6.5 Emerging Techniques

In this section, some “promising techniques” are addressed that can not (yet) be considered BAT due to the stage of development of these techniques. Nevertheless, in due time, they may qualify as BAT and therefore they are described briefly here. It should be noted that the description of promising techniques in this chapter is not intended to give a complete overview of all relevant developments.

Introduction
Recent developments and anticipated technology shows that the paper mill of the future can be probably described by the following characteristics:

- Decrease in paper mill water consumption and specific emissions by means of increasing water re-use, closed water loops and internal water treatment
- Increase in electricity consumption (specific to production)
- Decrease in paper mill noise level

Dynamic simulation and total site integration tools will provide new help in complex optimising task to manage the entire paper mill process. Automation and "intelligence" in paper machines will increase rapidly and become embedded in the paper machine. Sensors for instance will predict paper properties with help of few appropriate measurements and this will enable fast and efficient control of the process e.g. in grade change situations. New measuring methods are needed to manage fast processes. Besides consistency and flows measurements also on-line chemistry monitoring systems will become tools for process optimisation.

Cost of investing in new, more complex technologies is a significant factor in paper mills' profitability and is in favour of big units. The current trend to big mills is expected to continue. Increasing effectiveness and decreasing of emissions go hand in hand. The complexity of water treatment technologies tends to increase. To take care of these techniques and maintain them properly is again a challenge for smaller mills.

In the following sections promising novel techniques for reduction of raw material use and emissions are presented. These techniques are still under development. Some are currently researched with a promising perspective for future applications, others run already on full scale in a few applications.

Information include a short description of the technique, an assessment of the status of development, environmental benefits and cross-media effects, economical considerations, if data are already available, and a reference.

6.5.1 Minimum effluent paper mills - optimised design of water loops and advanced wastewater treatment technologies

Description: Advanced wastewater treatment in pulp and paper industry is mainly focused on additional biological- membrane-reactors, membrane filtration techniques such as micro-, ultra- or nano-filtration, ozone treatment and evaporation. Due to relatively less full-scale experience, sometimes relatively high costs and increased complexity of the water treatment, there are only a few full-scale applications of tertiary treatment of wastewater mill effluent up to now.

However, these techniques especially have a potential to be applied as in-line treatment as so-called "kidneys" to eliminate well aimed those substances that negatively interfere with the efficiency of paper production or paper quality.

An example of how to apply a combination of membrane filtration, ozonation and evaparation for process water treatment in a paper mill are shown in Figure 6.25. However, the choice and arrangement of the kidneys in the production process has to be determined case by case.

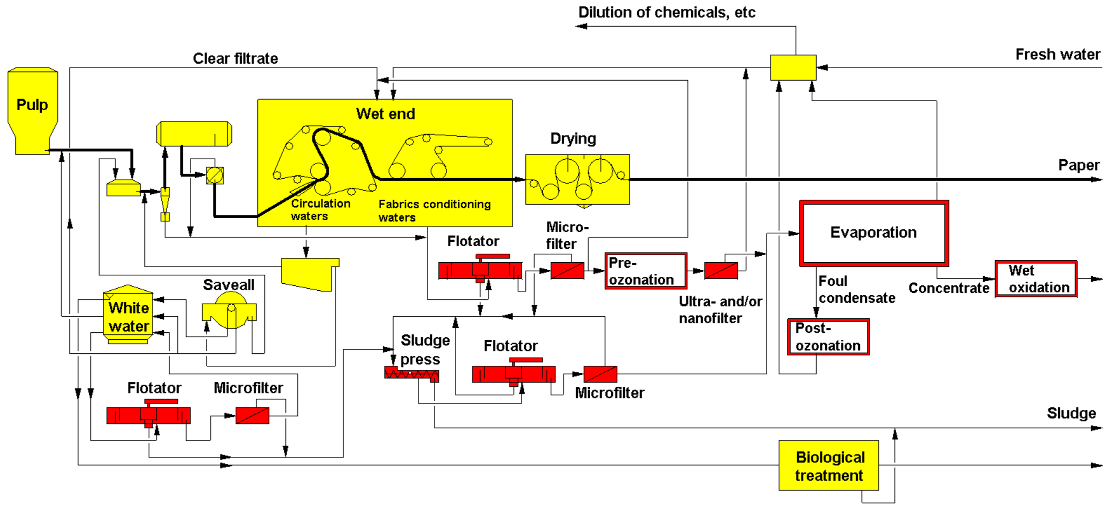

Figure 6.25: Toolbox for possible internal treatment and reuse of paper machine waters [Edelmann, 1997]

Status of development: Some of these techniques are only applied in pilot-scale. Full-scale experiences in paper mills are limited to a few examples in the world. Depending on the technique applied there are still operation problems and relatively high costs. The latter depend on the application and the local conditions.

However, when building new mills or upgrading and increase capacity of existing mills these techniques can be considered seriously. This techniques for water reclamation can also be used to reduce the fresh water consumption in existing mills without having the intention of completely closing the water system. It is expected that these techniques will have further applications in the paper industry in the near future. There is a trend to shift from end-of-pipe treatment to in-line treatment of partial streams of the process water. It can be expected that the pioneers using these techniques are located at recipients where they face very strict requirement or where the water body does not allow increasing the pollutant load. If this mills wishes to increase capacity they have to apply one or the other of the above mentioned techniques.

The status of water treatment technologies in paper industry can be summarised as the following:

- Save-alls filters (common technique). The output of super clear filtrate for re-use can be increased
- Flotation (industrially proven)
- Washing presses (industrially proven)
- Reject and sludge de-watering technique (industrially proven)
- Conventional biological treatment in different variants as e.g. activated sludge (single-stage or two-stage, with and without carrier material), trickling filter (combined with activated sludge), stand-alone submerged biofilters (one- or two-stage) or combined with activated sludge. All these techniques can be considered as industrially proven.
- Biological in-line treatment (first industrial applications realised)
- Pre-filtration + membrane filtration (UF, NF) (first industrial applications realised)
- Pre-filtration + evaporation (first industrial applications realised). If fresh water is replaced with evaporated water there are probably no effects on chemistry and on papermaking.

- Ozonation (first industrial application are to be expected soon). If fresh water is replaced with partially purified water there is a potential of built-ups of disturbing substances. For example, the inorganic salts are not affected and they can interact with process chemicals and equipment. Ozonation is still considered as relatively expensive and less expensive techniques must be developed. These potential effects have to be controlled and the knowledge on the water quality needed have to be increased.
- Enzymatic treatment of process water (under research phase)

Environmental implications: The objective of advanced waste/process water treatment technologies is usually to further remove pollutants that are not removed by common biological treatment as for instance by use of activated sludge plants. Those pollutants are residual COD, colour, nutrients or suspended solids. Advanced water treatment processes produce a high water quality. As a consequence there is a better chance to re-use the "effluent" in the process as fresh water. Thus, advanced wastewater treatment can contribute to further water system closure. However, it can also be applied to achieve lower discharge loads to the recipient.

Very often it is a significant increase of capacity of mills that give the incentive to look for new technical solution with less pollution. Some authorities in Europe require that the amount of effluent and waste of mills that wants to increase capacity must not exceed the level before the investment. This means that new ways had to be found to decrease the fresh water usage and to minimise the amount of solid waste.

Economical considerations: No data available

Literature:
[Edelmann, 1997], [Borschke, 1997]

6.5.2 Impulse technology for dewatering of Paper

Description: The driving force in developing new dewatering techniques in pulp and paper industry, as impulse technology, has been improvements in paper properties. This technology also has the potential for energy saving.

Impulse technology may provide opportunities to achieve high solids content after the impulse unit and thus saving heat energy for subsequent drying. In an ordinary press section the paper web reaches a dryness of about 40 %. In extended nip presses the web may reach dryness levels of about 50 %. From impulse drying, some reports have stated dryness levels of 55-65% before the drying section, which gives a possibility to decrease the heat consumption. Higher dryness levels means that less water has to be evaporated in the drying section by means of steam, and the drying section could be made smaller (shorter). The technology is also expected to provide a smooth paper surface with a high mechanical integrity and a sheet that retains a high bending stiffness. This combination of properties is of great value both in packaging materials and in printing papers.

Impulse technology tries to combine pressing and drying into a single compact process. The wet paper web is exposed to an intense impulse of heat energy under pressure between a press element and a heated element in a paper machine. This induces a sudden increase of the surface temperature of the paper to considerably higher temperatures than employed in traditional technology.

When the paper web gets into contact with the hot surface, generated steam starts to displace water in the paper web. The hot side of the web will be compressed due to thermal softening and may be subject to chemical modification. The web enters a second impulse stage immediately after the first unit. In the second stage, which acts from the reverse side, water is displaced in the reverse direction. The two impulse steps must be adequately balanced to produce a symmetrical sheet.

Status of development: Some different concepts have been investigated and tried under various names such as hot pressing or pressure drying. The development work is still at an early stage.

Many obstacles have been experienced in the development work and the technology has not yet resulted in full-scale implementation. It should be realised that this technology has been investigated and developed since the beginning of the 1970s without any final break-through.

Environmental implications: By increasing the dryness of the paper sheet from 50 to 51 %, there will be about 35 kg less water/t of paper to evaporate. Thus, the impulse drying technology has the potential of reducing the amount of water to evaporate by 175-350 kg/t of paper. This would simply save the amount of steam consumption by 175-350 kg/t or about 0.44 - 0.9 GJ/t of paper (assuming 2.5 MJ/kg steam), corresponding to about 10-25 % of present steam consumption in papermaking.
However, when calculating the energy saving, the energy needed for the impulse drying itself has be taken into account. While for impulse drying high temperatures are needed, steam cannot be utilised. On the other hand, paper mills normally have excess amount of steam available which is also a less expensive energy. Thus, the need for high value energy, like electricity decreases the possible benefits for environment and the potential for profitability.

Economical considerations: No data available

Literature:
[Talja, 1998], [SEPA Report 4712-4, 1997]

6.5.3 Condebelt process

Description: The Condebelt® drying process is a new way to dry paper and board. Initially, the process was simply intended to improve drying of paper and board and it was only later that the big increases in strength properties became evident. In the Condebelt® drying process the paper web coming from the press section is dried between two steel belts instead of traditional steam cylinders, as is shown in Figure 6.26.

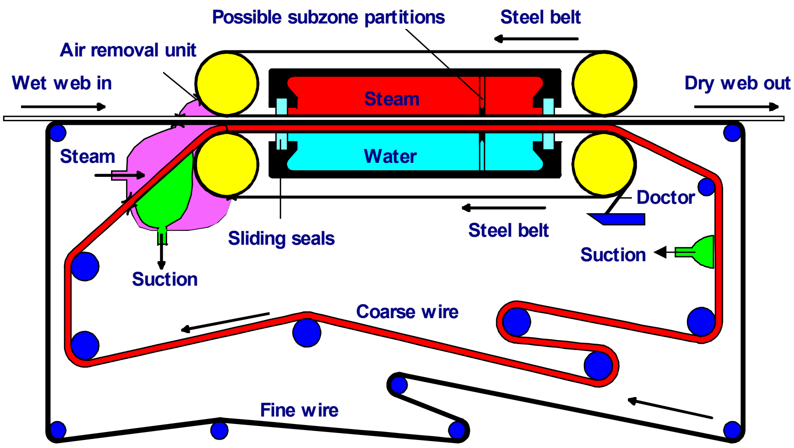

Figure 6.26: Schematic of the Condebelt® drying process (high Z-pressure type)

The web travels between a steam-heated upper, and a water-cooled lower steel belt. The hot upper belt evaporates the moisture in the web and which again will condense on the cooled lower belt. Water is carried away by the steel belt and coarse wire. The fine wire between the web and the coarse wire reduces wire marking on the backside. The web surface against the hot belt becomes very smooth. The high pressure and high temperature within the web result in a softening of the hemicellulose and lignin in the fibre material which "welds" the fibres together. This results in higher strength and better protection against adverse moisture effects. Thus, surface sizing could often be dispensed with, although normally they would be used.

Condebelt® drying improves significantly strength (20-60%), surface smoothness, dimensional stability and resistance against humidity. In Condebelt® drying, with recycled fibres it is possible to achieve the same strength values as with virgin fibres in conventional drying.

Status of development: At the moment (1999) there are two Condebelt® drying processes in commercial operation. The first one has been running since May 1996 at Stora Enso´s Pankakowski mill, Finland, producing core board, linerboard and special boards. The second one started-up in January 1999 at Dong Il Paper Mfg. Co.Ltd.´s Ansan mill in South Korea producing linerboard and fluting.

Bearing in mind that there are two commercial units in full-scale operation, Condebelt® can also be considered as available technique that has reached commercial stage and not anymore as "emerging technique". However, the major driving force to invest in Condebelt® drying is not protection of the environment, but greatly improved product properties.

Environmental implications: The use of this new drying technology does not result in significant direct energy savings. However, the strength improvements give the potential for savings through reduced basic weight. That means, more square meters from the same amount of fibres can be manufactured without loosing product quality. Furthermore, because of the improved paper sheet properties with Condebelt drying, it seems to be possible to use lower grade fibre material or high yield pulp (e.g. 10% less wood per tonne of liner). Higher strength and better protection against adverse moisture effects can have the effect that surface sizing could often be dispensed with, although normally they would be used.
Although the specific consumption of electric energy and primary steam roughly equals that of traditional drying there are greater opportunities to save heat energy. This is because almost all of the evaporated water and its latent heat can be recovered from the cooling water at a fairly high temperature (normally about 80°C). This energy can be used in other parts of the process also using heat pumping.
To summarise: The environmental benefits are potential savings of raw material (fibres, sizing agents) and a somewhat higher potential for energy recovery.

Economical considerations: No data available

Literature/References
[Retulainen, 1998], [Ojala, 1999]

6.5.4 Internal Heat Pumps

Description: Heat pumps are used for pumping heat from one medium (e.g. air) to another (e.g. water) Figure 6.27 shows an example of application for a paper machine.

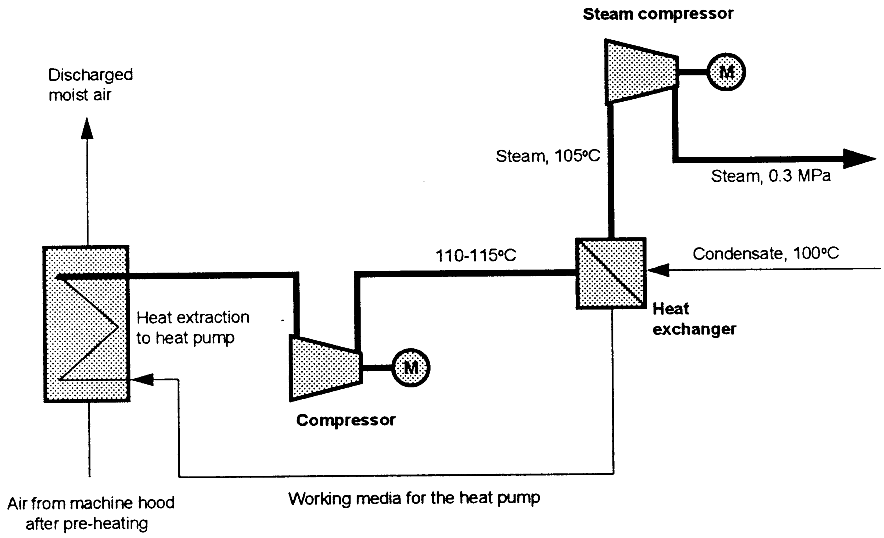

Figure 6.27: System with heat pump for generating process steam
The heat source consists of moist air from a paper machine

Status of development: There are many applications in the pulp and paper industry for heat pumps, but the investment costs are quite high which has hampered the use of this kind of equipment. Furthermore, the environmental problems that are associated with the conventional working media have made the use of heat pumps even more difficult even if the thermodynamics of the heat pump is very advantageous.

Environmental implications: As an example the discharged moist air may hold a temperature of 105°C with a dew point of 61°C. In such a case a heat pump may produce heat corresponding to 750 kWh/t or 2.7 GJ/t by means of only 1/3 or 250 kWh/t of power to the compressor motors. This is based on a coefficient of performance of 3, which is quite normal.

Economical considerations: The potential of this technology is large but the number of actual installations in the pulp and paper industry is small due to the investment cost as well as the mentioned difficulties with suitable working media. Since this is conventional technology, a breakthrough requires the discovery or development of a new suitable media, and also more cost-effective equipment, especially on the compressor side.

Literature: [SEPA-Report 4713-2,1997]

6.5.5 Total site integration tools

Description: Because of the complexity of the papermaking process technological development in the sector has been realised through step by step actions. The complexity of the process can be illustrated by an example on the use of water. Increased recycling of water will lead to a different process chemistry, lower utilisation of secondary heat, different water management practises, new reject streams, changes in the operation of effluent treatment, increased consumption of electricity and reduced consumption of heat. On the other hand, energy consumption is affected also by the production speed of the machine and by unit operation development of the paper machine. The technological choices will have effects on the energy balance of mill site. It can be concluded that intelligent process solution in the future will try to combine the whole energy - water - fibre - chemicals - system to create a good integration of the mill.

Status of development: Several computer-based tools capable to analyse the complex system including cross media effects described below (item 1 to 9) are under development and first analytical studies have been made with integrated paper mills.
However, it has to be pointed out that total site integration tools do not fully eliminate the need for pilot plant studies.

Environmental implications: The key issue is how to come up with process and mill concepts capable to lower emissions to air and water and at the same time to reduce the formation of solid waste and energy. The requirements for the new process are better paper quality and runnability, and better process management. This calls for more knowledge on the behaviour of the processes. Also the changes to the process caused by adoption of new techniques have to be identified so that compatible process technology can be developed.

Consequently, it is clear that new optimisation tools can support the development of future papermaking processes. Some computer-based tools contain the following items or functions:

1. Information on contaminant concentrations in the different parts of the process
2. Behaviour models for the contaminants
3. Process parameters for separation and treatment methods
4. Methods to optimise water treatment concepts with respect to contaminant concentrations and behaviour
5. Identification of heat sinks and sources
6. Methods to optimise the use of heat through careful process integration
7. Information on the emissions from the new mill concept to air and recipient and formation of solid wastes
8. Detailed process design based on the choices made
9. Methods to analyse and to develop the operational runnability of the process

Economical considerations: No data available. The total site integration tool software is not a big investment. But skilled people are needed that have to spend many man-hours to adapt the software to the given characteristic of a mill.

Literature
[Edelmann, 1999]