VIPP VALUES CREATED IN
FIBRE-BASED PROCESSES
AND PRODUCTS

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VIPP STANDS FOR **VALUES CREATED IN FIBRE-BASED PROCESSES AND PRODUCTS** AND IS AN INTERDISCIPLINARY, INDUSTRIAL GRADUATE RESEARCH SCHOOL LOCATED AT KARLSTAD UNIVERSITY.

Sweden invest second most in the world in research and development in relation to GDP, but global competition is becoming tougher and money alone will not maintain the world class position in pulp and paper or any other research field.
Co-operation between the industry and the research environment is of vital importance in the creation of a dynamic interaction between ideas/needs and innovations/results.

To meet future needs in industrial research and development, researchers who can handle both the interdisciplinary and the holistic perspective are required. Determined professionals with an open and collaborative mindset are vital for success.

The VIPP Research School at Karlstad University is an interdisciplinary research initiative, today primarily based on three strong research fields:

- pulp, paper and graphic technologies
- environmental and energy research
- service-orientated customer research

No other academic network is offering this perspective, which is especially designed for the Swedish pulp and paper industry and related fiber based industries. VIPP Research School offers a close collaboration between the research environment and the enterprises taking part.

The first measurable objectives have been met. Today, there are 14 doctoral students and enterprises involved. Supervision of projects, curricula and workshops are in place. I believe, that the doctors from the VIPP Research School will meet the demands of the industry, with expertise in both the product technology, the service offering connected to the product and the environmental area, to create competitive advantage.

Louise Törnefalk Svanqvist
Chairman of the Board, VIPP Research School

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MAXIMISED PRODUCT VALUE FROM LIGNOCELLULOSIC RAW MATERIAL THROUGH NEXT GENERATION OF SULPHITE PULPING

Dissolving grade pulp is made from wood and such pulps have a very high cellulose content, i.e. more than 90 percent. This makes them readily adaptable for manufacturing of products such as viscose staple fibres, MCC and cellulose derivatives. The high cellulose content in the dissolving grade pulp is important as residual hemicelluloses present in the pulp may impart detrimental effects during processing of viscose fibres.

The PhD project aims on separation of hemicelluloses and lignin from cellulose during sulphite cooking stages followed by bleaching sequences yielding rayon grade pulp with high cellulose content as well as lignin and hemicelluloses streams suitable for further refining. The sulphite cooking process that will be used will be mainly sodium based but later will also magnesium be included.

The study will be mainly focused on softwood, i.e. in the beginning pure spruce and then later pure pine respectively. The yield and the properties of the separated/dissolved wood component of lignocellulosic materials like pure cellulose (alpha cellulose), hemicelluloses and lignin will be optimized to get the best over all value from the raw materials used.

This PhD project is conducted in collaboration between MoRe Research, Domsjö Fabriker and the VIPP research school at Karlstad University. The aim is to gain new knowledge regarding multi stage sodium based sulphite cooking. The work will focus on how the cooking stages could be modified and optimized along with the alkaline extraction step in the bleach plant for selective separation of cellulose, hemicelluloses and lignin to the maximum extent.

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MoRe Research

ADITYA BIRLA
Domsjö

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REDUCATION OF THE ENERGY USE IN A TUMBLE DRYER WITH HEAT-PUMP TECHONOLOGY

My first paper ¨Modeling and experimental study of a closed-type heat pump tumbler dryer¨ is almost finished. During the autumn it will be sent to the journal ¨Drying technology¨. A new work which should end up in the second paper is ongoing.

The task is to decrease the energy use in a dishwasher by using a heat pump cycle. The most of the energy use is to heat the dishwasher in a dishwasher cycle. The concept is that the heat pump is obtaining the energy from a tank of water ¨energy store¨. During the heating of the dishwasher the energy store cools down and freezes to ice. The aim for the work is to examine how the compressor size and energy losses affect the energy use and heating time. To answer the question has a simulation model and an experimental setup of the system been developed and built. The plan is to have the paper finished in summer 2013.

In the last years Asko Appliances has started some projects where a heat pump solution is included. In these projects I have been involved and contributed with my experience of heat pumps. And if we look into the future even more activities regarding heat pump system is planned at Asko Appliances and the owner Gorenje group. Hopefully my experiences could be used even in these projects.

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ENERGY EFFICIENT WASTEWATER-TREATMENT IN PULP-AND PAPER MILLS THROUGH PRE-TREATMENT USING SEPARATION

The energy use in wastewater treatment is affected by the chemical makeup of the wastewater. Different production units at pulp and paper mills produce various chemical compounds that negatively affect wastewater treatment. Wood extractives, lignin, bleaching agents and residual sulphite are common such chemicals. These compounds increase the costs associated with wastewater treatment by increasing energy demand and lowering the efficiency of treatment. In this project, the means and effects of removing wood extractives and suspended solids from wastewater will be investigated.

Cooperation has been initiated with several other projects that have similar goals or are utilizing the same set of technologies. One such project is an Energimyndigheten sponsored project carried out by ÅF, Innventia and Alfa-Laval, in cooperation with three pulp and paper mills. The project investigates how membrane filtration can be used to improve energy use. Membrane filtration may make it possible to increase water reuse.

Screening trials of waste materials as sorbents for resin and fatty acids have been carried out at Skoghall Mill. Sludge from a sedimentation basin treating water from boardmachines and biological waste activated sludge where used as sorbents and the trial was carried out on CTMP effluents. The results of the screening trials were inconclusive and further work is needed.

During the autumn, experiments with solid mesh filters will be carried out on CTMP effluents. The goal is to test feasibility of physical separation of fine wood material, with sorbed fatty acids and resin acids, and agglomerates of lipophilic compounds in the wastewater.

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SYSTEMS ANALYSIS OF BIOREFINERIES

Flash pyrolysis is considered to be a promising technology for production of fuel oil substitute and chemicals and results in a densified product potentially enabling cost- and energy efficient transfer of biomass from existing biomass handling sites to the new sectors.

Repeated tests have shown that pyrolysis oil, though featuring some challenging properties, can be utilized in co-firing applications etc. In the longer term, it is interesting to increase the value of the oil produced by a more selective use of the several hundred different substances typically found in pyrolysis oil. Such use of the oil (tar) constituents can in addition to potentially higher financial return, also potentially result in a more sustainable use of resources and enable replacement of fossil fuel-based chemicals and fuels. Research has demonstrated that a pyrolysis reactor can be integrated with a fluidized bed boiler, thereby enabling simultaneous production of heat, power and pyrolysis oil. Other research has demonstrated that pyrolysis oil composition can be controlled by condensation temperature.

Increased condensation temperature can enable heat of vaporization to be recovered and used for biomass drying or transferred to district heating system, thereby improving overall efficiency for the pyrolysis plant. In my research project, previous research results and commercial operation parameters are utilized to model and evaluate a flash pyrolysis plant with sequential vapor condensation integrated with a fluidized bed CHP plant boiler. A thermodynamic model has been established, enabling prediction of pyrolysis heat and mass balances including condensation rate vs. temperature and condenser heat loads. The project evaluates and compares the performance and impact on the plant in terms of pyrolysis oil production, power generation, overall energy efficiency, plant capacity (asset) utilization and biomass consumption.

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FRESH FRUIT AND VEGETABLE WASTE IN THE FOOD SUPPLY CHAIN – QUANTIFICATION AND CAUSES

The result of several international studies suggests that 30-50 percentage of the food produced for human consumption is lost or wasted globally. Waste of food is a topic of considerable policy and international interest. However, few studies have been done on food waste at retail level. Fresh fruit and vegetable is the largest subcategory of retail waste and is also the category that has less reliable recorded data.

The primary purpose of packaging is to protect and preserve the food, to provide good durability, good quality, and facilitate efficient transportation as it transits through the food supply chain. If the packaging cannot handle this adequately, it will cause food losses and environmental impact with no benefit. The importance of appropriate packaging design is therefore critical and the impact of using too much packaging material must be put in relation to product losses that may result from the use of too little packaging material. Often, the environmental impact of the packaging itself is relatively small compared to the environmental impact of the production of food. Hidden costs associated with handling the waste are often overlooked. Hidden costs can be caused by poor packaging, inadequate handling of the produce or the box, and/or an ill-performing cold chain.

To minimize food losses, better understanding of the food supply chain and causes of losses is needed. The flow of fresh fruit and vegetable at a number of retail stores will be analysed in order to quantify how much fresh fruit and vegetable is lost and wasted, what causes the losses, how much the losses cost (calculated both in terms of economic and environmental cost), and identify how these losses can be prevented. Furthermore, the study aims to identify any other economic gains that improved packaging solutions would yield, such as lower handling costs, define where waste/inefficiency problems occur, and identify cost saving opportunities.

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BILLERUD

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FOOD-PACKAGING BARRIER FROM RENEWABLE RESOURCES

Today is the most knowledge about dispersion barrier empirical and when making a barrier it is important to understand why it is a barrier. The research is today focusing on making dispersion barrier from renewable resources. It would be preferable having knowledge about the important properties and how to achieve them. With the knowledge it would be easier to make dispersion barriers of renewable resources. Making dispersion barrier from renewable resources will contribute to a reduction of carbon foot-print. To replace the existing dispersion barrier with dispersion based on renewable resources one need to know more about the important properties for the barrier otherwise only qualified guesses will be used.

To be able to understand the barrier properties a model is used, which describes the oxygen mass transport. The model is based on diffusion and solubility of oxygen and this can be expressed as the permeability. For the diffusion, free volume theory is used, i.e. it describes the flexibility of the polymer in order to make room for the oxygen molecules. The solubility part is based in the Flory-Huggins theory.

The mixture in the dispersion will affect the barrier; having polymer in the system then the polymer properties is important, e.g. structure, molecular weight distribution and degree of crystallization. Having clay in the system will contribute to the tortuosity since it is described as impermeable. It is known that the surrounding affecting the barrier, therefore the surrounding temperature and humidity will be taken into account.

In order to try to answer why it is a barrier some experiment is used. The experiment might say the importance of the studied parameter and give a hint of the influence on the barrier properties. The parameter will be taken into account in the model. By combining the experiment with the model it will give more knowledge about the important properties for the barrier.

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EFFICIENT DRYING OF TISSUE PAPER

Thermal dewatering is accountable for approximately one third of the energy use in production of tissue paper. Drying performed at a high degree of gas recirculation, i.e. a high dew point of the exhaust gas, is shown to reduce the specific energy use and to improve the potential for drying process heat recovery.
The aim of the initial phase of this PhD-project is to determine how drying at high dew point gas conditions will affect heat transfer from the drying cylinder to the paper web. An important output will be the possibility to study how the dryer shell transient surface temperature varies during operation. This calculated temperature profile can be used for:

- Determination of energy transfer ratio for cylinder and hood
- Correlation of dryer surface temperature on papermaking process related events
- Structural analysis with dynamic temperature boundary conditions

Initial work has focused on studying existing literature within the area of paper drying and to create mathematical models for the coupled heat- and mass transfer that occurs during the dewatering process. A program to measure temperatures and dryness levels on the Metso pilot machine has been prepared. Focus for the measurement program is to establish cylinder to web heat transfer rates during the wet pressing part of dewatering. The measured data will primarily be used to check correlation between measured and calculated data.

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INVESTIGATION OF THE NON-UNIFORMITY DURING DEWATERING AND DRYING OF TISSUE PAPER GRADES

During the spring and summer, the main focus of my work has been to investigate the possibilities to use infrared (IR) and near infrared (NIR) cameras in order to characterise the moisture content of a lab sheet during a drying sequence.

The IR camera is used for IR thermography, where it's possible to capture image sequences showing the temperature of a sheet. Since evaporating water is an endothermic process the sheet is cooler than the surroundings as long as it is drying. When filming a drying sequence the temperature of the sheet reveals when the drying is completed.

To understand and quantify the influence of non-uniformity in sheets, lab sheets of four different grammages have been produced and dried while filmed. The average temperature of the sheet is calculated and logged against time. Initially there is a sharp drop in temperature, and then the temperature slowly increases until all water is removed. An interesting result from these measurements is that the sheets with higher grammage somewhat unexpected actually reach a lower minimum temperature before the slow increase in temperature.

While IR thermography and NIR dot measurements are well documented techniques, using NIR images is not as common. Water is highly absorbent of light of NIR wavelengths, so by measuring the intensity of the reflected light, the NIR images reveals where moisture is present. Since light must be reflected against the surface of the sample, controlling the illumination becomes very important. After evaluating several sources of illumination, an IR heater has been found to provide the best illumination.

If it's not possible to eliminate all other light sources, it's also important to remove artefacts of unwanted illumination in the signal. To achieve this, it would be suitable to have a highly reflective diffuse surface always present in the image sequence, from which a mean of the background noise can be calculated. Such equipment is being evaluated for investment.

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INNVENTIA

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A NEW SENSOR FOR IMPROVED FIBERLINE CONTROL

A new pulp mill sensor that measures the content of dissolved lignin in pulp slurry has been developed by BTG Instruments. This sensor uses a unique method for the analysis of dissolved lignin that results in a robust and accurate lignin determination. By using this state-of-the-art sensor it will be easier to control the washing efficiency of the different washers in the pulp mill, which will lead not only to reduced energy consumption and lower production cost but also a lower environmental impact. The sensor can also be used in bleaching control, thus ensuring an optimal consumption of bleaching chemicals, which will also lead to the benefits mentioned above.

Several sensors have been tested in different positions at a number of sulphate and sulphite mills in Sweden and abroad. The sensors have been installed in positions with different consistencies, ranging from 1 % up to 10 %. The positions have not only varied in consistencies but also in black liquor concentrations, hence significantly different dissolved lignin contents. Sensors have been installed in the brown stock washing stages as well as before the first bleaching stage.

Without disclosing too much information, it suffices to say that the results have been very encouraging. It has been possible to determine the dissolved lignin content in pulp slurries irrespective of consistency. Positions early in the pulping process and positions later in the process have all shown good results. One mill has connected the sensor to its DCS system and is currently using the results to control one of its washers.

The sensor has also been evaluated in the pump loop at BTG Instruments' R&D laboratory in Säffle. Various process conditions have been simulated in order to understand the implications of black liquor content, consistency, flow, temperature and pH. The results have shown that the sensor is very robust in its performance regardless of the differencies in the mentioned parametres.

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