Inline Process Water Treatment In Paper Mill Enables Closed Loop Operation - No Effluent Discharge

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Introduction

As the raw material for the production process, 100% recycled paper is used, inevitably in the production processes of packaging board mills large quantities of water have to be used, which is recycled many times in the papermaking process and finally discharged as waste water. The mill has been reducing its effluent volume through the years and is only allowed to discharge a maximum of 30 m^3/day of treated effluent by the water authorities.

We have experience with **full** integration of process water treatment in the water circuit of paper and board mills. In these so called "zero discharge mills" all process water is reused in the mill after biological treatment.

In 2004, a treatment plant was implemented to treat the water in the closed loop of the paper mill in central France. It is a combination of an anaerobic IC reactor and a conventional activated sludge system.

The use of anaerobic technology has numerous advantages if compared to full treatment in conventional aerobic systems, such as lower energy consumption, energy production from biogas, lower sludge production, better effluent quality, take out of sulphur components, etc. Since the quantity of aerobic sludge production is limited, the discharge of surplus sludge is less problematic.

Closed loop water treatment

In some cases, water is simply a scarce and expensive resource.

Paques BY The Netherlands Paul Boulenger
PB Organization, France

Some paper mills decided in the past to run a closed loop system without any form of treatment. In these paper mills the COD concentration of the circuit-water rises to values of 20,000 mg/1 up to 45,000 mg/1. This causes several problems with the circuit-water, such as odour, higher viscosity, slime forming bacteria, high conductivity, hardness increase, all of which make the paper machine run slower or loose production time. Integration of an anaerobic / aerobic waste water treatment plant in a closed circuit takes away these traditional disadvantages.

At a mill in central France the main reason for implementing circuit water treatment were the odours in the mill, its surroundings as well as in the product.

The process water treatment plant

After initial study of the process water data the following

Table 1 Design waste water characteristics

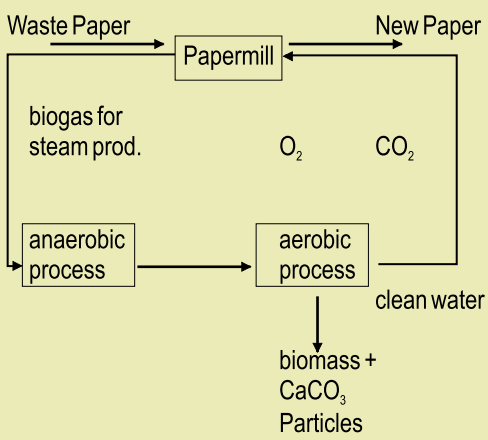
Flow	rrO/h	110
COD-total	mg/l	5,000
TSS	mg/l	200
pH		6.5
Temperature	(°C)	38
SO_4	(mg/l)	200

design characteristics of the process water treatment plant of the mill were determined:

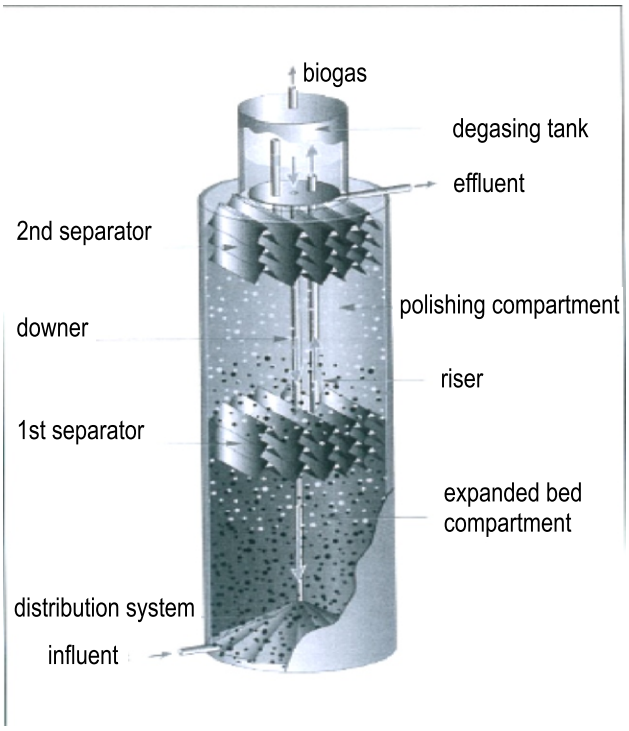
On the basis of the numbers, the following plant sizes were chosen:

The process water arrives from a Waco filter and is collected in a conditioning tank with a volume of 220 m^3, where nutrients are dosed and some acidification takes place. From the conditioning tank the water is fed to an IC-reactor, with a volume of 390 m^3. The effluent of the IC-reactor falls into the aeration tank by gravity. The aeration tank consists of two aeration compartments, each with a volume of 600 m^3. The activated sludge is separated from the treated effluent by a conventional secondary clarifier with a diameter of 18 m. The treated effluent is then reused in the production processes in the paper mill.

Figure 1 : Black Scheme of the closed loop treatment
In-Line Biological Process Water Cleaning Process



Flan 2: Schematic drawing IC reactor.



The plant does not generate any odours, because all potentially smelling off gases are vented and introduced into a filter unit.

A block diagram of the closed loop treatment plant is given in figure 1 .

The use of combined anaerobic and aerobic treatment in zero discharge mills has a number of advantages on physical treatment such as low COD concentrations in the mill, less odor in the mill, better dewatering capacity of the paper on the machine.

Biopaq® IC technology

The bulk of the COD is removed by conversion into biogas in the IC (Internal Circulation) -reactor, a high rate anaerobic system. The IC-technology **was** developed by Pawns in the late Eighties and is available in a large number of standardized sizes, enabling us to provide a tailor made solution for each individual customer. 'To date over 75 of our IC-reactors are successfully operating in Pulp and Paper Industry throughout the world.

The IC reactor can be considered as two anaerobic treatment compartments on top of each other, one high loaded and one low loaded. Its special feature is the separation of biogas in two stages within a tall reactor. The gas collected in the first stage generates a gas lift leading to internal circulation, which gives the reactor its name.

At the mill an IC-reactor of 5 m. diameter and 20 m. high was chosen. This size typically fits for recycle mills of 200 ton/day production capacity.

A schematic drawing of **an** IC-reactor is given in *Figure 2.*

Activated sludge system

As aerobic post treatment a conventional activated sludge system was chosen, the aeration tank is consisting of one line, with two tanks with a volume of 600 m^3 each. Each of the tanks is equipped with a jet aeration system, using Korting-ejectors, which are robust in operation, have good mixing capacities, produce no noise and no aerosols. Besides **this, they** can easily be taken out of the system for maintenance, without having to stop the installation.

Table 2 Quality of the water returned to the mill

COD	mg/l	300
BOD	mg/l	5
TSS	mg/l	20
pH		7.8
Temperature	°C	25 - 35
Ca	mg/l	250
SO4	mg/l	200

Figure 3 : COD load to closed Loop treatment

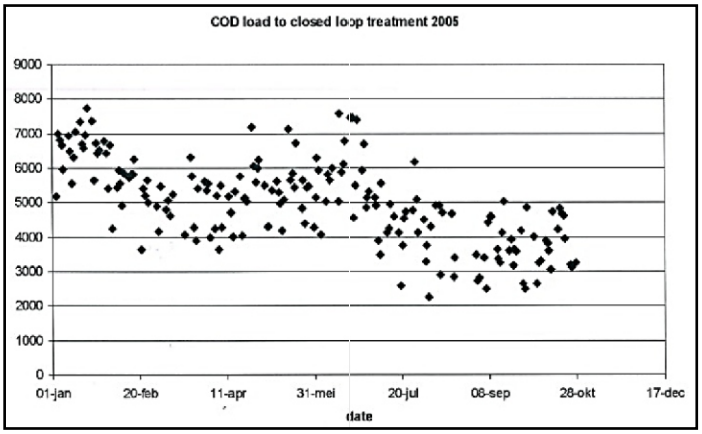


Figure 4: Overall COD removal efficiency 2005

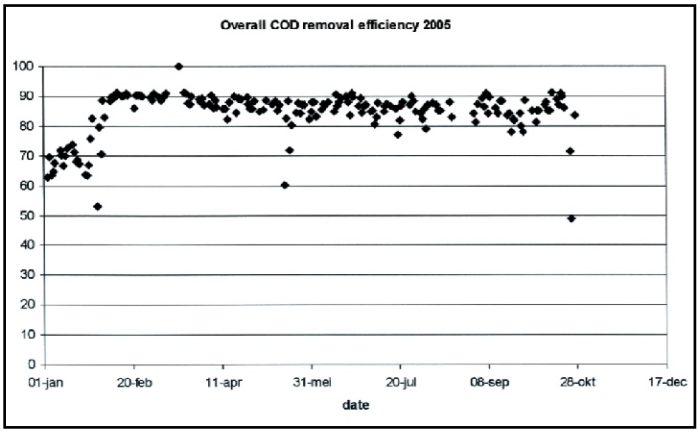


Table 3 Overview of operational cost of zero discharge treatment plant

Item	/year	
Energy	25,000	
Chemicals	30,000	
Maintenance	20,000	2% of EIM Investment
Labour	45,000	1 fte
Sludge disposal	0	all sludge returned to mill
Effluent discharge	0	
Total Opex	120,000	
Capex	250,000 20 years at 7%	
Steam value (biogas)	— 50000	

The outlet of the second aeration tank is falling into the secondary clarifier, which has a diameter of 18 m. The settled sludge is returned to the aeration tanks and mixed with the effluent of the IC-reactor. The effluent of this process water treatment plant is completely reused in the mill and no effluent is discharged to River.

Results closed loop treatment

In this paper, the results of 2005 are discussed, the first full year of operation. During this period the COD load to the closed loop treatment **plant was generally varied**.

For instance, for a mill is between 3,000 and 8,000 kg COD/day, *see graph figure 3 on next page.*

The overall COD removal efficiency of the closed loop process water treatment plant **was** 85 to 90 %, as can be seen in the graph below. About 65 % of the COD was removed in the IC-reactor and converted **into** biogas, resulting in an average biogas flow of 1,200 to 1,500 in /day.

Quality of the return water

The water returned to the mill has a very good quality, which can be summarized as follows:

The operation and the climate in the mill improved significantly after introduction of the process water treatment plant after some initial adaptation issues. The performance *of* the paper machine improved significantly.

Operational cost

The operational and capital cost for treatment of the water can be detailed as follows:

At a production of 50,000 ton/year of paper the actual operational cost of the zero discharge treatment is €1.4 per air dry ton, which corresponds to approximately 0.5% of the product value. This is in line with the experience of other mills with similar treatment although the size of operation has a certain influence. For instance for a troll with a capacity of 350,000 tpy cost evaluation has shown that specific operational cost can even be lower (< €11ton product). The

use of Hops for production of green energy will also bring extra benefit as compared to steam generation. Based on the ROC's certificates in the UK this is an attractive route.

The capital cost for internal treatment are in the range of €4 per ton of paper produced.

Conclusions

In a world where energy prices are rising and climate change because of CO_2 production becomes more and more important, anaerobic technology **becomes an attractive alternative** for treatment of Waste water from paper mills.

In this case, in France for example, an emission reduction of 1500 ton CO_2/year is obtained.

At the mill the performance of the closed loop waste water treatment system has been good. The quality of the return water is of a standard very well suitable for use in the mill and actually improves the climate in the mill as well as the operation of the paper machine.

Traditional disadvantages of closed loop operation in paper mills are taken away with integration of a combined anaerobic aerobic treatment plant within the process water circuit.

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