with the absorbency (rate and uniformity) of the substrate. Overprint layers became thicker when the first ink layer was thinner and, consequently, turned uneven when the first layer was uneven. Moreover, the time between the applications of the two inks was important. When immobilisation of the first ink was too slow or uneven, it disturbed the ink trapping so that the overprint layer became uneven.
Output from this project offers a palette of tools to use when studying liquid absorption and its impact on print quality: a) experimental approach to separate the influence of uneven absorption from surface roughness, b) aqueous staining technique to characterise absorption non-uniformity, and c) technique to characterise ink trapping non-uniformity.

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