초청강연

Strategis for Low Energy Demand MF of Secondary Effluent for Reuse

김 규 진

(호주 UNSW 분리막연구센터)

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STRATEGIES FOR LOW ENERY DEMAND MICROFILTRATION OF SECONDARY EFFLUENT FOR REUSE

K.J. Kim and K. Parameshwaran

UNESCO Centre for membrane Science and Technology, University of New South Wales, SYDNEY 2052.

INTRODUCTION:

Wastewater reuse is increasingly advocated for a number of reasons: (i) depletion of freshwater resources, (ii) limitations of the potable water and wastewater conveyance systems, and (iii) protection of surface waters from effluent contamination. Compared to the conventional technologies available for the treatment of wastewater to the reusable standard, membrane processes appear to be more attractive as they require less space, less chemicals and less maintenance intensive and easier automation. More importantly a membrane process can produce high quality effluent.

Membrane processes, however, suffer from fouling thus high energy demand is limiting its widespread application. Earlier studies show that it is preferable to filter at constant flux than at constant transmembrane pressure, since it avoids over-fouling during the initial stage of filtration. Further high pressure air backwashing proved to be effective in foulant removal. However, high pressure backwash is an energy intensive process. Therefore developing a strategy that could reduce energy consumption will provide cost saving and make membrane process more attractive option.

In this project we intended to develop an operational strategy so that the energy demand by the air backwashing capable membrane unit can be reduced. For this purpose, membranes are operated at different modes with controlled flux and the results are discussed.

EXPERIMENTAL:

A schematic structure of the membrane system and its operation is shown in Figure 1.
The water to be filtered (Table 1), which is the clarified effluent from a biological treatment system, is pumped by the feeding pump from a storage tank to the membrane unit (USF Memcor), where the suspended solids contained in the feeding flow is separated from the filtrate by the microfilter (Polypropylene, pore dia=0.2 μm, A=1 m^2).

TABLE 1. Typical quality of the feed and permeate of the membrane unit.

Parameter	Feed	Permeate
SS (mg/l)	50-100	0
Turbidity (NTU)	>52	<1.2
COD_{Cr} (mg/l)	140-200	100-145
BOD_5 (mg/l)	30-42	14-20

With the accumulation of solids on the membrane, the trans-membrane pressure (TMP) builds up (see Figure 2). A backwashing of the filter using the compressed air is started as soon as the TMP reaches a pre-selected level (see Figure 2), which is called the backwashing TMP or TMP_b. Each backwashing brings the TMP to a significantly lower level, called TMP_0. Feeding, and hence a new cycle, is restarted after the backwashing. TMP_0 generally increases with the cycles, indicating the deterioration of the quality of the membrane filter due to the deposit of the fouling materials on the surface of and into the pores of the filter. A chemical cleaning is carried out when TMP_0 increases to a certain level. A chemical cleaning removes most of the fouling materials from the filter, bringing the TMP_0 close to that of a new filter.

Most experiments were carried out in dead end mode. A few tests were also performed in cross-flow and intermittent (10 min-ON and 2 min-OFF) dead-end modes. The feed solids concentrations (TSS 40-400 mg/l) were adjusted by adding the activated sludge mixed liquor to the SBR effluent. During all the experiments, the permeate was pumped by a peristaltic pump, hence, maintaining a constant flux (30-90 l/m^2h) throughout a run. At the end of each run the membrane was chemically cleaned using an alkali solution provided by the Memtec.

RESULTS:

Typical TMP profiles of the secondary effluent operated at different levels of imposed flux and solids concentration are shown in Figure 3. At the low imposed flux of 35 l/m^2h; Figure 3a) the air backwash appears to be very effective for foulant removal showing that the backwash brings back to TMP_0 to its starting value (3-5 kPa). However, the TMP_0 increased in each cycle when imposed flux was high (90 l/m_2h; Figure 3b).

Operation at higher imposed fluxes require more frequent backwash than that at lower imposed fluxes, as shown in Figure 4. Higher TMP_b (50 kPa) resulted in not only a greater increase in TMP_0 (not shown) after each backwash, but also increased the time taken for one cycle (Figure 4). However, the increase in cycle time due to the higher TMP_b decreases with increasing imposed flux.

Figure 5 shows variations in cycle time versus net flux (imposed flux) for various solids concentrations at imposed flux of 35 l/m^2h. Time for one cycle (backwash interval) exponentially decreased with increasing net flux (imposed flux) and influent solids content (see Figure 6). It can also be seen that the influent solids concentration has greater impact on the cycle time when the imposed flux is low.

As imposed flux increases the backwash frequency sharply increases whereas the net flux slowly increases, as shown in Figure 7. There will be a trade-off between capital and operating (energy/chemical) costs. For example, an imposed flux of about 30 to 35 l/m^2h will double the membrane area of an imposed flux of 90 l/m^2h for the same production rate. However, the low imposed flux will require an order of magnitude less energy for blowbacks (Figure 8).

A preliminary cost assessment (Figure 9) was carried out to examine the trade off between capital and operating cost to demonstrate the potential for optimal operating conditions. The variation of energy cost and energy + capital cost reach a minimum when the plant operates at an imposed flux between 56 and 63 l/m^2h.

CONCLUSIONS:

Results in this study can be summarised;

(i) The imposed flow to the filtration unit influences not only the production of the filtrate, but also the frequencies of backwashing and chemical cleaning.

(ii) The backwashing TMP (TMP_b) has a significant influence on the backwashing frequency and also on the pumping energy consumption.

(iii) The influent suspended solids concentration (TSS) influences the frequency of the backwashing and chemical cleaning, and also the pumping energy consumption.

(iv) Cost analysis based on energy and capital costs indicates the unit needs to be operated at low imposed flux for 'energy saving'. However, if capital and energy costs are combined, the cost operation would be at about 56 to 63 l/m^2h.

Figure 1. The membrane system and the filtration process.

Figure 2. A typical TMP profile.

Figure 3. Typical TMP profiles of the secondary effluent operated at different levels of imposed flux and solids concentration.

Figure 4. Cycle time versus imposed flux at backwash pressures (TMP_b) of 20 and 50 kPa. Solids concentration was 43-48 mg/l.

Figure 5. Cycle time variation versus net flux for various solids concentrations at imposed flux of 35 l/m^{2}h.

Figure 6. Cycle time versus influent solids concentration at imposed fluxes of 35 and 90 l/m^{2}h.

Figure 7. Net flux and blowback frequency versus imposed flux.

Figure 8. Power consumption by feed pump and air compressor versus imposed flux.

Figure 9. Capital and energy costs for membrane filtration.

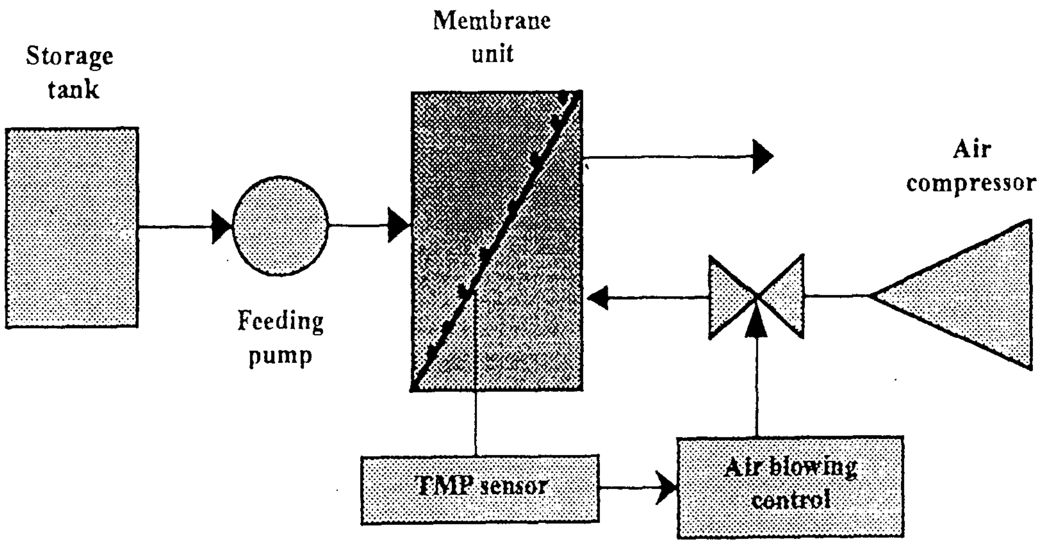

Figure 1: The membrane system and the filtration process

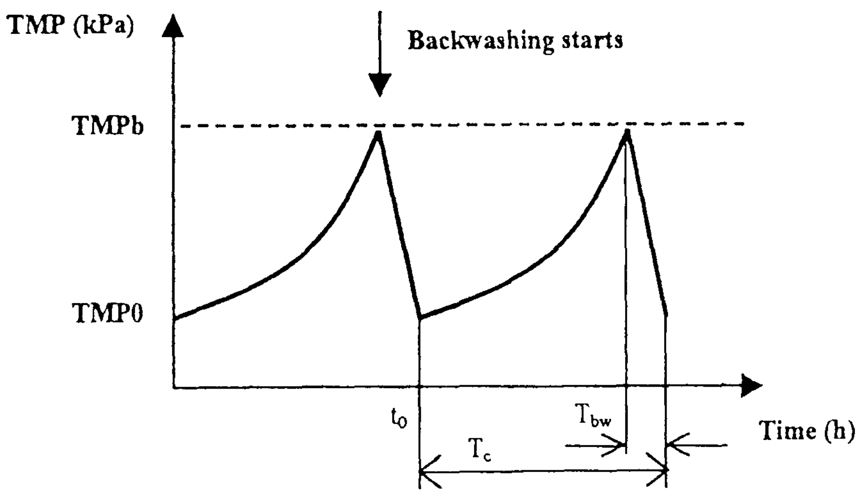

Figure 2: A typical *TMP* profile

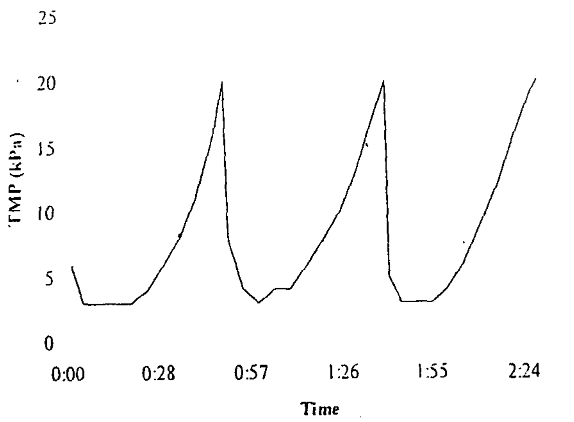

Figure 3a. TMP variation at 35 L/m^2.h (TSS = 88 mg/L)

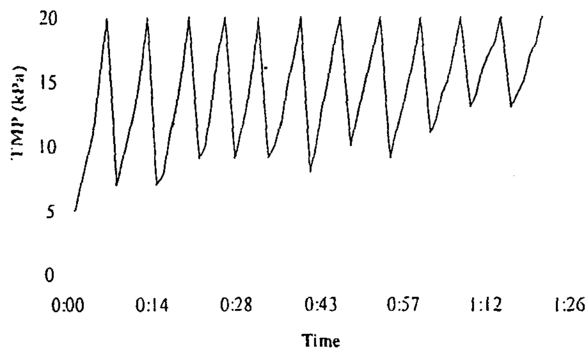

Figure 3b. TMP variation at 90 L/m^2.h (TSS = 87 mg/L)

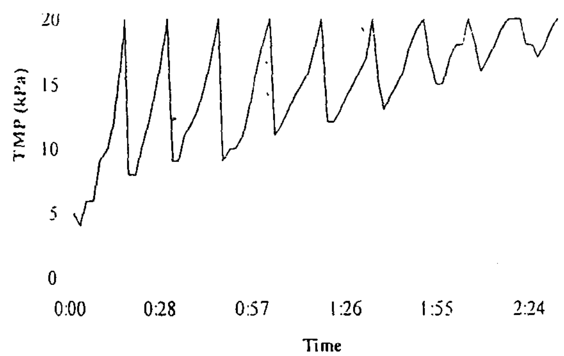

Figure 3c. TMP variation at 35 L/m^2.h (TSS = 392 mg/L)

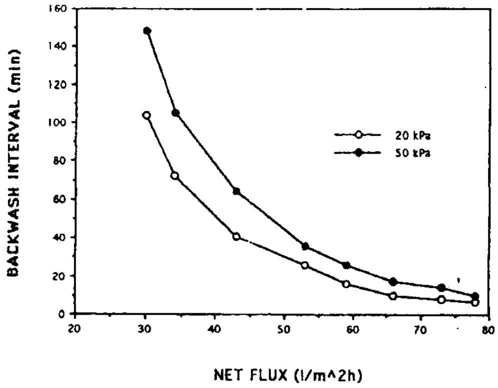

Figure 4. Backwash interval versus net flux.

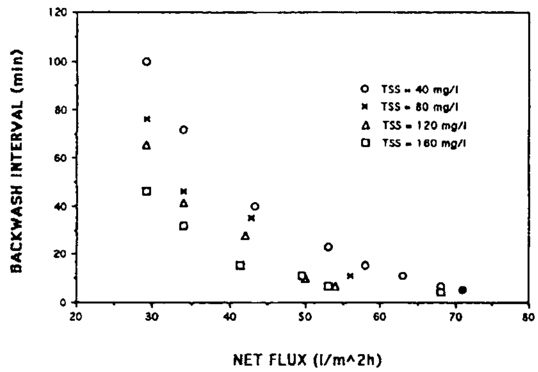

Figure 5. BACKWASH INTERVAL VS IMPOSED FLUX

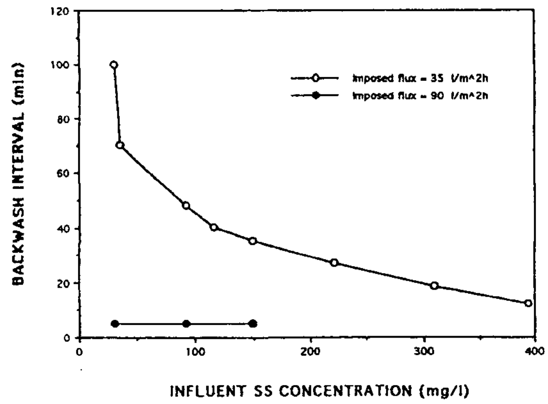

Figure 6. BACKWASH INTERVAL VS INFLUENT SS CONCENTRATION

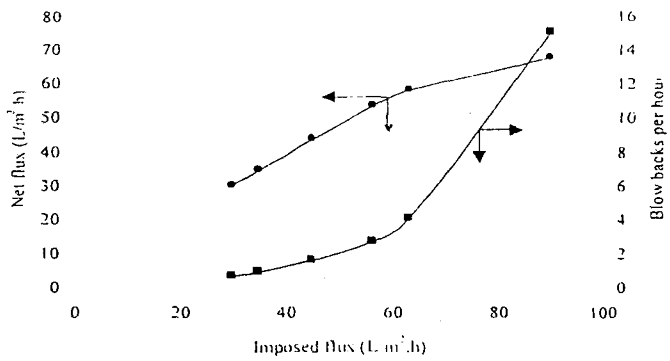

Figure 7.
Relationship between imposed flux, net flux and blowback frequency.

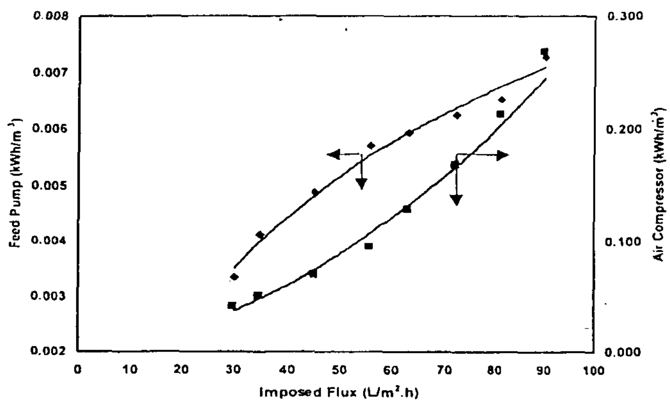

Figure 8.
Power consumption by feed pump and air compressor as a function of imposed flux.

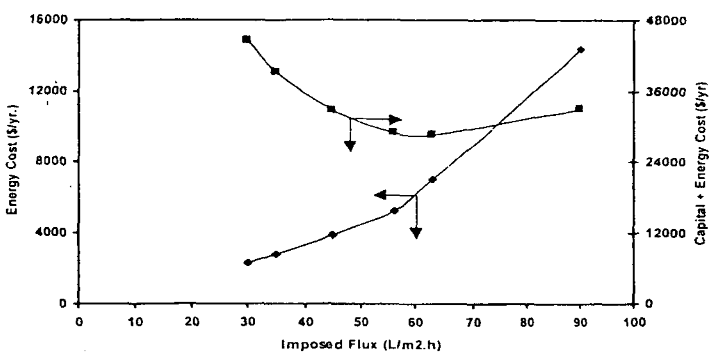

Figure 9. Capital and energy costs as a function of imposed flux .