

Application of biological treatment for zero effluent at packaging paper mills

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Abstract

For the production of high quality corrugated medium and test liner it has been shown since 1995 at a new large size mill in Germany, that no or practically no effluent discharge is necessary when the process water is treated in an anaerobic/aerobic conventional treatment plant, which is followed by sand filtration. In this paper, three different projects are described which show, that the number of process steps can be reduced in order to make the process more simple and compact. The first modification is, that thermo tolerant bacteria are cultivated and utilized for the treatment process and thus, previous cooling is not required anymore. Another improvement in comparison with the German mill is, that all reactor tanks are constructed in the form of vertical tanks with a small footprint and a third new view is, that not all produced effluents need to be of the same high quality standard. Besides further resource conservation and waste minimisation these improvements lead to an economically attractive process for the production of non de-inked recycle grades.

Introduction

In 1995 the first in-line anaerobic/aerobic treatment plant was commissioned in the closed circuit of the new 1000 tpd paper corrugated medium and test liner mill at Kappa Zülpich Papier in Germany (ref. 1 and 2). This mill belongs to the new paper group "Kappa Packaging", which is the packaging paper division of former KNP-BT. During the last four years, a lot of experience was collected and concepts were developed in order to make the design simpler and more compact. One of the first ideas was, that the biological process should be able to operate at water temperatures in the range of 40 to 60 °C, like the actual process water temperature is in the mill. In the existing treatment scheme (see Figure 1) the influent needs to be cooled down to 35 °C before the treatment, which requires extra equipment. This causes extra maintenance costs and results in heat losses. Therefore, research was started into thermophilic anaerobic and aerobic treatment. This research is a joint project by the paper group Kappa Packaging, Wageningen Agricultural University and Paques BV.

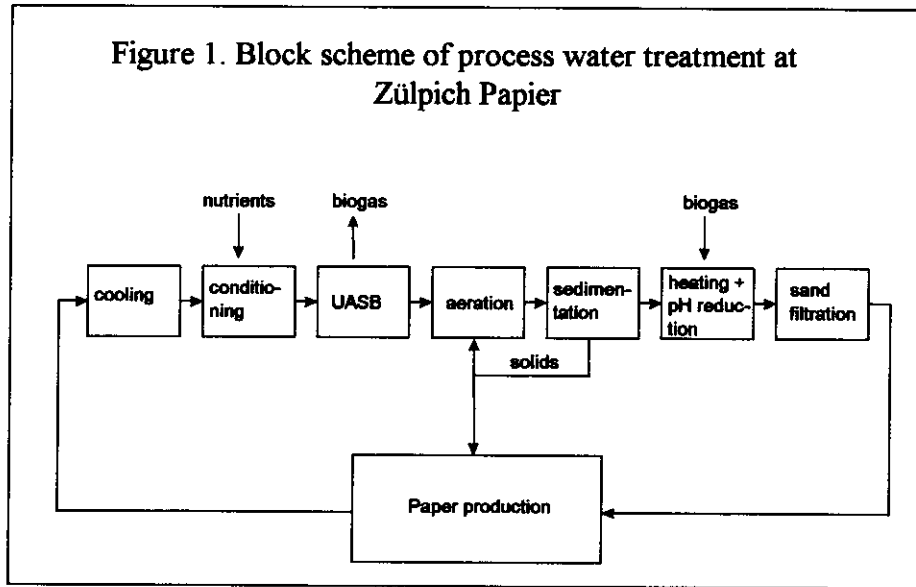
Another issue of importance is, that the process water flow to be treated has to be significant enough to keep the COD level below 5000 mg/l and thus the dissolved Calcium remains below 500 mg/l (there is a typical relationship of COD to Calcium of 10 to 1 in the process water of European recycle mills).

The next point for improvement in our view is, that the aerobic sludge tends to accumulate so much CaCO₃, that it settles almost like sand and after some time a thick layer of sediment is formed on the bottom of the aeration tanks. Therefore, in later designs, vertical concepts for aeration tanks have been chosen.

A further novel consideration is, that aerobic polishing is still necessary after the anaerobic treatment, but the outlet BOD does not need to be at surface water standards and not all of the effluent needs to meet Suspended Solids levels of less than 10 mg/l.

The last key issue is, that the investment and the operational cost of the treatment concept must remain economically attractive.

Above mentioned facts absolutely don't mean that the German plant does not work very satisfactorily. On the contrary, the quality of the entire treatment plant outlet flow is of a high standard for a very acceptable cost level of 3.63 DM (1.8 USD) per ton of paper (capital plus operation). However the question is, if this high quality is really necessary. Besides this, as described above, it has become clear that some operational circumstances can be improved. Our goal is, to design a plant as compact and simple as possible, that takes away the disturbing components from the process water and provides a purified water quality at the specific requirements of the mill. This last point means, that for existing mills, the concept is mostly tailor made.



In this paper, three alternative concepts are presented, that have been installed recently in European paper mills. The first one is the thermophilic treatment plant at a board mill in the Netherlands, which we will refer to as the Dutch board mill. The second one is the process water and effluent treatment concept at VPK Oudegem in Belgium (the Belgian mill) and the third one is the COD removal plant in the closed circuit at Papelera de la Alqueria in Spain (the Spanish mill). Before going into treatment process descriptions of these mills, information is given about the new reactor concept called the Internal Circulation (IC) reactor. This is a more compact anaerobic reactor compared with the conventional UASB reactor, which has been applied in more than one hundred pulp & paper mill effluent projects over the world until now.

Description of the IC reactor

The IC technology is based on the proven UASB process, as it is an up flow granular sludge bed system which is applied as a pre-treatment step in effluent treatment to convert 85% of the BOD into methane gas. In fact the IC reactor consists of two UASB reactor compartments on top of each other, one high loaded in the lower part and one low loaded on top of that. Its special feature is the separation of biogas in two stages within a tall reactor tank. The biogas collected in the first stage drives a gas lift resulting in an internal circulation of wastewater and sludge, which gives the reactor its name.

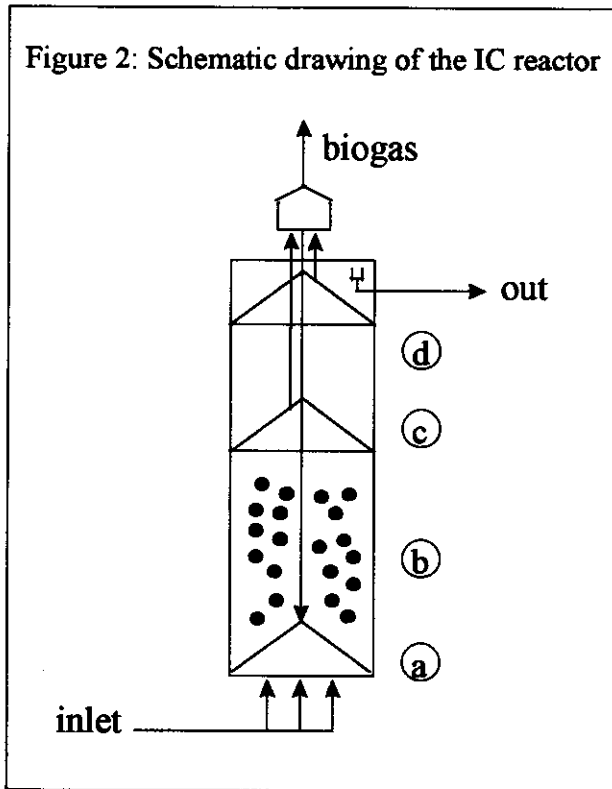
In the IC system four important process steps can be identified (see Figure 2):

- a) Influent feed and mixing system.
- b) Fluidized bed compartment.
- c) Gas collection and water circulation system.

d) Polishing compartment.

a) Influent feed and mixing system

The influent is pumped into the reactor via a distribution system, where it is effectively mixed with the circulating water/sludge resulting in dilution and conditioning of the influent. This distribution system is specially designed to assure an even distribution into the fluidised bed compartment by applying a special hood construction.



b) Fluidised bed compartment

In this compartment the wastewater plus granular sludge mixture is expanded by the upward flow of influent and circulated water/sludge mixture, to produce a fluidised bed. The intensive and effective contact between wastewater and biomass results in high conversion rates.

The mixed and high active biomass in this compartment makes the IC reactor suitable for the treatment of both low and high strength wastewaters. The biogas produced in this compartment, is collected in a three-phase separator called first settler, where it is channelled into a gas riser. Part of the water/sludge mixture is thus transported to the gas/liquid separator on top of the reactor where the biogas is separated from the liquid and removed from the system.

c) Gas collection and water circulation system

In the gas riser the up flow velocity of the water/sludge mixture is increased by the gas lift principle. This principle is based on the difference of biogas quantity in the gas riser and downer (no pump required). After the separation of the biogas in the top of the reactor the water/sludge mixture is directed downwards to the bottom of the reactor via a concentric downer-pipe, so the recirculation phenomenon of the IC reactor is a fact.

The circulation rate depends on the influent COD and is thus self-regulating: higher influent COD leads to higher biogas flow, leads to more circulation, leads to more influent dilution.

d) Polishing compartment

Having passed the first settler the main wastewater stream continues its route upward through the polishing compartment, where the remaining biodegradable COD is removed and the rest of the generated biogas is collected in the second settler. Due to the low gas production and a laminar relatively low liquid up flow pattern in this compartment, the biomass retention is very good.

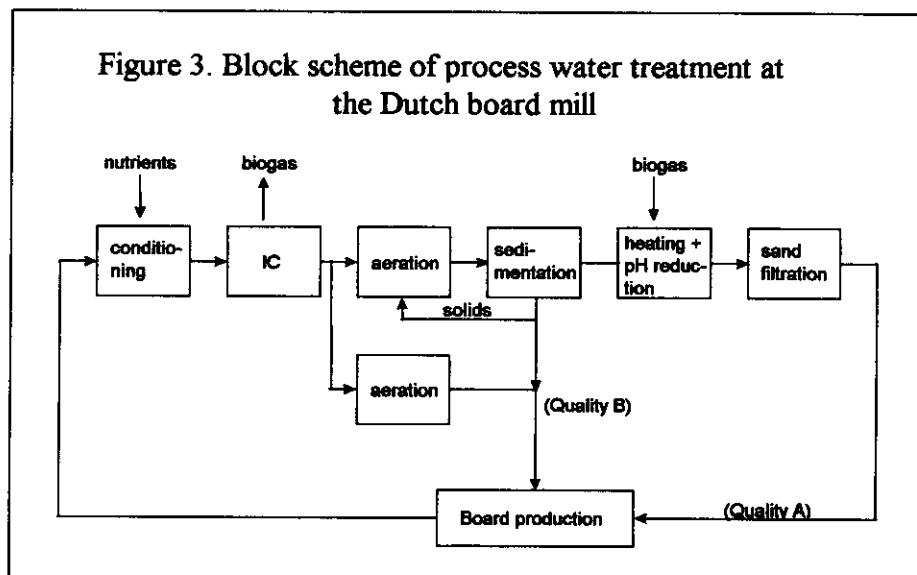
As sludge concentration in this second reactor compartment is mostly lower, spare volume is available for expansion of the sludge bed out of the lower compartment. This prevents sludge losses during high peak loads.

Closed circuit treatment without cooling at the board mill

The Dutch board mill produces 400 tpd of solid board and has been operating with a closed water circuit since 20 years. Due to more COD in the raw fibres material as well as more strict requirements with respect to odour in the paper and in the surroundings of the mill, a treatment plant was needed in order to maintain the closed circuit.

In Figure 1 a simplified block scheme is given for the process water treatment plant at the German mill. As can be seen, there are seven process steps before the water is at the desired quality. In Figure 3, the bloc scheme is given for the treatment concept at the Dutch board mill. The difference is that the cooling has been eliminated and that the water can be treated in two lines. The first line requires six process steps and produces a water quality "A" that is reused by the mill. The second line has only three treatment steps and produces an effluent of lower quality standard (quality "B"), which is suitable for the dilution of the pulp.

Equipment wise it can be mentioned, that the UASB reactor has been replaced by an IC (Internal Circulation) reactor in order to cope with higher temperatures, to increase biomass activities, to improve mixing and to save space. The aeration tanks have been designed with a water level of approx. 10 m, whereas the aeration takes place by externally placed aeration jets that are provided with compressed air. The investment cost level was approx. 2.5 million USD.



The plant has a design load of 90 m³/h of process water in order to maintain the process water COD at a level of 3000 - 4000 mg/l. The operating temperature is 55 °C.

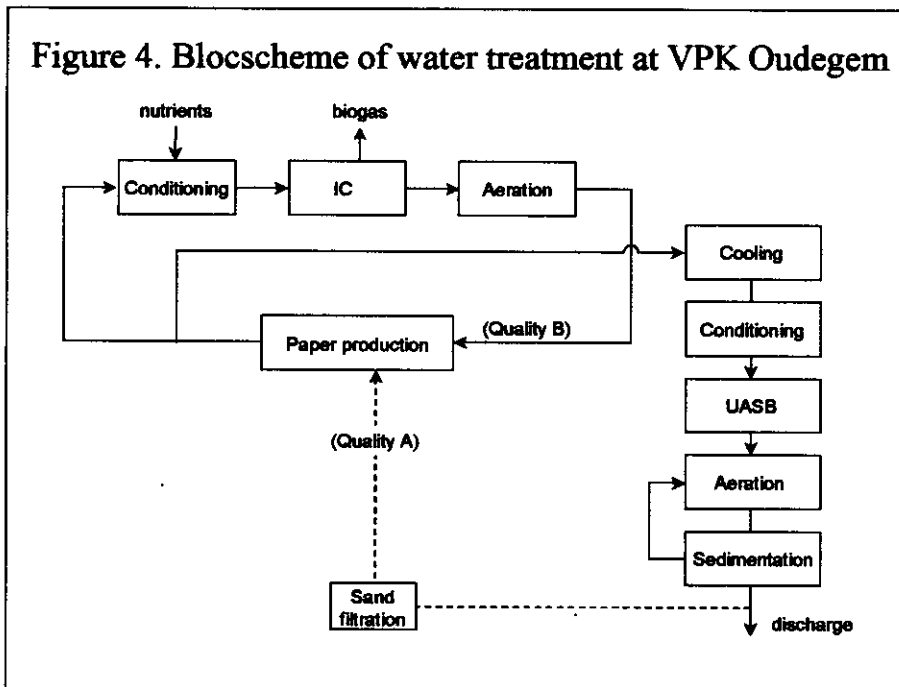
The process water temperature at the Dutch mill was already at 55 °C and the water circuit was already closed completely, so there would not be much time available for cultivation of the bacteria. Therefore thermophilic bacteria were cultivated during one-year operation in a 70 m³ pilot

reactor at another mill and these were transferred to the thermo tolerant treatment plant in October 1999.

Increased production and less effluent at the Belgian mill

VPK Oudegem produces 1000 tpd of corrugated medium and test liner and is increasing its production to 1500 tpd. They already had an anaerobic/aerobic effluent treatment system in place, which can treat a maximum of 150 m³/h of effluent. This plant has developed serious problems with CaCO₃ precipitation due to a gradual increase of inlet concentrations and a limited effluent volume that was allowed for discharge. To enable the expansion it was decided, to invest 3 million USD in an anaerobic/aerobic treatment plant in the water circuit of the mill, thus reducing the COD in the circuit from above 10,000 to below 5,000 mg/l. The circuit treatment takes 300 m³/h of non-cooled clarified water and brings it back in the mill circuit after purification. In this way the bulk of the COD is converted into methane gas by an IC reactor in only a few treatment steps, whereas the existing effluent treatment plant can operate much more relaxed with an influent COD of 5,000 mg/l instead of 10,000 mg/l.

The plant was successfully started up in October 1999. As can be seen in Figure 4, there has also been made a start to recover the current river discharge flow as quality "A" water by means of additional sand filtration. This water replaces fresh water for sealing purposes.

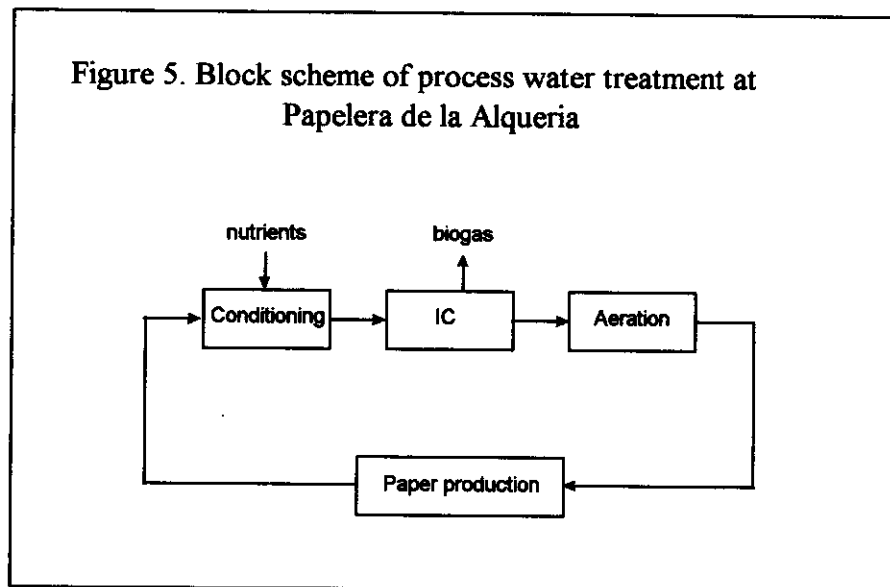


No effluent at the Spanish mill

Papelera de la Alqueria is located near Alicante in Spain and produces 100 tpd of corrugated medium and test liner. The mill is currently going through an extension phase. They are technically capable to operate completely effluent free, but due to the accumulation of too much soluble COD in the process circuit, they have to sluice out polluted water to the sewer from time to time in order to keep the COD below 18,000 mg/l.

It was decided by the mill, to install an anaerobic/aerobic treatment process to keep the COD below 5,000 mg/l. Figure 5 shows in a simple block scheme that the concept consists of only three treatment steps namely conditioning, anaerobic treatment by an IC reactor and aeration. The plant is constructed in a way that the water temperature can be 55 °C, because in closed circuits the heat losses are minimized so that temperatures will increase. Start-up is planned for March 2000.

In order to operate at temperatures from 40 °C to 60 °C it will be necessary to cultivate thermophilic bacteria. Since anaerobic bacteria grow very slowly, this is a time consuming process. In the case of the Dutch board mill, the thermophilic bacteria were cultivated beforehand in a pilot plant, but in the case of the Belgian and the Spanish mill, it will be necessary to increase the temperature in such a way, that thermophilic bacteria can be developed during normal operation.



Conclusions

After successful commissioning of the in-line treatment plant at a new mill in Germany in 1995, further developments were initiated to come to a simpler and more compact treatment concept, which suits the needs as well as the budget of recycle paper manufacturers.

With the commissioning of three new in-line treatment systems respectively in The Netherlands, Belgium and Spain, it is expected that the target of zero discharge at recycle mills will become a viable option for application in existing mills with no treatment yet, for mills that already have an existing effluent treatment plant, as well as for new mills that will be constructed in the future. Due to the operation of closed water circuits, the process water can be quite hot namely 40-60 °C, which is known to improve the speed of the paper machine. The application of thermo tolerant bacteria as described in this paper, keep the treatment process scheme rather simple and provide maximum operational flexibility. New reactor concepts provide better economic alternatives and reduce the footprint of a treatment plant considerably.

Acknowledgments

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References

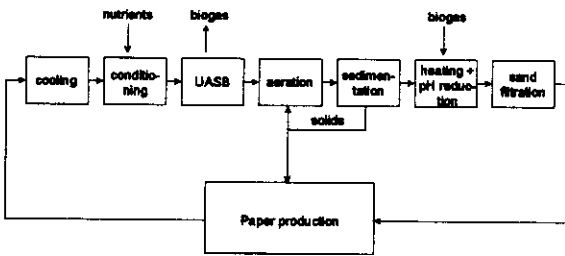
1. Habets, L.H.A.; Knelissen, J.H.; Hooimeyer, A., Improved paper quality and run ability by biological process water recovery in closed water circuits of recycle mills. Tappi Environmental Conference, 5-8 May 1996, Orlando, Florida.
2. Göttching, H.C.L., Totally closed white water system in the paper industry: A case study. ATIP Conference 21 - 24 October 1997, Bordeaux.

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Block scheme of process water treatment at Zulpich Papier



Schematic drawing of the IC reactor

