Skim Milk Concentration on a 7,5 m^2 Vibro-I

- The 7,5m^2 Vibro-I removed 95 L permeate from 120 L Skim Milk in 2 hours at 2 bar
- Vibro-I can concentrate 16 Liters of Skim Milk per m^2 membrane to a Ratio of 4,62 in 2 hours at 2 bar
- The pressure loss in Vibro-I systems is extremely low – **Low Energy Consumption**
- The system can be CIP cleaned and has no membrane spacers – **Sanitary**
- The absence of a fast crossflow pump gives less pump shear – **Better Product**

Preface:

To demonstrate the capabilities of the Vibro™ Technology in Dairy, a pilot study of Skim Milk concentration was performed at SANI Membranes, Allerød, Denmark.

A 7,5 m^2 Vibro-I UF Pilot system was used to concentrate 120 L Skim Milk to a Ratio of 6 in under 4 hours.

The system was fitted with used MK membranes from Synder Filtration (30 kDa sanitary PES membranes). All proteins and fat were concentrated during the experiment and the permeate consisted mainly of carbohydrates and salt.

The experiment was executed as a batch production over a feed tank where the protein concentration in the entire 120 L Skim Milk was increased gradually. The trans membrane pressure was kept at 2 bar throughout the experiment and Pressures, Temperature, Brix, Flux and total Permeate amount was registered.

The system was CIP-cleaned before and after the experiment and came back to the initial water flux after the normal Dairy CIP.

System and Experiment:

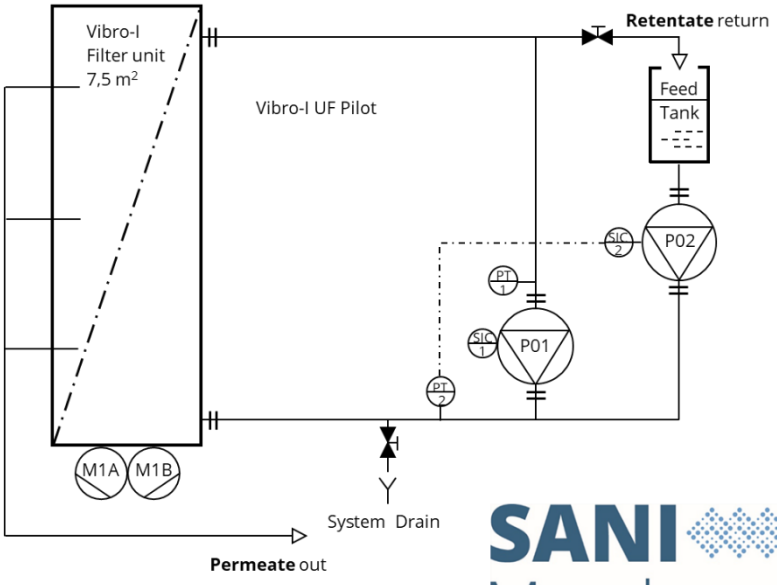

Figure 1 is a schematic diagram of the 7,5m^2 Vibro-I system used

SANI Membranes ApS
Solvang 23A | DK-3450 Allerød
Denmark
info@sanimembranes.com

Skim Milk Concentration on a 7,5 m^2 Vibro-I

The system consisted of a 7,5 m^2 Vibro-I Filter Unit with 2 vibration motors (M1A and M1B). The vibration was turned on by the PLC as soon as the unit was filled with media (PT1 ≥ 0,2 bar) and stopped again when the system was stopped (PT1 ≤ 0,2 bar).

The feed pump (P02) slowly filled the system until it was full (PT1 ≥ 0,2 bar). After that it was PLC regulated to keep the desired trans membrane pressure (PT2 = 2,0 bar).

The Mix Flow Pump (P01) was set to 25% throughout the experiment which corresponds to a very slow crossflow of below 0,1 m/s (less than 0.1 kW). The function of the Mix Flow Pump was purely to keep the retentate moving in the entire system and thereby avoid fouling cakes from forming in the highly concentrated retentate.

The system was fitted with a 150 L feed tank system to hold the 120 L Skim Milk. The retentate was cooled in the feed tank during the experiment.

The permeate was removed continuously from the experiment from start to finish. The total amount of permeate was continually registered and brix was measured in the fresh permeate. The ratio between retentate and permeate can be calculated as:

$$\text{Ratio} = \frac{\text{Initial Feed Volumen}}{\text{Initial Feed Volumen} - \text{Permeate Volumen}}$$

The retentate return valve was open during the entire experiment to get the same concentration and temperature in the entire batch of retentate. In the beginning approx. 7 L per minute retentate was returned to the tank, at the end of the experiment the amount had decreased to 840 ml per minute due to the higher viscosity of the retentate. All brix and temperature measurements were performed on the retentate return stream.

The initial water flux and the water flux after the experiment and a normal Dairy CIP cleaning was 22,5 LMH at 0,5 bar.

The initial feed was 120 L of Egelykke pasteurized Skim Milk with 0,1% fat, 4,7% carbohydrates, 3,5% proteins and 0,11% salt. The temperature was 5,6°C and the brix was 10,8.

The 7,5 m^2 Vibro-I System during the Skim Milk concentration

SANI Membranes ApS
Solvang 23A | DK-3450 Allerød
Denmark
info@sanimembranes.com

Skim Milk Concentration on a 7,5 m² Vibro-I

Results and Discussion:

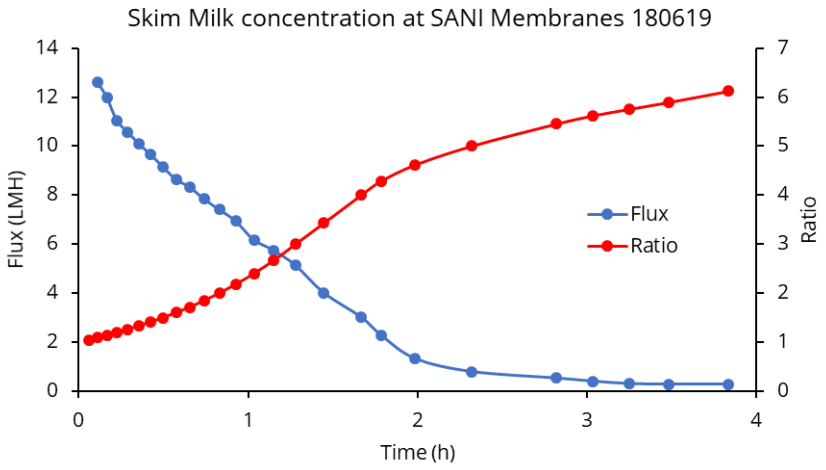

Figure 2 is a representation of Flux and Ratio as a function of time during the experiment

Figure 2 shows the relationship between the Flux and the Ratio of retentate and permeate. The initial Flux (from 5 to 6 minutes at 5,6°C) is 12,65 LMH and it gradually falls during the experiment as the Ratio goes up. After 2 hours of operation a Ratio of 4,62 is reached and the Flux is 1,33 LMH. In the end of the experiment the flux went below 1 LMH as the amount of 'free' water in the retentate was very minute.

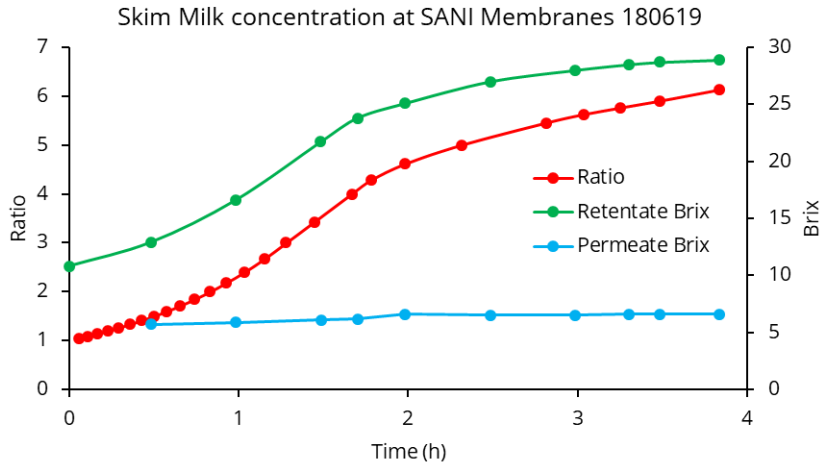

Figure 3 is a representation of Ratio, Retentate Brix and Permeate Brix as a function of time

Figure 3 shows how the Retentate Brix closely follows the Ratio linearly up to around 2 hours (Retentate Brix 25,1 and Ratio 4,62). After 2 hours the curve of the retentate Brix slowly gets closer to the curve of the Ratio and the Permeate brix also increases from the initial 5,7 to 6,6 in the end of the experiment. The raise in permeate brix is due to an increase of lactose in the retentate at very high Ratios.

SANI Membranes
MORE FILTRATION, LESS ENERGY
SANI Membranes ApS
Solvang 23A | DK-3450 Allerød
Denmark
info@sanimembranes.com

Skim Milk Concentration on a 7,5 m² Vibro-I

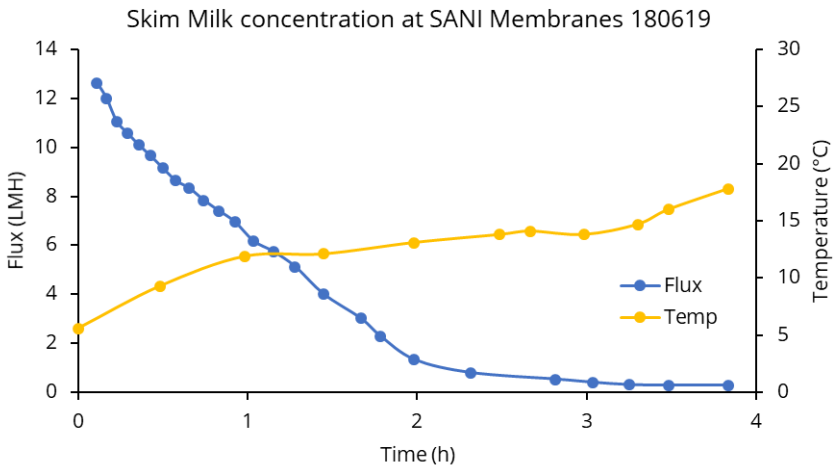

Figure 4 is a representation of Flux and Temperature as a function of time

Figure 4 shows that we succeeded to keep the temperature below 14°C until 3 hours had elapsed. After 3 hours the amount of retentate was so small (≤ 22 L) that we could not keep the temperature below 14°C. The temperature increased to 18°C at the end of the experiment where the Ratio was above 6.

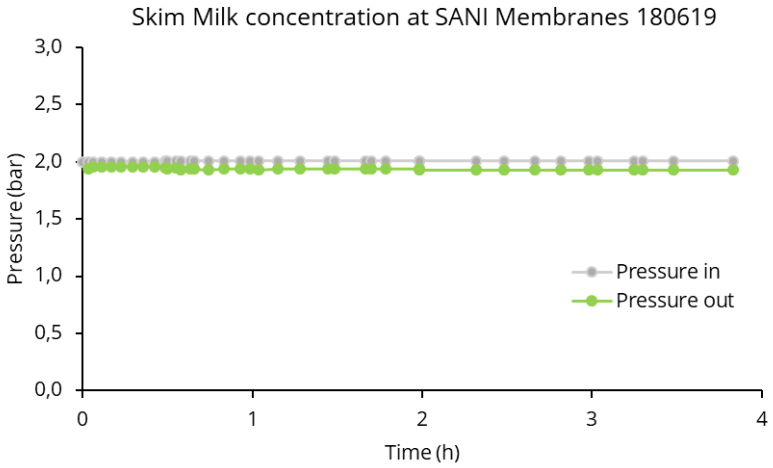

Figure 5 is a representation of Pressure in (PT2) and Pressure out (PT1) as a function of time

The pressure loss in the membrane modules can be seen on figure 5. Initially the pressure loss was 0,04 bar and it gradually increased to 0,08 bar in the end of the experiment. The increase in pressure loss is due to the dramatic increase in viscosity of the retentate. The pressure loss is very minute compared to traditional membrane systems and is only due to the use of the Mix Flow Pump, which keeps the fouling cakes from forming in very high viscosities. The minute pressure loss can be directly converted into energy saving which becomes even bigger when the reduced need for cooling is also considered.

SANI Membranes ApS
Solvang 23A | DK-3450 Allerød
Denmark
info@sanimembranes.com

Skim Milk Concentration on a 7,5 m² Vibro-I

Conclusions:

- The 7,5 m² Vibro-I removed 94 L permeate from 120 L Skim Milk in 2 hours at 2 bar
- Vibro-I can concentrate 16 Liters of Skim Milk per m² membrane to a Ratio of 4,62 in 2 hours at 2 bar
- The pressure loss in Vibro-I systems is extremely low – **Low Energy Consumption**
- The system can be CIP cleaned and has no membrane spacers – **Sanitary**
- The absence of a fast crossflow pump gives less pump shear – **Better Product**

Industrial Systems for Skim Milk concentration:

For larger industrial systems a continuous production is favorable and will perform better than the 7,5m² Vibro-I pilot. A cascade system where the retentate is concentrated continuously in two stages would be the way to go. The first filter unit with plug flow, with no Mix Flow Pump and the second loop with a Mix Flow Pump to handle the higher concentration. The plant could also be designed for other Dairy processes like skier, whey protein solutions, yogurt etc.

Continuous two stage Dairy concentration Vibro-I plant

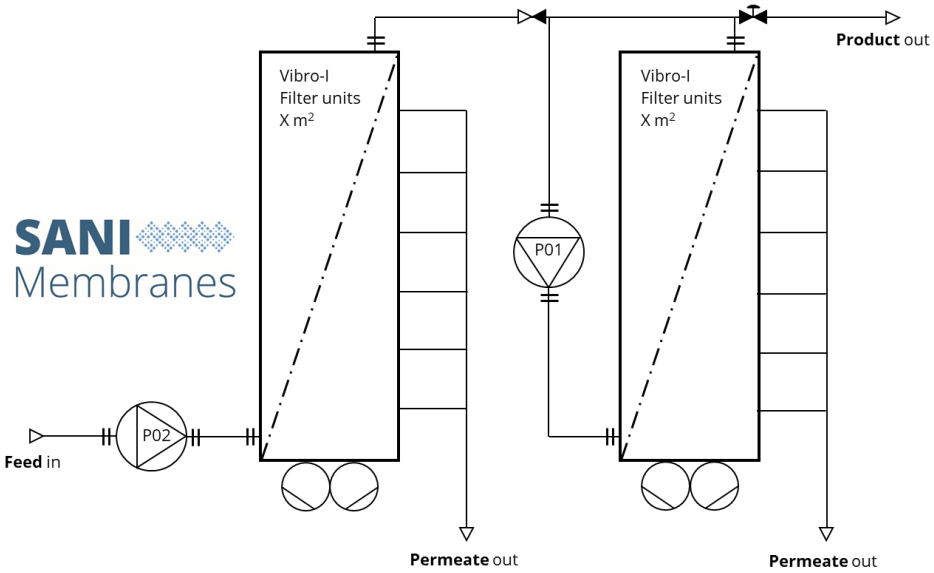

Figure 6 is a sketch of a Dairy plant for continuous concentration with two stages

SANI Membranes
MORE FILTRATION, LESS ENERGY
SANI Membranes ApS
Solvang 23A | DK-3450 Allerød
Denmark
info@sanimembranes.com