TurboClean® Food and Dairy Membrane Elements

Abstract

The TurboClean® element can reduce by-pass flow by 35% - 44% when compared to commercially available sanitary membrane elements. This improves overall hydraulic control in the pressure vessels, resulting in energy savings, improved membrane life, and significant improvements in processing and cleaning efficiency. The TurboClean® element was developed by TriSep Corporation as a sanitary membrane that uses a hard outer shell.

This paper gives details about the TurboClean® product, its operating principles, and potential energy savings. It includes pilot plant data obtained in side by side testing against other sanitary spiral wound membrane products.

Background

TriSep Corporation is a manufacturer of spiral wound reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and (MF) microfiltration elements. Several years ago, TriSep began development of a new sanitary spiral wound membrane product that would have desired improvements over existing sanitary products.

Sanitary Requirements for Spiral Wound Membrane Elements

A basic design requirement of a sanitary element is that it has no 'dead zones', or non-flow areas. Conventional spiral wound elements use a 'brine,' or peripheral seal, to prevent feed water from bypassing through the annular area formed between the pressure vessel inner diameter and the element outer diameter. This results in a dead zone or stagnant area between the outside of the element and the inside of the pressure vessel.

For food and dairy applications, it is a requirement that some of the process fluid must by-pass, or flow around the outside of the element, to insure that this annular area is continuously flushed and that there are no areas in which product can become stagnant or which are not fully exposed to cleaning agents.

Different manufacturers employ different means of enclosure in an attempt to provide mechanical stability for the element while assuring this by-pass flow. These methods

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include a ‘cage’ wrap, or alternatively, a “net” wrap around the outer diameter of the element. Either is considered ‘soft wrapped’ and allows a significant amount of the feed flow to by-pass around the outside of the element.

A third method, the hard shell TurboClean® design by TriSep Corporation, incorporates an impermeable hard plastic shell with a machined groove that spirals around the shell from end to end to allow bypass flow. The soft shell and hard shell designs are illustrated in Figures 1 and 2, respectively.

Figure 1
Soft Wrapped Element

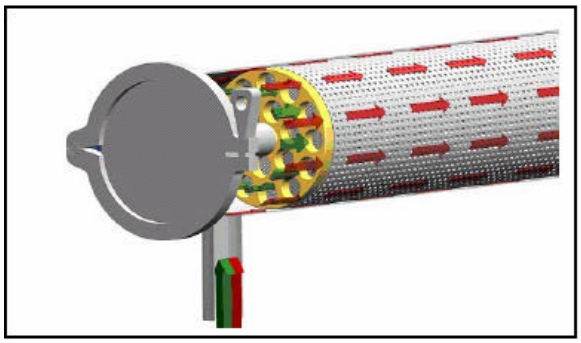
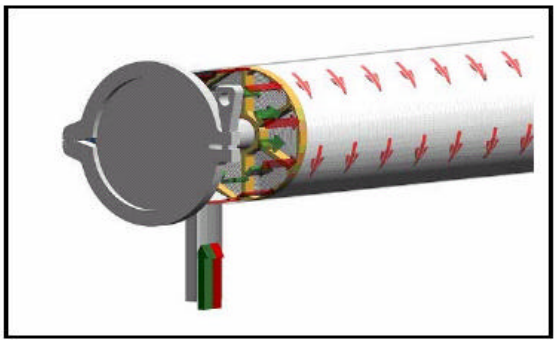


Figure 2
Hard Shell Element



Sanitary membrane elements in Food and Dairy Systems

In the food and dairy industry, membranes are installed in multi-stage, continuous recirculation systems. The variation in the specific permeate flux at different concentration levels, changing viscosities, and different fouling characteristics of the process streams, requires high recirculation flows to insure adequate feed flow through the membrane element.

A constant velocity over the membrane surface of the process liquid is maintained by a recirculation pump in each stage. Stages contain a number of pressure vessels, all connected in parallel to a main feed manifold. Conventional sanitary elements have significant clearances between the “soft wrap” and the inside of the pressure vessel, resulting in by-pass of feed flow around the element of 40% - 60%. This adds to the required recirculation flow.

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Figure 3
Typical 3.8” Diameter Sanitary Element

It is easy to see in Figure 3, that the open area will allow for significant by-pass flow of the process (and cleaning) liquid. Liquid can also flow out radially from within the element to the outside of the element. If the hydraulic resistance to flow through the element is higher than the hydraulic resistance to flow around the element, the liquid will take the path of least resistance and by-pass the element.

Comparative tests at a major California Cheese producer were performed to compare the by-pass flow of the TurboClean® element to a standard “net” wrap element, by isolating one pressure vessel in a continuous recirculation stage.

The vessel was equipped with flow control valves on the feed and concentrate side, pressure gauges on feed and concentrate, and flow meters to measure the concentrate and permeate flow, as shown in Figure 4.

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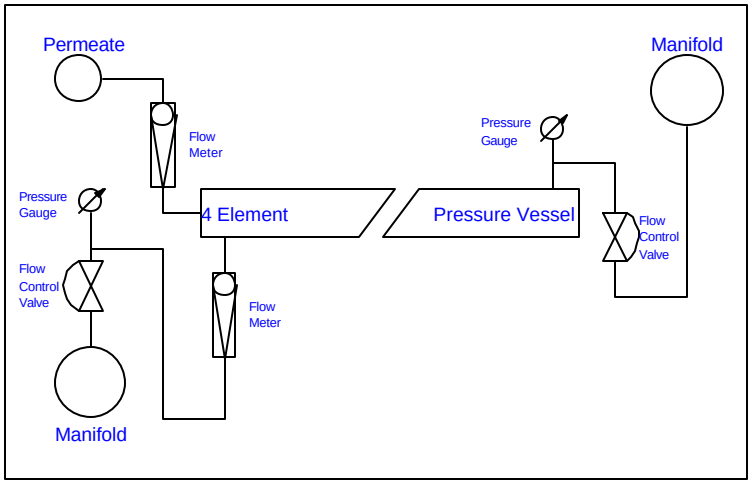
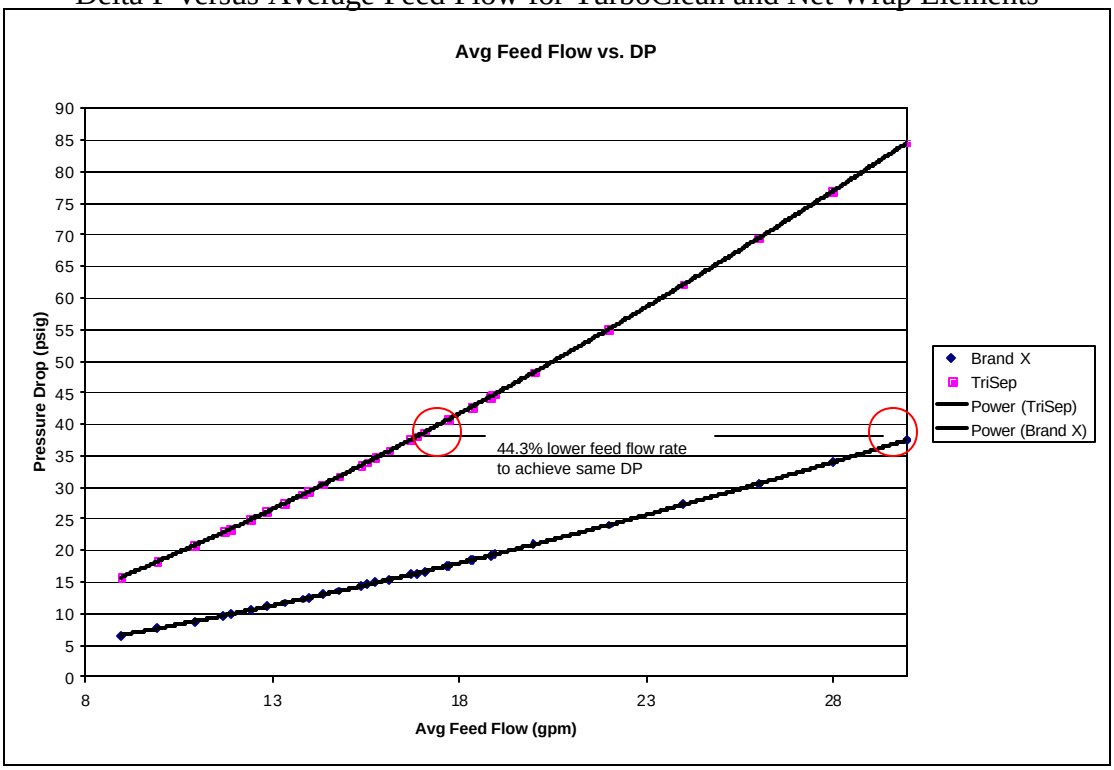
Figure 4
Pilot Test Diagram



The tests showed a reduction in feed flow rate of 44 % when comparing the TurboClean® elements versus conventional "soft-wrapped" elements. Figure 5 shows that the desired feed brine pressure drop (?P) of 36 psig could be obtained with a significantly lower feed flow rate to the pressure vessel.

Figure 5
Delta P versus Average Feed Flow for TurboClean and Net Wrap Elements



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What effect will this new element design have on the food and dairy industry? The hard shell TurboClean® energy savings can be as high as 44% of the required recirculation flow, and in certain application, a corresponding decrease in required cooling energy.

Improved hydraulic flow control may also lead to increased membrane life and improved membrane cleaning efficiencies. Although initial tests tend to support this hypothesis, conclusive data is still pending.

Effects of improved hydraulic flow control may result in improved separation efficiencies, since the effect of high by-pass flow is to reduce membrane cross flow and increase concentration polarization (a higher solute concentration at the membrane surface than in the bulk stream) on the membrane surface. Reduction of concentration polarization is directly related to cross flow rates in the membrane element. As can be seen in Figure 5, there is a limit to the amount of cross flow that is attainable with standard net wrap or cage wrapped elements.

Figure 7
Energy Savings from Reduced Recirculation Pumping Energy

Customer	Pump KW	Pumps	$/Kwh	% savings	Hrs year	Elements	Savings per element	Annual savings
Plant A	11	4	0.09	0.44	8000	112	$126.95	$14,217.98
Plant B	18.7	1	0.07	0.44	8000	48	$95.99	$4,607.68

Conclusion

The ability to have an increased control over the hydraulic environment in these systems will lead to better process and cleaning efficiency, which will have a positive effect on the membrane performance as well as the life of the element. Reducing by-pass flow can result in 35% - 44% reduction in pumping energy as well as a corresponding reduction in cooling requirements. Improved hydraulic flow control may also result in increased membrane life and improved separation efficiency.

About the Author

Hans Thomassen is Director of Specialty Separations at TriSep Corporation. Mr. Thomassen has over 30 years of experience in the food and dairy membrane separation industry, and has done extensive work on hydraulic flow in membrane elements.

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