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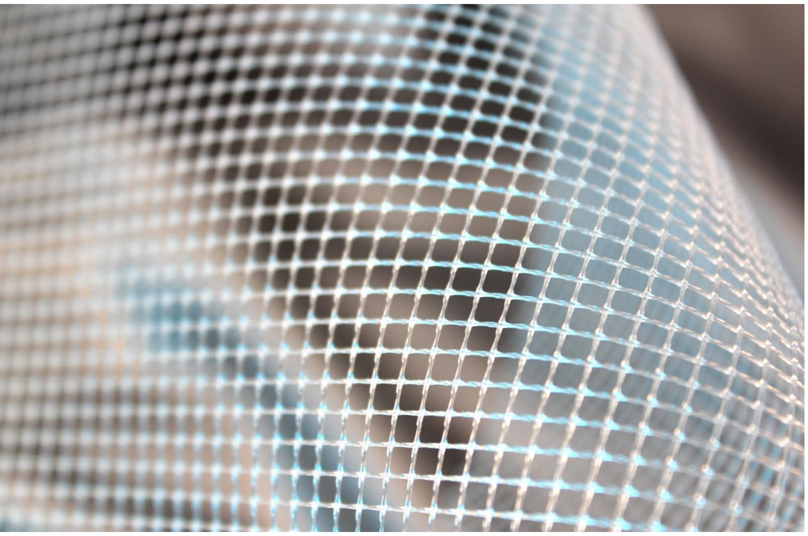
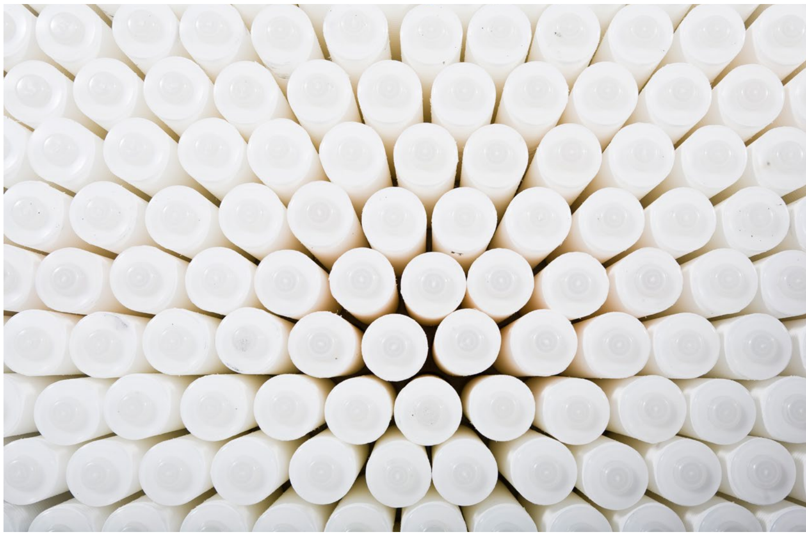
GLOBAL NETTING SOLUTIONS

REVERSE OSMOSIS SERIES





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The feed spacer plays a vital role in reverse osmosis (RO) water treatment. Long considered a simple commodity, it appears to offer vast potential for research and innovation that could drive advances in RO water production.

In an industry with such large-scale inputs of power, water, and capital, small gains in operational efficiency can mean big savings or increased output. For RO plants around the world, they key word is energy. An RO plant typically needs at least 150 psi and can require as much as 1000 psi to efficiently operate its RO arrays. Pressure at those levels consumes a large amount of power.

The change in pressure from feed water inlet to concentrate outlet is known as pressure drop. Pressure drop is a key measurement of the energy efficiency of an RO plant. Maintaining pressure, or having a low pressure drop, is often a vital concern for some RO plants. It is also expensive: high pressure is costly to achieve and maintain. Plants have different sources and prices for power, of course, but the overall cost for energy is trending up.

Given the tremendous volume of water processed by RO plants, as well as the extremely high energy costs, even small improvements in efficiency can translate into large savings or increased product water output. A great deal of research and innovation pursuing these goals has focused on membrane chemistry, including changes to the polymeric formulation and different methods of membrane production.

However, the next leaps in RO filtration efficiency could come from the feed spacer. Recent developments of different configurations and chemical formulations offer a path of research that had not been the focus of the industry before.

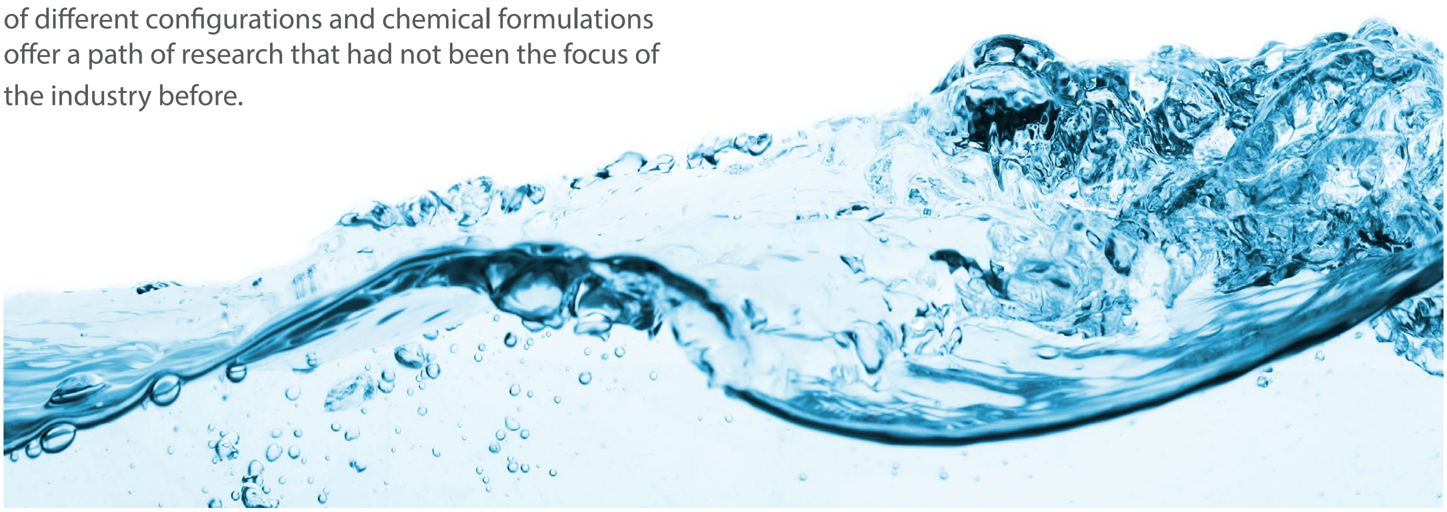
RO Process

Reverse osmosis is achieved when pressure is applied to the concentrated side of the membrane, pushing purified water into the dilute side while the rejected impurities are flushed away in the discharged water.

Frequently known as scrim, mesh, net, or netting, feed spacers act as one of the layers of wound materials in Reverse Osmosis (RO) filters and provide vital separation between the membranes to achieve superior filter performance.

The RO spiral wound element consists of membrane envelopes (also called membrane leaves), wrapped around the central, perforated, permeate tube. As shown on Figure 1, the membrane element structure contains also a feed spacer that separates the surfaces of adjacent membrane envelopes.

The feed spacer, configured as a net, keeps the feed channel open, allowing feed water to flow inside the feed channels, along the membrane element. Figure 2 shows an actual RO spiral wound filter.



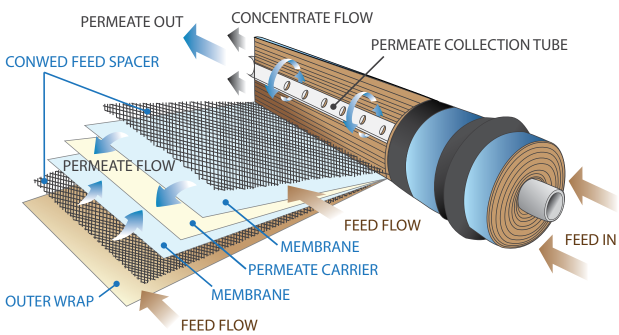


Figure 1. Schematic configuration of spiral wound filter

Figure 2. RO spiral wound filter

RO Challenges

Three primary challenges are identified in the RO water treatment process. They are studied, analyzed and acknowledged as a concern for membrane manufacturers, winders and RO plant operators and builders. Pressure drop, membrane damage and biofouling and scaling are all concerns that drive technology efforts to develop more efficient RO products.

I. Pressure Drop

The high pressures necessary for RO water treatment require commensurate levels of energy. Any increase in pressure drop represents a loss in applied feed pressure and hence a loss of efficiency, energy and money.

Any reduction in pressure drop represents a direct savings to the plant. In an RO plant, the applied pressure comes ideally as much as possible from high feed stream throughput, and not from overcoming feed spacer resistance. However, a feed spacer with no resistance is not the answer either; RO elements require turbulence in the feed stream to work efficiently. That turbulence comes mostly from the water rushing across and through the feed spacer, and is important because it reduces salt buildup on the membrane.

To address the challenge of pressure drop, feed spacer developers experiment with different feed spacer configurations for optimum flow and lowest intrinsic resistance while still trying to maintain a sufficient degree of turbulence. Spacer configurations are created and tested to measure pressure drop across the feed spacer.

The impact differences lead to believe that the feed spacer may have a role to play in reducing pressure drop. As feed spacer developers continue to examine different alternatives, the nature and scope of the impact the feed spacer has on pressure drop should become more evident.

II. Membrane Damage

When RO membrane manufacturers roll their elements, they wind layers of membrane, feed spacer, and permeate spacer tightly into the cylindrical element so recognizable in the RO industry (Figures 1 and 2). The membranes themselves are susceptible to damage during the manufacturing process when they are tightly pressed against the feed spacer. As with many aspects of the RO process, winding the membranes and feed spacers involves tradeoffs.

The feed spacers need a high degree of dimensional stability - that is, stiffness - to maintain separation between the membranes. However, the stiffer the feed spacer, the more likely it is to damage the membrane. A softer feed spacer, for instance one made from resins other than polypropylene, is gentler on the membrane - but that in turn compromises some of the stiffness and stability.

RO membrane elements undergo extensive quality control checks before being shipped, including testing flux and rejection performance. Elements with membrane damage cannot be repaired; they are discarded, and accrued to the membrane manufacturer's scrap rate, driving up costs. Research suggests that changes to feed spacer resins might offer breakthroughs in terms of the tradeoff of structure and membrane damage. Ongoing testing indicates there might be gains to be made in feed spacer structure without causing membrane damage, but determining that requires an effective way to test the spacers to predict potential membrane damage.

As part of the effort to understand feed spacers' role on membrane damage, there is testing of different chemical configurations and the impact they may have on RO membranes. This connects directly to the research concerning the effect different spacer configurations have on pressure drop.

Therefore, developing unorthodox or novel feed spacers that may offer gains in pressure drop are not viable if they cause excessive membrane damage. Currently, there is not a standard way to test membrane damage without winding an element. Conwed, however, is attempting to measure and predict what impact different feed spacers will have on membranes in the winding process. An early screening of feed spacers could help understand potential improvement on feed spacers and its effect on membrane damage. The ultimate goal is to develop even higher quality feed spacers, with the potential impact on membranes tested, measured, and documented.

III. Biofouling

Biofouling occurs when unwanted microorganisms and algae grow on the feed spacer or membrane surfaces. Biofouling could happen in any RO desalination system and it causes two main problems for RO plants. First, the fouling material clogs the membrane and the feed spacer, leaving less of the membrane surface area permeable. This increases flow resistance and leads to higher pressure drop, so the RO plant has to pump water at a higher pressure to overcome resistance.

Second, biofouling also impairs the quality of the permeate water.[1] To address these problems, RO membrane elements have to be cleaned, which causes a reduction of available RO membrane units for water production. All of these factors contribute to an increase in water production costs.

With this in mind, Conwed is evaluating the impact different feed spacer configurations might have on biofouling. As with the experiments investigating pressure drop and membrane damage, the biofouling experiments suggest that further R&D is absolutely warranted.

REFERENCES

1. Reid, Katherine, Mike Dixon, Con Pelekani, Karyn Jarvis, Mason Willis, Yang Yu; "Biofouling control by hydrophilic surface modification of polypropylene feed spacers by plasma polymerization," Desalination 335 (2014) 108–118.

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GLOBAL HEADQUARTERS

2810 WEEKS AVE SE
MINNEAPOLIS, MN 55414
TEL 800.426.0149
FAX 800.426.0137
EMAIL contact@conwedplastics.com

EUROPEAN HEADQUARTERS

MARCEL HABETSLAAN 20
3600 GENK, BELGIUM
TEL +32.89.848310
FAX +32.89.848320
EMAIL sales@conwedplastics.com

CONWED®
GLOBAL NETTING SOLUTIONS
www.conwedplastics.com