DIFFERENT WAYS TO DECREASE EMISSIONS IN SC-PAPER MAKING – TO MEET NEW POLLUTION PREVENTION LIMITS

T. Lappalainen * (1); M. Mäkinen (1)

(1) Fiber Technology Center, Laboratory of Paper Technology, Department Chemical of Technolgy, Lappeenranta University of Technology, William Ruthin katu 1, FIN-48600 Karhula Finland

Abstract

In recent decades, the pulp and paper industry has reduced its discharge waste streams and this trend seems to continue. Environmental pressures to minimize the effluent flows in the mechanical pulp production will continue and significance will be emphasized in Europe in the near future. The most recent pollution prevention program in Europe, the EU Directive known as the IPPC (Integrated Pollution Prevention and Control) and the BAT concept (best available techniques) play the main part in this development. The BAT Reference document (BREF) is the background material and handbook for industries and authorities issuing permits. It sets recommendations for certain product grades. The main principle in BREF document is that the higher emission loads to environment are the more intensive ambitions should be also invested in discharge issues.

In this study, emissions of paper mill that produce SC-paper was decreased into the range of BREF-document which is 2 to 5 kg COD /per paper ton by investing in additional separation processes in a TMP- GW- and wastewater treatment plant. The effect of this change on the operation and manufacturing costs were calculated based on process simulation. Options to cut emission costs by increasing the proportion of purchased pulp or fillers proved not to be profitable ways to decrease emissions to BREF-level.

A critical point is to observe that the capabilities of conventional waste water equipment alone are not at present adequate to meet the limits of today´ s pollution prevention programs such as IPPC. The possibility to decrease emissions coming out of the external effluent treatment plants is to invest in additional separation technologies inside of pulping processes and post processing of external wastewater treatment. Simulation cases showed furnish changes are not cost effective ways to decrease emissions. The internal purification stages remove the risks to exceed the emission limits of paper making. These simulation studies show that the best ways to meet pollution prevention limits e.g. BREF – levels is to invest internal water purification and not only count on the capabilities of external purification to eliminate emissions out from papermaking process.

Introduction

In EU, the IPPC-directive (Integrated Pollution Prevention & Control) has been founded for pulp & paper industry to guide in environmental issues. One report in it is the BREF-document in which BAT (best available technologies) have been presented for meeting the specific ranges in emission discharges. It standardizes emissions per ton of product that should be applied in every EU-country. BREF-document does not make any distinguished requirements between old and brand new mills. The general goal of BAT in BREF is to encourage old mills to meet the ranges by making BAT investments in near future. However, old mills have different cost structures than new ones. This results to a situation where straight payback for environmental investments alone might be difficult to find without pressure from authorities. The reason why only ranges have been set in the BREF for certain paper grades and pulping mills is that furnish in paper production varies mill by mill. Guidelines of emissions per product ton cause that more polluting raw material and process concept demands more sophisticated efforts or investments also in

pollution prevention and control issues e.g. in quality improvement investments. In addition, guidelines define that emissions of all fiber components to be produced integrated to paper manufacture lines have to be summed according their shares in the fiber furnish. However, the BREF-document is so defined that one way to decrease emissions is also to increase the portion of purchased pulp or e.g. filler in the product. Emissions of product tons are responded locally.

The more efficient devices have to be employed when BCTMP or Kraft pulping plants are integrated to PM as means to use pulps in SC-paper machine. If the economy or quality properties of paper making do not allow to use neither high share of Kraft or filler content in paper, the ability to purified water in conventional wastewater treatment alone is not adequate to meet IPPC-limits. This is the reality even when wastewater treatment works with maximum possible reductions if fiber furnish is near to improved newsprint. This means case when the major pulp component in the furnish is the high brightness TMP and chemical pulp and filler contents are low in the paper.

IPPC-directive favors to some extent European non-integrated pulp& paper production which purchase its virgin pulps from e.g. Brazil. Another trend is to produce pulps in non-integrated mill e.g. in BCTMP-plant and use this to replace chemical pulp in the fiber furnish. Paper makers in central European can get competitive advantages from this. They can decrease their emissions in their non-integrated paper machines to the BAT-level only by manipulating the furnish of paper. However, virgin fiber producers in non-integrated paper mill can not utilize however the synergy benefits of pulp integration.

An only possibility to oppose this lowering trend in the competitiveness of integrated mills is to find synergy benefits for integrated pollution preventing and controlling in integrated pulp & paper mills. Then instead of two separated systems, one compact water and effluent treatment system is a better option. Synergy benefits and principles of emission control and prevention in integrated pulp and paper mills will be studied further in this paper. The “prevention” is done inside the process and “control” with “end of pipe” techniques. This idea has been followed in this paper as it has been recommended in the directive.

Methods and materials

The manufacture of chemical pulp is the biggest contributor of emissions in paper manufacture as it can be seen in table I. In the first part, it is compared how effluent loads can be managed by manipulating the furnish of paper if integrated chemical pulp is used in furnish. The effluent loads have been presented in table I. The range presented in BREF is ***2 to 5 kg COD per product ton*** for mechanical printing papers in virgin furnish.

The table I Generic emission value ranges after biological wastewater treatment. Efficient performance of biological wastewater treatment is necessity to achieve these values. Data in BREF-document pp.178 [1]

	COD-discharge after biological wastewater treatment [kg/pulp ton]
PGW	3-5
TMP	5-8
BCTMP (spruce) BCTMP (aspen)(1) BCTMP (spruce)(2)	12-30 15-24 3-8
Kraft pulp	8-23 in page BREF-document pp. 104
DIP	3.1 in the page BREF-document pp. 246

(1) Yield losses in ref [2] is converted to COD by multiplying yield losses with 1.6

(2) Effluent free concepts for integrated BCTMP plant producing high brightness BCTMP-pulp has been presented [3], [4]

-at lower limits tertiary treatment also produce reusable water to PM

-higher limit only 70% of BCTMP-plant wastewater is purified for PM.

In the second part of this paper, the low effluent concept is applied in the case of integrated TMP and GW-plant. The process layout is shown in figure 1. The clear filtrate from TMP-plant is purified by combined UF and NF (ultra and nano filtration). The ultra filtrated wastewater form bleach plant is reused in GW-plant. TMP takes its make-up water from the PM. Process concept of TMP is the same as defined in the BREF-document. The process layout in GW plant is very generic. The GW and TMP are bleached by peroxide dosage 2.5%. The filler content in paper and chemical pulp contents in fiber furnish in each case has been presented in Table II. The main goal is to evaluate how many Euros per decrease in COD costs with different ways and which has best effects on discharge decreases.

Table II. The studied cases. The content of filler and the proportion of purchase pulp in chemical pulp usage are used as variables. The way A presents the case where furnish is manipulated and way B presents case where the process concept is changed.

	Way A	Way B
Base case	Filler content 20%, purchased pulp 100 %, total chemical pulp content 20 %	TMP and GW wastewater internal purification UF & NF Tertiary wastewater purification in wastewater treatment block
Case #1	Filler content 30%, proportion of purchase pulp from 0%	Same as in base case
Case #2	Filler content 20% proportion of purchase pulp 100%, total chemical pulp content 30 %	Same as in base case

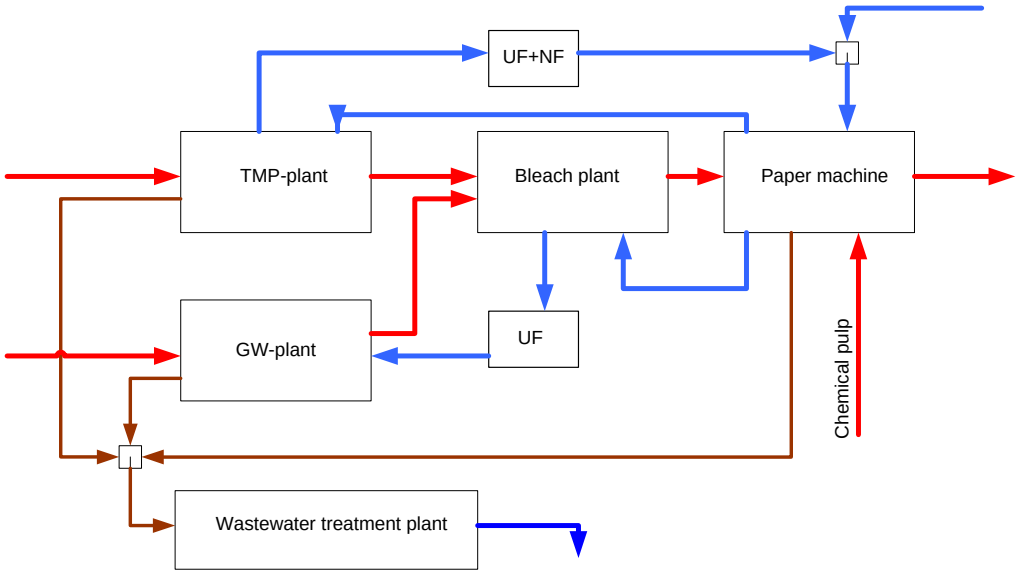

Figure 1. Process layout studied. Portion of produced TMP to GW was 75:25. Wastewater from integrated chemical pulping plant was not treated in the tertiary stage.

Results and discussion

BREF reports that all emissions of integrated pulping departments to paper machine have to be added according to the fiber furnish. The paper mill can operate at lower effluent levels when it uses as much as possible the purchased pulps, because material suppliers will take care of their effluent costs as IPPC is defining. Figure 2 shows totaled emissions with different pulp furnishes if the chemical pulp from integrated pulping plant is replaced by purchased chemical pulps. The range of emissions that BREF-document sets for production of mechanical printing papers in integrated mills (SC and LWC-paper), which is 2-5 kg COD/ton paper is depicted in Figure 2. In this case, the filler content of SC-paper furnishes is around 20%. In this figure, the average furnishes in the mills has been presented. Furnishes naturally vary paper by paper e.g. in different grammages.

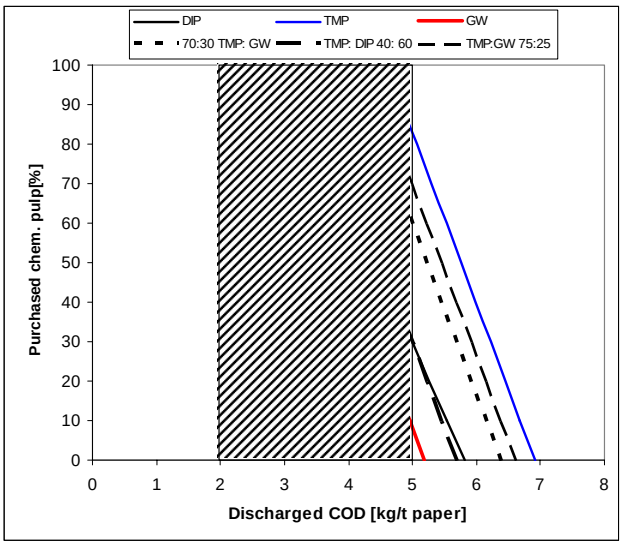

Figure 2. Discharged COD with different furnishes. Virgin filler and chemical pulp contents in total furnish is 20% (except in DIP-case, virgin filler 5%+15% filler with DIP), discharges used in calculation for DIP 4.5 COD kg/t (90%), TMP 8.0 COD kg/t (90%), GW 5 kg/t (90%), after primary clarification and biological wastewater treatment with mentioned reduction of COD (inside the brackets) in the treatment.

Options to get in the limits are to mix GW or TMP with DIP or use TMP and GW mixture in the pulp furnish. The higher the share of GW in virgin pulp furnish is the lower share of purchased chemical pulp is demanded to meet IPPC-recommendations. Discharges from bleached TMP are so high that GW or DIP should be mixed or alternatively the share of purchase chemical pulp in the furnish has to increase above 80%. However, in every mill, the main goal is to decrease the chemical pulp share in furnish by well bonded TMP. Thus there is a contradiction between cost efficiency of production and IPPC-recommendations. As table I shows chemical pulp production is locally the most polluting pulping process although it would not be integrated to a PM. On the other hand, a good question is whether, it is more profitable to make the environmental investments in the TMP-process than to use purchase pulp in paper.

BCTMP process integrated to PM and using conventional wastewater treatment concept does not meet recommendations. However, effluent loads can be decreased by competitive ways. Utilizing synergy of water systems in pulping plant and paper machine additional costs can be decreased to insignificant values as it was reported [3], [4]. Replacing pulp for integrated chemical pulp could be BCTMP. The figure 2 shows this phenomenon. Low effluent concepts enable to use integrated BCTMP and replace

chemical pulp in fiber furnish, especially in integrated chemical pulp application. In the case of integrated chemical pulping, the easiest way to meet IPPC-limits would be to increase the share of integrated BCTM pulp that is produced with low effluent process, because BCTM pulp has the most similar pulp properties compared to other pulp presented in Figure 3 and Table I.

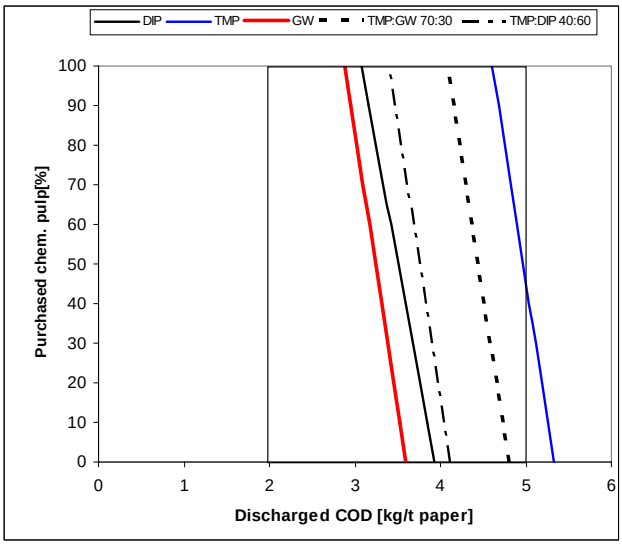

Figure 3. Discharged COD in different furnishes. The share of purchased chemical pulp in pulp furnish is 10% (also in DIP-case 10%), discharges used are 3.1 COD kg/t for DIP (85%), 8.0 COD for TMP kg/t (90%) and 5 kg/t for GW (90%) after primary clarification and biological wastewater treatment with the COD reduction that is mentioned inside the brackets

The integrated Kraft pulping mills have significant needs to reduce emissions. As in the BREF, it has been said that “A significant reduction of both chlorinated and non-chlorinated organic substances in the effluent of pulp mills have to be achieved to a large extent by in-process measures”. The biggest contributor of discharges is the chemical pulping plant in the case where all pulping plants (GW, TMP, DIP or chemical pulp) have been integrated to paper production as it was presented in table I.

The high shares of GW or DIP are only ways to decrease COD-emissions under 5 kg/ ton paper if low filler content and high share of integrated chemical pulp is used the furnish. However, in the case of low chemical pulp content and high filler content, mixture of TMP and GW or DIP has to form a web structure to achieve high enough strength is in post-processing stages (wet pressing, open loops in PM, calandering, coating stages or printing house processing). Runnability of PM can drop to unacceptable state if furnish is changed to wrong direction e.g. too weighted by low freeness pulp. On the other hand, the brightness of furnish is always nearer the mechanical pulp brightness. Thus, emissions per mechanical pulp ton can not be diminished by decreasing amount of its bleaching. Higher share of chemical pulp only affects paper dry strength and decrease emission if it is purchased or bleached to the lower level. The filler retention to fiber network is also limited. Probably, this assumption of 30% is already too high being an average value for manufacture.

In the figure 4, 5, and 6, the effect of biological wastewater treatment plant on discharges is presented. In case # 1 and base case, the discharges are only slightly under the recommended kg COD/ paper ton. The process concepts do not allow any kind of process disturbances in the water treatment or inside pulping and paper making conducted into wastewater treatment plant. Limit is exceeded without investments for pollution preventions and controlling systems. Filtration units inside the process act as preventing units

and tertiary flotation acts as controlling unit in the wastewater management system. In the Figure 4, 5 and 6 is presented, that it is possible to decrease the risk of exceeding discharges limits with studied ways. In the cases of the way B where internal purification stages are employed the discharges are not dependent so much dependent on the reduction capability of the external wastewater treatment plant as in the way A. In base case B, the reduction can vary between 80 and 90%. This range is typical for well-functioning activated wastewater purification plant. Thus, it is possible to operate inside the BREF-limits by process concepts presented and furnish used in base case of way B.

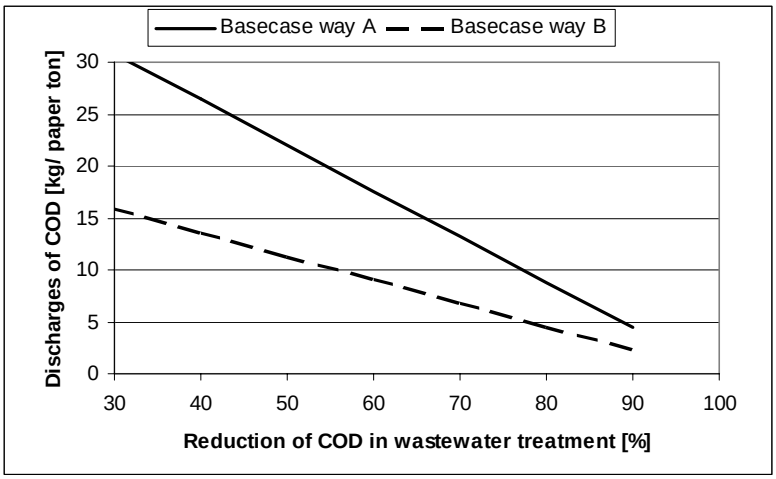

Figure 4. Discharges in base cases. In way A, no additional environment investment filler and purchase chemical pulp contents 20%. In the way B, filtration units in TMP-plant and bleach plant was employed. Furnish is the same way A and B.

In the cases #1 of way A and B the integrated chemical pulp is used in the furnish. Emissions in the way A has been tried to decrease by increasing the filler content from 20 to 30%. The effect of furnish change on emissions load is not as high as desired. Integrated chemical pulp is not possible to use totaled amount in the presented furnish even if after the additional environmental investments. Only way to go under limits is to replace chemical pulp by some low effluent pulp e.g. BCTMP. This is shown in Figure 5.

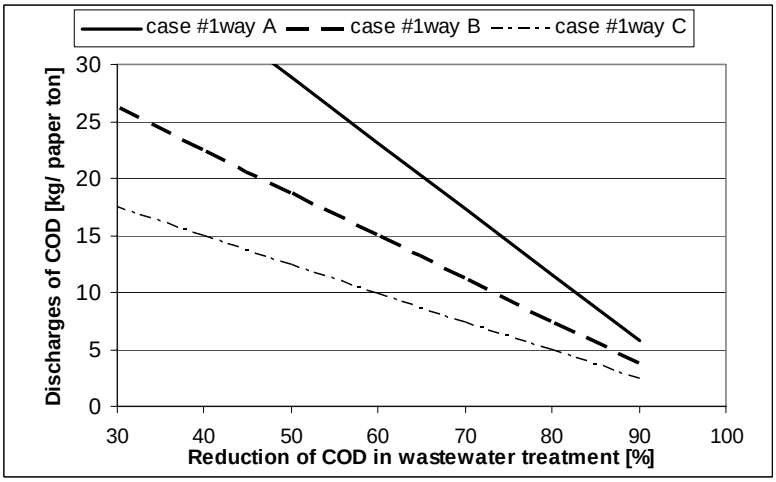

Figure 5. Discharges in cases #1. In way A, no additional environment investment, filler content 30% and integrated chemical pulp content 20%. In the way B, filtration units in TMP-plant and bleach plant was employed. Furnish was not changed between way A and B. In case #1 way C, chemical pulp has been partly replaced with BCTMP.

Case #2 of way B represents the best results in emissions decrease. However, the increase of purchased chemical pulp share up to 30% is very expensive as figure 7 shows. It is possibly a tempting way to meet emission limits. However, the emissions are not decreased to fit the limits with a big marginal even in this case in which purchased pulp portion is the highest (way A). The functioning of external wastewater treatment plant is a necessity if staying inside the limits in the production is the goal. The investment in way B assures that it is very likely to be able to operate the pulping and paper mill inside the limits set in BREF-document all the time.

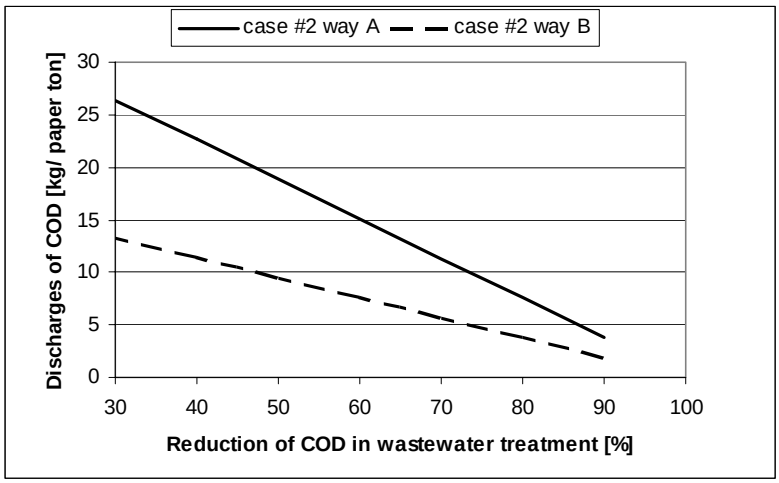

Figure 6. Discharges in cases #2. In way A, no additional environment investment, filler content 20% and purchase chemical pulp content 30%. In the way B, filtration units in TMP-plant and bleach plant was employed. Furnish was not changed between way A and B.

The cost effect of the reduction of emissions on the costs structures of paper making can be seen from figure 7. The total costs versus amount of emissions are the lowest in the case when chemical pulp is replaced by low effluent pulp e.g. with BCTMP.

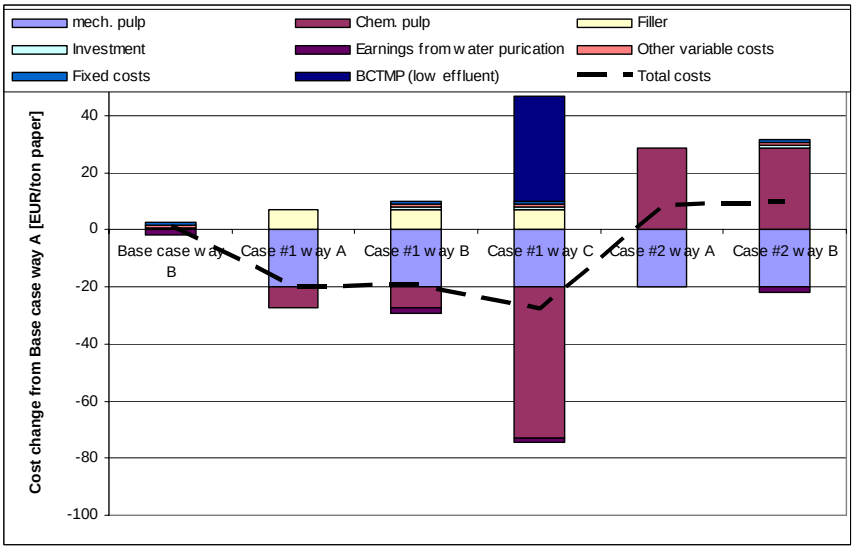

Figure 7. Cost changes from base case. The price of TMP 270 EUR/t, Chemical pulp 400 EUR/t, filler 80 Eur/ dry ton. Costs of UF, NF and tertiary treatment have been comprised and divided into investments, other variable costs and fixed costs. Earning from water purification separated from variable costs. In case #1 way C, chemical pulp has been partly replaced with BCTMP.

As figure 7 shows, the proportion of additional investment for emissions prevention is insignificant when composition of furnish is used as a means to meet pollution prevention recommendations. However, the mechanism showing in figures 4 to 7 that the manipulation of paper furnish is not an efficient way to decrease emissions either in a cost efficient way or from the process point of view. The only cost efficient ways to decrease emissions by furnish manipulations are to increase the filler content and replace the integrated chemical pulp by the low emissions and costs pulp e.g. low effluent BCTMP. The level of emissions is always dominated by the most polluting process, (mechanical pulping or integrated chemical pulp). The concept presented for BCTMP in [3], [4], seems to be easy to be carried out and the more controllable wastewater stream from pulping plant can be achieved. The problem arising in this concept is the cost efficiency of concentrate treatment. In BCTMP wastewater are very similar with TMP but more concentrated because of higher yield losses in pulping [2], [3]. In that case the fuel value should be higher and more the concentrate should be easier to dispose but however, concentrations of inorganic substances are higher which causes problem in the cost efficiency of the boiler. In TMP case, the fuel value can be lower than in BCTMP.

Conclusions

The main principle in BREF document is that the higher emission loads to environment are the more intensive ambitions should also be invested in discharge issues. The way how these emission levels are achieved has not been standardized. It is possible to achieve the limits e.g. by investing more to wastewater purification or add usage of purchase pulps. In this paper it has been presented that it is possible to decrease the emissions of a paper mill into the range of BREF-document that is 2 to 5 kg COD /per paper ton by both ways. Additional separation processes in a TMP- GW- and wastewater treatment plant should be employed compared to generic pulping concepts. Option to cut emission by increasing proportion purchased pulp or fillers are not profitable ways to decrease emissions to BREF-level. Replacement of chemical pulp by BCTMP or and the investments for additional separation equipment are the best ways to decrease emission IPPC-levels.

A critical point is also to observe that the capabilities of conventional wastewater equipment alone are not adequate to meet the limits of today's pollution prevention programs such as IPPC in some specific cases. The possibility to decrease emissions coming out of the external effluent treatment plants is to invest in additional separation technologies inside of pulping processes and post processing of external wastewater treatment. Simulation cases showed furnish changes is not a cost effective way to decrease emissions. In addition, the internal purification stages minimize the risks to exceed the emission limits of paper making. These simulation studies show that the best ways to meet pollution prevention limits e.g. to BREF – levels is to invest to internal water purification and not only count on the capabilities of external purification to eliminate emissions out from papermaking process.

References

1. The European Commission, Integrated Pollution Prevention and Control (IPPC), Reference document on Best Available Techniques in the pulp and paper industry, December 2001 p. i-xv, p.F3-201
2. Holmbom, B., Konn, J., Pranovich, A., Sundberg, A., Willför, S., What is the true yeild of TMP and CTMP? What is lost in refining and bleaching?, *International Mechanical Pulping Conference*, 7- 9 June 2005, Oslo, Norway
3. Lappalainen, T., Heinänen, H., Mäkinen, M., Effluent free manufacture of BCTMP - costs and profitability in the near future, *International Mechanical Pulping Conference,* 7- 9 June 2005, Oslo, Norway
4. Final report of effluent free BCTMP-project, Unpublished