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ScienceDirect
Desalination 201 (2006) 277–289
DESALINATION
www.elsevier.com/locate/desal

Case study of an ultrafiltration plant treating bleach plant effluent from a pulp and paper mill

Anna-Karin Nordin, Ann-Sofi Jönsson*
Department of Chemical Engineering, Lund University, PO Box 124, SE-221 00 Lund, Sweden
Tel. +46 (46) 222-8291; Fax: +46 (46) 222-4526; email: ann-sofi.jonsson@chemeng.lth.se

Received 29 January 2006; Accepted 20 June 2006

Abstract

Bleach plant effluent is treated in the ultrafiltration plant at Stora Enso Nymölla pulp and paper mill. The plant is the largest of its kind in the world, with a total membrane area of 4800 m^2 (2900 m^2 on the softwood line and 1900 m^2 on the hardwood line) and a processing capacity of 400 m^3 bleach plant effluent per hour. The ultrafiltration plant has been in operation since 1995. The operating conditions have been altered with time. In this work the present performance of the ultrafiltration plant has been evaluated and ways to improve the performance further have been investigated. The largest changes are found at the ultrafiltration plant on the hardwood line. On the hardwood line the ultrafiltration plant consists of six stages in series, with a volume reduction of about 98%. A drastic decrease of flux with axial position in the modules in the last stage was revealed. The flux was found to be zero in the last part of the modules because of the high frictional pressure drop caused by the high viscosity (7.7 cP) of the liquid in the last stage. Using a calculation tool, it is shown that the flux in the last stage can be increased and the energy requirement decreased if a higher inlet transmembrane pressure is used or if the cross-flow velocity in the last stage is decreased.

Keywords: Ultrafiltration; Bleach plant effluent; Viscosity; Frictional pressure drop

1. Introduction

Bleach plant effluent is treated in the ultrafiltration (UF) plant at Stora Enso Nymölla pulp and paper mill [1–3]. The plant is the largest of its kind in the world, with a total membrane area of 4800 m^2 divided between two separate lines, the softwood line (2900 m^2) and the hardwood line (1900 m^2). The UF plant removes non-biodegradable, high-molecular-mass organic matter from the effluent, reducing the total chemical oxygen demand (COD) of the effluent by 50%. The low-molecular-mass organic matter remaining in the permeate is decomposed in an activated

*Corresponding author.

0011-9164/06/$– See front matter
doi:10.1016/j.desal.2006.06.004

sludge plant before being discharged to Hanöbukten, a bay in the Baltic Sea. The retentate is incinerated in the bark boiler of the mill.

The UF plant has been in operation since 1995. The closed-loop management of process water in the mill has contributed to an increase in the feed concentration from the original 8000 mg/l COD to more than 10 000 mg/l ten years later. At the same time, increased production has resulted in a feed flow increase from 300 to 400 m^3/h. The aim of this work was to evaluate the performance of the UF plant on the hardwood line at the operating conditions of today and to investigate how the operating parameters could be optimised to meet these conditions. A calculation tool that enables the influence of various process parameters to be studied has been implemented. The tool allows the user to predict the performance of a full-scale UF plant without the need for extensive experimental work; a limited number of experiments are sufficient to perform the calculations. Flux, frictional pressure drop and retention of COD and TS (total dry solids) were measured at varying operating conditions. Bleach plant effluent and retentate from the penultimate and the last stage in the six stage full-scale UF plant on the hardwood line were used in the experiments.

2. The UF plant at Nymölla mill

Stora Enso Nymölla mill is located in the south of Sweden. It is an integrated pulp and paper mill that produces magnesium bisulphite (magnefite) pulp and fine papers. The Nymölla mill has an annual capacity of 470,000 tonnes of fine paper. The pulp is manufactured in two separate production lines, one for hardwood and one for softwood. The bleaching sequence is oxygen, chelate and peroxide (OQP). The O-stage is alkaline and the pH is adjusted with sodium hydroxide. Since sodium causes clogging of the recovery boilers, the effluent from the O-stage cannot be recycled to the recovery system of the mill, but has to be disposed of. In 1992, investigations of methods that could lower the COD of the water discharged to the environment were initiated. After extensive pilot-plant testing, an ultrafiltration plant for the treatment of the bleach plant effluent from the oxygen stage was installed. The plant was constructed by MoDo Chemetics (now Kvaerner Chemetics, Sweden) and PCI Membrane Systems (now ITT Aquious–PCI Membranes, UK) jointly, and was commissioned during the spring of 1995. Data for the UF plant are summarised in Table 1.

Table 1
Design data for the ultrafiltration plant at Nymölla mill [1]. The plant is equipped with tubular membranes (I.D. 12.5 mm, length 3.6 m) manufactured by ITT Aquious - PCI Membranes, UK

Production line	Softwood	Hardwood
Total membrane area (m^2)	2900	1900
Membrane type	ES404	EM006
Nominal cut-off (Da)	4000	6000
Number of stages	7	6
Module inlet pressure (MPa)	0.7	0.8
Cross-flow velocity (m/s)	1.8	3.2
Installed power (kW)	450	800

The bleach plant effluent contains fibres, as do most process streams in pulp and paper mills. Tubular modules are used in the UF plant at Nymölla mill since this module design can handle successfully liquids containing fibres or particles without the need for extensive pre-treatment. The membrane material for both lines is polyethersulphone. For the hardwood line, however, a more hydrophilic material was required to achieve good performance. The manufacturer then developed a new membrane (EM006) with modified polyethersulphone for this application.

The volume reduction factor in the UF plant is high; around 50 for the softwood line and 60 for the hardwood line. The retentate has a COD about