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Ultrafiltration of kraft cooking liquors from a continuous cooking process

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Abstract

Two cooking liquors and a black liquor were fractionated by ultrafiltration. The liquors were withdrawn from different stages in a kraft pulp mill employing continuous digestion. The ultrafiltration was performed at 90°C with two ceramic membranes with cut-offs of 5 kDa and 15 kDa. Only small differences in membrane performance were observed when concentrating the three liquors to 90% volume reduction. The average flux was 55 l/m^2 h for the 5 kDa membrane and about 115 l/m^2 h for the 15 kDa membrane. The concentration of lignin was on average 230 and 155 g/L in the retentate from the 5 kDa and 15 kDa cut-off membranes. The ash content was reduced from 37–40 g/g total dry solids to 20–30 g/g after ultrafiltration.

Keywords: Kraft black liquor; Lignin; Ultrafiltration; Ceramic membranes

1. Introduction

A modern kraft pulp mill has an energy surplus in the form of bark and the lignin present in the kraft black liquor. One way to reduce this surplus is to extract lignin. The demand on a lignin removal process is that it should separate lignin from the cooking chemicals, NaOH and Na_2S, to avoid losses of these chemicals from the mill; preferably the fractionation is done without disturbing the delicate Na/S balance. Two processes have this ability: precipitation and ultrafiltration (UF).

Generally, precipitation is used to extract lignin from kraft black liquor [1–7]. UF has been used mainly to purify the lignin fraction in cooking liquor from sulphite and kraft pulp mills in order to use it as a valuable chemical product [8–10]. Process improvements obtained after UF have also been studied [11–15].

The optimal dry substance for precipitation is reported to be 27–30% [5]. The kraft black liquor used for precipitation is therefore commonly

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withdrawn after the third evaporation stage in the recovery system. The concentration of the liquor to be treated by UF is not that critical, even though the flux of the membranes is reduced as the concentration increases. This means that there is considerable freedom in the choice of liquor for treatment with UF.

In previous studies kraft black liquor withdrawn before the evaporation unit has been used [16–18]. The aim of this work was to elucidate possible differences in membrane performance when treating cooking liquor withdrawn at various stages in a continuous digester. A comparison of the membrane performance when treating kraft black liquor from batch and continuous digestion is found in Holmqvist et al. [19]. UF was performed at 90°C with two ceramic membranes with cut-offs of 5 and 15 kDa.

2. Materials and methods

2.1. Kraft black liquor

The kraft black liquors used in this investigation were supplied by the Södra Cell Mönsterås pulp mill, Sweden. The Mönsterås mill has an annual capacity of 750,000 t of bleached totally chlorine-free (TCF) softwood and hardwood pulp. Continuous digesters are used at the Mönsterås mill. The degree of delignification is kappa 29–31 during softwood pulping.

Three liquors were included in the investigation. The liquors were withdrawn from modified continuous cooking (MCC) circulation, from isothermal cooking (ITC) circulation and before the evaporation unit. Softwood was used as raw material when the liquors were withdrawn. The liquors were used without adjustment of pH. There was no prefiltration of the liquors from the MCC and the ITC circulation, apart from the screen in the digester wall. The liquor withdrawn before the evaporation unit was filtered with a 0.2 mm screen in the pulp mill.

2.2. Equipment

Two ceramic Kerasep membranes (Orelis, France), with cut-offs of 5 and 15 kDa, were used in the experiments. The membranes were made of Al_2O_3-TiO_2. The length of each flow channel was 1.2 m in both membranes. In order to minimize the need of prefiltration, 15 kDa membrane elements with seven channels had been used in previous investigations [16–19] because of the relatively large channel diameter of these elements. However, 5 kDa membranes with seven channels was not available. Therefore, an element with 19 channels was used, even though the feed flow channel diameter is much smaller in these elements (see Table 1). During the experiments, it was seen that fear of blocking the flow channels was groundless. No such blocking was noticed, although no prefiltration was used. Data for the two membranes are given in Table 1.

In the experiments a K01 membrane module (Orelis, France) was used. The module was erected vertically because ceramic membranes have a poor resistance to bending stress induced by vibration in the equipment.

A centrifugal pump (NB32/25-20, ABS Pump Production, Sweden) regulated with a frequency converter (Lust CDA3000, Lust Antriebstechnik, Germany) provided the cross-flow velocity and feed pressure needed. The feed pressure and cross-flow velocity were regulated by the frequency converter and a valve on the retentate side after the module. Pressure was measured before and after the membrane module and on the

Table 1
Data for the ceramic membranes used in the investigation

Cut-off (kDa)	5	15
Diameter of each flow channel (mm)	3.5	6
Number of channels	19	7
Membrane area (m^2)	0.245	0.155