Highlights 2012

Water management in the paper industry: Solving scaling problems and recovering recyclable materials by means of membrane processes

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Paper production requires large amounts of water. To produce 1 ton of paper, a paper machine needs several hundred m³ of water. Skillful circuit design and re-use have brought the fresh water demand of an average paper production unit down to around 10 m³ / t today. Water extraction and treatment play an important role in the economic efficiency of the paper industry. For this reason, Papiertechnische Stiftung (PTS) in Munich organized two seminars on the topic of water from 11 to 13 June 2012, under the headings “Membrane technology in the paper industry” and “Water circuits in paper production”. The first one was carried out in cooperation with the Deutsche Gesellschaft für Membranotechnik DGMT e.V., supported and represented by Dr. Ines Bettermann (CUT Membrane Technology GmbH & Co.KG). With around 50 participants mainly from paper mills and plant construction companies, each of the two events attracted great interest. Lectures were presented by experts from the industry, universities and PTS.

Membrane technology in the paper industry: A success, despite critical conditions

Although membrane systems have become state of the art in many industries, they continue to be an exception in the paper sector. This may be due to the high volume flows or sometimes difficult water compositions involved, for example calcium concentrations of > 300 mg / L. The seminar, which has been organized for the fourth time in a row by PTS, nonetheless demonstrated that membrane systems can be used economically and successfully also in the paper industry. Widely known, but of constant interest, is the MBR technology (Ingulf Schroeter lecture, Hager + Elsässer GmbH), which is currently used in nine large-scale installations in European paper mills. The technique of coating pigment recovery from the wastewater of high-quality paper coating processes has been known for more than 20 years as well. The presentation of Ms Tuija Kuula (Metso Paper Inc.) showed that it can be used very economically with an ROI of <0.5 years. This was confirmed by a reference list of 40 full-scale plants worldwide. The applied ultrafiltration technology from Metso Paper Inc. is also suitable for the treatment of so-called white waters and thus the actual circuit water of a paper mill. Mr. Thomas Boehme (Propapier PM2 GmbH) presented one of these systems, which has been operated very successfully and without technical problems in the mill for some time.

Recovery of recyclable materials from wastewater

Applications, where membrane technology is not only used to treat water, but creates direct economic benefits for the operator by recovering another valuable material, were of particular interest. In this context, the seminar participants discussed ongoing developments of membrane techniques for the concentration of lignin and hemicelluloses. Dr. Frank Lipnizki (Alfa Laval - Business Centre Membranes A/S) presented an industrial plant for the extraction of hemicellulose from the wastewater of a pulp mill that will soon be put into operation. A variety of uses are conceivable for both lignin and hemicelluloses, e.g. to produce biopolymers or alternative fuels. A presentation about anaerobic MBR technology met with great interest as well (lecture by Dr. Benjamin Simstich, PTS). In principle, the procedure is the same as in a conventional (aerobic) MBR, but membrane operation is linked to an anaer-
obic reactor here. The advantage of the process is that it generates biogas with at the same time minimal energy demand and residue production. The technology is currently under development in several companies and several full-scale plants have already been implemented, though so far not (yet) in the paper industry.

**Innovative applications**

Mr Buurmann-Behne (Pall GmbH) presented a cost-effective alternative to traditional sand filters for freshwater treatment in paper mills: a dead-end ultrafiltration system with minimal flushing water volume. Other technological developments that proved to be of interest to the professional audience included a pretreatment process for water softening (PhD Marie-Pierre Denieul, Veolia Environnement Recherche & Innovation) as well as the ZELIX membrane system of PANTREON GmbH (lecture by Dr. Andreas Lüer, see Fig. 3) with practical examples of biomass ultrafiltration from anaerobic digestion.

**Future workshop: Results of ongoing R & D activities**

The development of a ceramic nanofiltration membrane having a separation limit of 200 D enables entirely new applications of membrane technology. The known advantages of ceramic materials, especially their high resistance, make it possible to use this membrane in highly demanding areas, e.g. processes with very hot partial streams (lecture by Dr. Hannes Richter, Fraunhofer-Institut für Keramische Technologien und Systeme IKTS, Institutsteil Hermsdorf and Ms. Daniela Roemer, PTS).

The last three lectures of the seminar were devoted to other ongoing research and development projects. Organizer Dr. Simstich presented his research on the use of submerged MBR technology at 50° C. This unusual membrane use indeed poses a challenge to biology and materials, but opens up opportunities and possibilities that cannot be offered by conventional mesophilic MBR operation. Ms Daniela Roemer (PTS) presented the goals and first results of the EU research project “CapWa”, which investigates the use of gas permeation membranes for water recovery from the moist exhaust air of paper machines. The event was concluded by the lecture of Mr Sebastian Tews (GKU Gesellschaft für kommunale Umwelttechnik mbH), who introduced a project about concentrate treatment conducted by the University of Stuttgart (Department of Sanitary Engineering, Water Quality and Waste Management).

**Re-definition of aims for the use of membrane processes: Valuable materials instead of only H2O**

To sum up, three central statements can be made about the future of membrane technology in the paper industry:

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The text is about the development and implementation of innovative processes in the paper industry, focusing on biogas generation, dead-end ultrafiltration systems, ceramic nanofiltration membranes, and submerged MBR technology. It highlights recent technological advancements and ongoing research projects, emphasizing the potential for using membrane technology to produce valuable materials rather than just water.
Membrane processes used for water treatment only have certainly potential for further development; but on account of their lower economic efficiency they only have a chance in isolated cases today.

The biggest opportunities for further developments and new installations are offered by membrane processes that recover recyclable materials in addition to water treatment. The following processes have proved to be particularly promising here: coating pigment recovery, the anaerobic MBR process and the extraction of lignin and hemicelluloses.

Membrane processes for fresh water treatment offer advantages and will be developed further.

Against this background, it was decided to organize the seminar again in 2014, focusing on the "Recovery of recyclable materials from wastewaters of the pulp and paper industry".

Scaling problems in the water circuits of paper production

The seminar “Water circuits in paper production”, which has been held by PTS every two years for many decades, had an entirely different focus this year: Scaling problems, focusing especially on the causes and possible avoidance strategies. The use of CaCO3 as filler and coating pigment is standard practice in papermaking. Recovered paper, the main raw material used for papermaking today, introduces large amounts of calcium in the mill water circuit. In recent decades, it has become increasingly evident that closed loop recycling management and the multiple recycling of papermaking fibers tend to raise the calcium concentrations in the circulation waters of paper mills (lecture by Georg Hirsch, TU Darmstadt, PMV).

There are basically three options to prevent lime deposits: avoiding the introduction of calcium, targeted precipitation and removal of calcium, or avoiding the dissolution of CaCO3 from recovered paper to retain most of it on the fibers and remove it from the circuit with the new paper product. Based on the carbonate balance, pH is the central parameter here. The fact that microbial activity has a major influence on the pH of complex water circuits as well was highlighted by two presentations on biocide use given by Ms Elke Tiedtke (Kolb Distribution Ltd.) and Mr Roland Fliegen (Ashland Industries Deutschland GmbH). The relationships between pH and anaerobic microbial activity as causes of odor problems and scaling as well as an optimized water circuit design were explained by Mr Holger Jung (PTS) (see, Fig. 6). His presentation was based on the experience and data gained by consultancy and research projects on water circuit optimization, a service PTS has been providing to its customers from the paper industry for many years. Together with the project partners from industry, PTS regularly develops customized solution concepts to reduce odor or scaling problems.

The lectures by Mr Bernd Mueller (Siemens AG) and Mr Frank Wiemeyer (KOWITEC Ingenieurgesellschaft für Wassertechnik mbH) introduced various technological possibilities for the specific elimination of calcium carbonate from water. Dr. Torsten Richter (BK Giulini GmbH) showed in his presentation that lime deposits can also be prevented with the help of chemical additives (see Fig. 5).

To sum up: Even though scaling problems have been an issue in the paper industry for decades, they continue to be high on the agenda to date. In particular the trend towards increasingly closed water circuits and the higher calcium contents of recovered paper contribute to this development.

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Fig. 5: Calcium carbonate deposits on a membrane: The effect of antiscalants is clearly visible in the SEM image (lecture by T. Richter, BK Giulini GmbH)

Fig. 6: An optimized water loop makes it possible to reduce anaerobic microbial processes as well as the formation of organic acids. This raises the pH and reduces the dissolution of calcium carbonate, causing its concentration in the water circuit to decrease (lecture by H. Jung, PTS)