APPENDIX 2

Appendix 2.1: Determining of Membrane Resistance:

When a pure solvent such as distilled water is filtered through the membrane, the permeation flux J_w is proportional to the applied TMP, ΔP_T:

$$J_w = \frac{\Delta P_T}{\mu R_m}$$

where R_m is the intrinsic hydraulic resistance of the membrane, calculated from the experimental measurement of J_w.

From the experiment, $J_w = 3.23148 \times 10^{-7}$ m/s, $\Delta P_T = 0.25$ bar $= 0.25 \times 10^5$ N/m^2

and μ at 20°C = 1.002×10^3 Ns/m^2

Thus,

$$R_m = \frac{0.25 \times 10^5 \text{ N/m}^2}{(1.002 \times 10^3 \text{ Ns/m}^2)(3.23148 \times 10^{-7} \text{ m/s})}$$

$$= 7.721 \times 10^7 \ m^{-1}$$

Two limitation phenomena occur during UF of a solution such as whey containing macromolecules and suspended particles: (1) polarization due to a liquid layer of macromolecules concentrating on the membrane, and (2) fouling which is mostly considered as the addition to the membrane resistance of an additional resistance resulting from adsorption, gel formation, or particle deposition (Daufin, 1988).

As affected by these phenomena, the equation of flux is written as

$$J = \frac{\Delta P_T - \Delta \Pi}{\mu (R_m + R_f)} = \frac{\Delta P_T}{\mu (R_m + R_f)}$$

where $\Delta \Pi$ is the difference in transmembrane osmotic pressure induced by accumulation of macromolecular solutes over the membrane, μ is the permeate viscosity, and R_f is the additional resistance due to fouling which generally increases with time.

Concentration polarization occur very rapidly. During whey UF through the membrane, we observed that 10 to 15 minutes after the beginning of the experiment the value of $\Delta\Pi$ could be considered as constant, similar to Daufin's (1988) observation. By contrast, fouling was much slower and the decline in flux with time during UF was almost exclusively due to it.

Let us assume that polarization is a reversible phenomenon whereas fouling is mainly irrevesible. In such conditions, if after an UF test the membrane is only rinsed with water, measurement of water permeation flux J_w' under ΔP_T pressure makes it possible to determine the irrevesible fouling resistance R_f' from

$$J_w' = \frac{\Delta P_T}{\mu (R_m + R_f')}$$

And from the relation discussed before, $R_f' = R_m (J_w/J_w' - 1)$

Values of J_w' are similar irrespective of the water rinsing time. Here, R_f' is considered as equal to R_f although a small part of fouling might be removed by rinsing.

$$R_f = 7.721 \times 10^7 \text{ m}^{-1} [(3.23148 \times 10^{-7} / 3.16111 \times 10^{-7}) - 1)$$

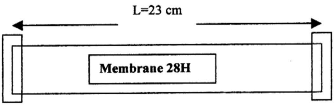
$$= \mathit{1.719 \times 10^6\ m^{-1}}$$

Appendix 2.2: Formula for Flux Calculations:

$$\text{Flux } (m^3/m^2.s) = \frac{\text{volume accumulated}}{1000 \text{ (effective area of membrane) (time in second)}}$$

Average Flux = Σ each flux reading /number of reading taking

Superficial velocity of liquid, U_L = liquid flowrate/ cross section area of tubes



Inner diameter of tube,d = 0.2mm

Effective area = 1.5 $m^2 = \pi dNL$; where N = number of tubes

$N = 1.5/(\pi \times 0.0002 \times 0.23)$

$N = 10380 \sim 10400$

Cross section of tubes = $\pi d^2/4 \times N = 0.0003267\ m^2$

$U_L = F_{liq}/\ 0.0003267$ m/min

= 0.0510112 (F_{liq}) m/s