

Membrane technology for wastewater recycling in textile industry

The situation

Bamberger Kaliko GmbH in Bamberg, North Bavaria, has successfully operated in the textile finishing sector for about 150 years. Their range of products includes textile fabrics for book covers, roller blinds and various technical textiles. Especially in the field of fabrics for roller blinds, Kaliko GmbH is among the leading manufacturers worldwide. They produce about 20 million m² textile, which is a turnover of 30 Mio. € per year.

Bamberger Kaliko GmbH is known for eco-friendly finishing processes without the use of solvent-containing materials, such as chlorine, CFC or PVC. This textile finishing method involves a high process-dependent water consumption of approximately 600 m³/d. The fresh water needed is taken from their own wells and after treatment used in their production. One third (approx. 200 m³/d) of the inflow evaporates. Therefore, only 400 m³/d production wastewater needs to be treated in the company's own wastewater treatment plant before they can reuse the clarified water as service water or discharge it to the municipal sewage treatment plant.

Kaliko have operated their own wastewater treatment plant for 20 years. Previously, their plant existed of a buffer / homogenisation tank, chemical treatment stage, lamella separator, biological treatment stage, sludge treatment stage and collection tank. In the chemical treatment stage upstream of the lamella separator, iron-III-chloride and lime were added to the wastewater flow. The precipitated and flocculated substances contained within the wastewater settled in the lamella separator. The pre-treated wastewater was additionally treated in a conventional biological stage.

The limit values for treated wastewater were defined as follows:

COD < 1.000 mg/l

pH: 6 - 7

Temperature < 30 °C

Production conversions, process modifications and increasing volumes lead to overload of the 'old' plant. It was no longer able to meet the required standards. In addition, the municipality increased the surcharge for heavy pollution so that higher wastewater charges had to be paid. There has been a growing trend of rising wastewater charges in general in the course of the past years. Wastewater clarification has therefore become an important location

factor with an impact on industries' competitiveness and safe-guarding their location.

Bamberger Kaliko therefore decided in 2007 to upgrade their wastewater treatment plant. The aim was not only to adapt the plant to new requirements but also to verify the reuse of nearly hundred percent of the generated wastewater in order to be in the future totally independent of the scarce resource water, discharge standards and rising wastewater charges.

When looking for a suitable concept for clarification and complete reuse of textile wastewaters, it soon turned out that there would not be a standard solution. It was



Dissolved Air Flotation test plant

therefore discussed with several suppliers how to develop an overall solution on the basis of the following pre-conditions on site:

- Discontinuous production of wastewater over the day / week
- Strongly varying pH from 6 to >13
- Strongly varying pollution degree / load
- High intensity and variation of colour
- Temperatures varying between 25 °C and 80 °C
- Sewage sludge compostability

In cooperation with HUBER SE, Bamberger Kaliko developed a first concept, with a MBR plant as the heart of the system.

A four-month pilot test was carried out to identify the general suitability of the MBR process for this application. During the pilot test phase the design parameters required for the biological process and membrane filtration could be determined as well as the necessary method of pre-treatment.

Another requirement was a quality of the treated wastewater that would not negatively influence later dyeing processes. Particulate COD, iron, salt and water hardness are critical parameters in this respect and must not exceed certain limits.

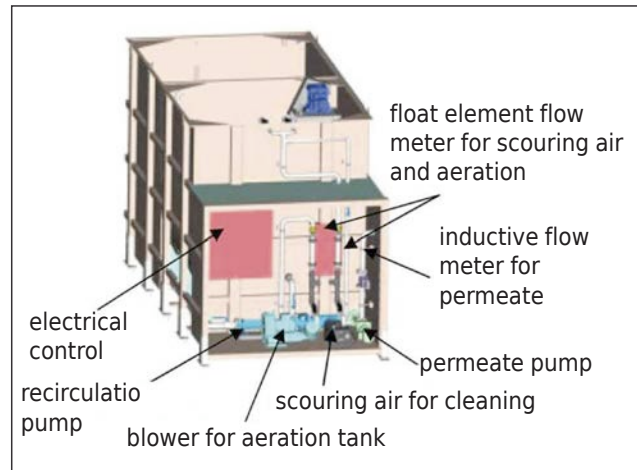
Trial operation and parameters

The wastewater to be tested was taken from the customer's lamella separator. It soon became apparent that solids separation in the lamella separator was insufficient and the precipitated sludge therefore concentrated in the biological stage within a very short time.

Several preceding settling tanks were added to improve solids separation and generate a virtually solids-free inflow. As this arrangement would not be feasible later with the full scale plant, it was decided after the membrane tests to add a test run with a dissolved air flotation plant.

In case a dissolved air flotation plant is combined with the addition of precipitants and flocculants, colloiddally dissolved particles can be flocculated and by means of finest disperse air bubbles separated at the flotation surface. Chemicals dosing and mixing with wastewater takes place in a preceding tubular reactor.

The MBR test plant consists of two chambers, the aeration chamber and filtration chamber. The aeration chamber has a volume of approx. 14 m³. Biodegradation of the biomass takes place in this chamber under aerobic conditions. Via an overflow and circulating pump the aeration



MBR test plant setup



VRM® pilot plant: membrane biology with filtration chamber

tank communicates with the filtration chamber and the rotating membrane modules installed inside.

A "permeate pump" generates an underpressure at the membrane modules with the effect that the permeate is drawn off. Through rotation of the membrane plates and introduction of air bubbles via integrated scouring air lines, a cross flow is generated at the membrane surface that effects membrane cleaning. The VRM® 20/36 with a membrane surface of 108 m² is designed for the average permeate flow of 2 m³/h.

Trial operation and basic results

After some optimisation, both parts of the trials were very successful. The operation with chemical treatment stage and flotation plant achieved not only the separation of solids but also the neutralisation of the frequently varying wastewaters. This created optimal inlet conditions for the MBR plant. The tests were completed after two weeks already. The project engineering phase for the MBR plant was extended to four months to obtain reliable data of biological degradability, membrane tolerance and basic data for scale-up.

HUBER specialists provided intensive support to the local plant operating staff throughout the test phase. The influent and effluent as well as the operating conditions within the integrated aeration chamber were analysed three times a week.

An overview of the analysis results in the form of biological parameters is provided in the table below. Random analysis of the effluent was performed to determine iron, calcium, magnesium and hardness in order to obtain information about the permeate reuse suitability.

Concept for full-scale implementation

After completion and evaluation of pilot testing, scale-up to the real throughput of 400 m³/d began. Individual existing elements, such as the buffer tank and sludge treatment system, were integrated in the final concept. The existing biological wastewater treatment stage, however, was abandoned in favour of the new MBR plant. This is the new plant set-up:

- ▶ Mixing and balancing tank (MAB) with 250 m³ volume

(existing already)

- ▶ Dissolved air flotation plant designed for the maximum flow of 60 m³/h with preceding chemical precipitation and flocculation
- ▶ Biological treatment stage (nitrification) with 250 m³ volume
- ▶ Two VRM® 20/300 membrane filtration plants with 12.5 m³/h throughput capacity and 900 m² membrane surface each
- ▶ 150 m³ permeate storage tank

The existing inlet storage tank has been equipped with a stirrer and serves since to equalize the strongly varying inflow from production. The flotation plant is fed from this tank. The solids-free effluent from the dissolved air flotation plant flows directly into the MBR system. A combined stirrer and aeration system has been installed in a second existing inlet storage tank, which could then be used as the biological treatment stage of the MBR plant. The height of both tanks was increased to create a higher maximum tank volume. The biological sludge flows by gravity from the aeration tank into the two filtration chambers from where the sludge, without the filtrated permeate, is returned to the biological system.

The VRM® membrane units have a membrane surface of 900 m² each. The discharged permeate is collected in the former secondary clarifier and available for further use.

The existing pre-screening system and complete sludge treatment system (for primary and secondary sludge) have been retained unchanged. The new plant was completely integrated in the overall plant concept.

The technical implementation of the plant comprised two

	Unit	COD	BOD ₅	NH ₄ -N	NO ₂ -N	NO ₃ -N	PO ₄ -P
Average inlet values	[mg/l]	2810	700	10.18	1.03	4.36	19.08
Average permeate values	[mg/l]	154	12	0.73	0.28	7.28	8.01
Reduction	[%]	94.5	98	92.9	72.9	n. b.	58.1
	Unit	Fe II	Fe _{total}	Fe III	Ca	Mg	°dH
Average permeate values	[mg/l]	0.30	0.45	0.16	200	16.4	32.3

Inlet and outlet values and reduction rates of the VRM® 20/36 pilot plant



Stirrer / disperser in bio-tank



Biotank (left), mixing & balancing tank (right)



VRM® chamber



Scouring air introduction into VRM® plant

steps. At first, the flotation plant with chemical treatment stage as pre-treatment facility was installed. As an interim solution until MBR start-up, the virtually solids-free flotation effluent was directly discharged into the local sewer network. Already at that time, the effluent quality achieved was far better than that achieved by the old plant so that direct discharge to the municipal sewage treatment plant was possible. This gave all parties involved sufficient time to install the second treatment stage: rebuild the old buffer tank and install the MBR plant. The membrane plant consists of two lines to have a redundant system. Also other key components have been designed as redundant units to ensure maximum plant availability. The plant was put into operation in September 2008.

Operational experience

The new MBR plant has been in service for about 1.5 years. After an optimisation phase, that became necessary due to strongly varying inflows, the plant has very stably been operating to date, producing high-quality service water for reuse in the production process. Special operational experience could be gained and incorporated as plant improvements.

- ▶ Acidification of the wastewater within the mixing and balancing tank was experienced in the course of plant start-up. This acidification was caused by fractions of coating products within the wastewater that contain starch. The pH was regulated by adding strongly alkaline production wastewater.

- ▶ The precipitants and flocculants applied in the chemical treatment stage of the flotation plant have great impact on the performance and economic efficiency of the overall plant. Sufficient time was therefore taken to identify the type and amount of precipitants and flocculants most suitable for Kaliko's specific wastewaters. Aluminium salt was used as precipitant and anionic polymers as flocculants. The consumption and costs of chemicals are meanwhile lower than with the old plant.
- ▶ Through optimisation of the volume transfer between the biological and filtration chamber the residence time in the biological stage could be reduced with the result of also reduced COD and BOD concentrations within the permeate and longer intervals between chemical purifications.
- ▶ Some of the colourants used for production could not completely be removed and coloured the permeate. Particularly red colourants have turned out to be problematic. The coloured permeate cannot be returned for reuse. Due to the high colour content of approx. 20 m³/d the wastewater is separated into an extra tank and treated in the chemical stage and flotation system to a degree that allows its discharge to the municipal disposal system.

The diagram below illustrates the COD reduction achieved through flotation and the efficiency of degradation provided by the MBR system. Even with the mixing and balancing tank strong COD variations can be observed in the inlet to the flotation and MBR plant, with peaks of

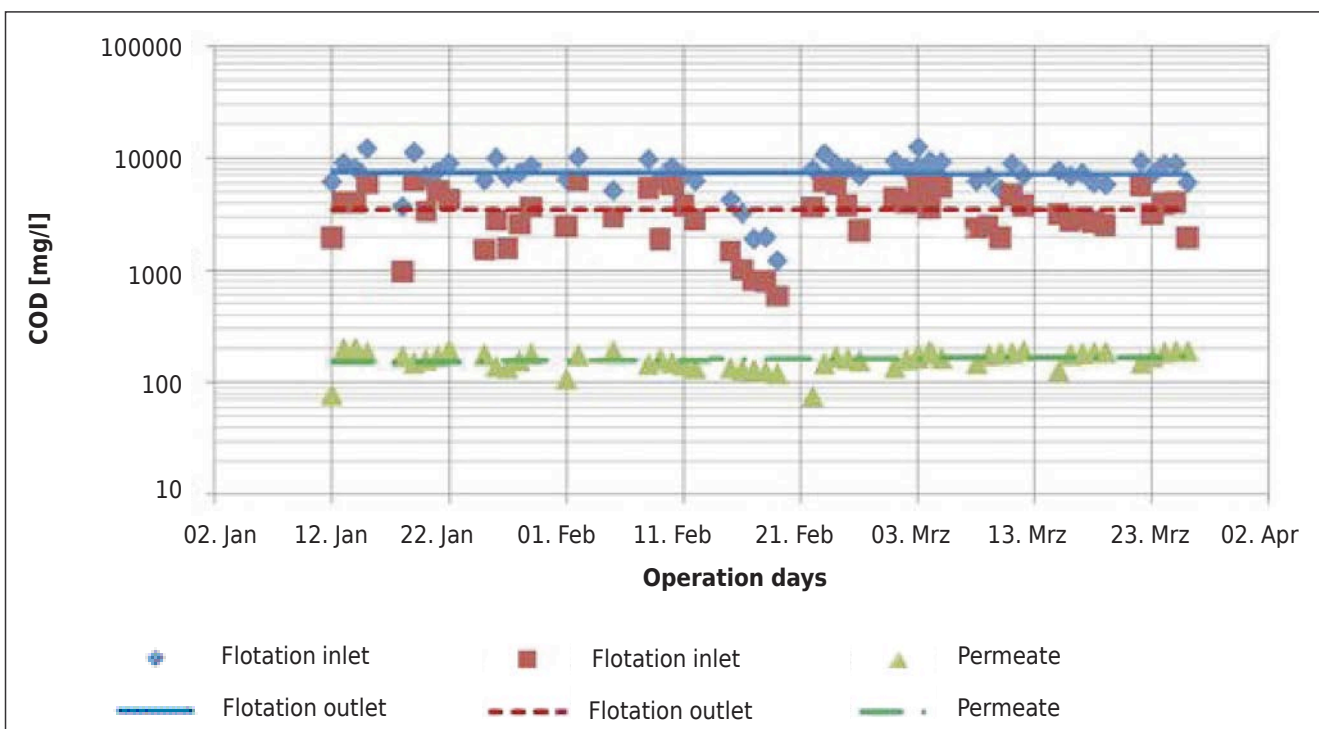
11,000 mg/l upstream of the flotation plant. On average, the flotation plant achieves a COD reduction of 7,500 mg/l to 3,500 mg/l, which is an average reduction rate of 53.3 %.

The MBR plant operates with an activated sludge concentration of 9 g/l and reduces the COD to 170 mg/l on average. The resulting reduction rate is 95 %. The BOD measured in the permeate lies between 8 and 12 mg/l. These measurements and reduction rates give proof of the experience gained from the pilot tests.

Summary

It can clearly be concluded that plant operators benefit from their investment. They benefit financially because they save wastewater discharge fees due to the reduced volumes discharged to the municipal sewer system. In addition, they achieve an image improvement that fits well in their philosophy. They have always placed great value on sustainable and ecological operational concepts. COD values of up to 11,000 mg/l are presently achieved in the plant inlet. These can be reduced to below 200 mg/l in the effluent from the MBR plant. As to the relevant iron concentrations, similar results as in the pilot tests are achieved. Other parameters are currently not determined as they are irrelevant for both discharge and reuse.

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COD concentration development since January 2010