Infrasonic backpulsed membrane cleaning of micro- and ultrafiltration membranes fouled with alumina and yeast

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Abstract

Membrane fouling is universally considered to be one of the most critical problems in the wider application of membrane filtration. In this research microfiltration and ultrafiltration membranes were fouled during a cross-flow filtration process, using yeast and alumina suspensions in a flat cell. Infrasonic backpulsing directly into the permeate space was then used to clean the membrane, using both permeate water and soap solutions. Ultrasonic time domain reflectometry (UTDR) was used to detect and measure the growth of fouling on membrane surfaces, during the filtration and cleaning processes. The objective of this work was to examine the efficiency of back-pulse cleaning, using different combinations of membrane materials and foulants, in flat cells. The results show that a flux value of between 60% and 95% of the clean water value can be recovered after cleaning, by using a sequence of three 6.7 Hz backpulses, each pulse being 35 s long with a peak amplitude of about 140 kPa.

Keywords: fouling; microfiltration; ultrafiltration; backpulsing; ultrasonic; membrane cleaning

Introduction

Membrane filtration was not considered to be a technically important separation process until about 25 years ago. Currently, membrane filtration technology can be found in a wide range of applications in many industrial fields. These include the food, beverage and diary industries, as well as biotechnology, metallurgical, pulp and paper, textile, pharmaceutical, and chemical industries. Likewise, membranes have become prominent in water treatment for domestic and industrial water supply, including seawater desalination and also microfiltration of brackish water (Mulder, 1996).

Membrane fouling is a major problem in membrane filtration technology. Fouling is caused by the adsorption of the foulant, not only on the surface of the membrane, but also inside the membrane pores. This reduces both permeate flux and membrane selectivity, and leads to reduced life time and efficiency of the membranes (Zahid, 1993).

Various techniques exist to reduce membrane fouling and to clean membranes, where necessary. These include chemical cleaning, backpulsing, physical brushing, modification of membrane chemistry, feed particle addition, feed pre-treatment and hydrodynamic techniques (such as turbulent flow, air sparging, and adding inserts), periodic pulsation, and increasing the surface roughness to introduce flow instability. Many of these methods can effectively reduce membrane fouling, but do not seem to be sufficiently effective to give a continuously high flux rate. Backpulsing is a cleaning technique that has been shown to continuously remove deposited foulants from the surface of the membrane (Mores and Davis, 2000).

The backpulsing method of cleaning has been studied by several research groups. Rodgers and Sparks (1991, 1992, 1993) and Wilharm and Rodgers (1996) conducted backpulsing ultra-filtration (UF) experiments with dilute protein solutions (bovine serum albumin) as the foulant, and using flat-sheet polymeric membranes. They found that for laminar cross-flow the flux values after backpulse cleaning of the membranes increased by up to 100% of that of a fully-fouled membrane. They concluded that the reason for the flux increase was that the 'drumhead' motion of the membrane, due to the backpulse pressure (which was lower than the feed pressure), was only sufficient to remove the foulant layer.

Redkar and Davis (1995) used continuous backpulsing during the microfiltration (MF) of washed yeast cell suspensions, with flat sheet cellulose acetate membranes, and found that the permeate flux increased 10-fold over that observed without continuous backpulsing. Redkar et al. (1996) used backpulsing for the MF of yeast suspended in deionised water and obtained permeate fluxes that were up to 85% of that of the clean membrane flux.

Various methods, which provide information about the behaviour and progression of membrane fouling, have been used to measure or monitor fouling in both industrial and laboratory membrane applications (Peterson et al., 1998). The non-destructive and non-invasive ultrasonic technique, which is a comparatively inexpensive measurement technique for the investigation of membrane fouling, can successfully monitor the growth of fouling layers and has been used by many groups (Peterson et al., 1998; Mairal et al., 1999; Mairal, 1998; Li et al., 2004; Mairal et al., 2000). Peterson et al. (1998) found that ultrasonic time domain reflectometry (UTDR) could be utilised for the real-time measurement of the changes in membrane thickness under high-pressure operating conditions. They also found that this technique did not interfere with the collection of standard performance data – for example, the permeate flux.

Recently, Li and coworkers used UTDR to monitor membrane fouling (Li and Sanderson, 2002; Li et al., 2002a,b,c). Li and Sanderson (2000) described the application of the UTDR technique to the continuous visualisation of particle deposition

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