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Water & wastewater

Enhancing reverse osmosis with feed spacer technology

By 2025 nearly 1 billion people will lack access to fresh, drinkable water. Reverse Osmosis (RO) water treatment will play a major role in alleviating water scarcity, but energy costs are involved. This article looks at how feed spacer technology can enhance RO element performance.

Any improvement of the membrane or element technology can increase the efficiency of the RO process. In a co-research project, Conwed Plastics and LANXESS' Liquid Purification Technologies business unit have proven that innovations in feed spacer technology lead toward enhanced RO element performance.

Reverse osmosis: the process

Reverse osmosis is a water purification technology to remove mainly monovalent ions (e.g. NaCl) that utilizes a semipermeable membrane. An applied pressure is used to overcome natural osmotic pressure. Such RO membranes are being offered as spiral wound elements for a huge variety of desalination applications. Frequently known as scrim, mesh, net, or netting, feed spacers act as one of the layers of spiral wound RO elements and provide vital separation between the membranes to achieve superior filter performance. A spiral wound element refers to a membrane configuration which is comprised of 'flat sheet membrane – permeate channel spacer – flat sheet membrane – feed channel spacer' combinations rolled up around a permeate collection tube. As shown in Figure 1, the membrane element structure contains the 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 element.

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 plant operators:

- Pressure drop
- Membrane damage
- Biofouling and scaling

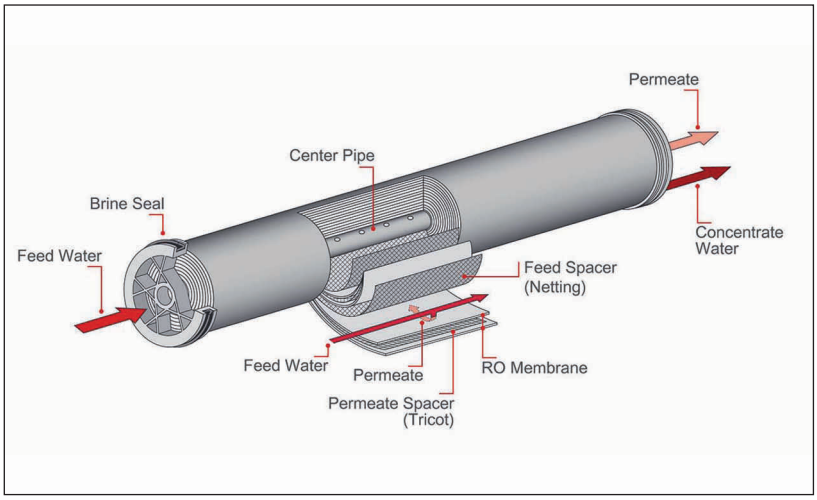

Figure 1. Construction of a spiral wound RO module in detail.

These challenges have driven combined technology efforts of Conwed Plastics and Lanxess to develop more efficient RO products.

Effect of feed spacer on pressure drop

The feed spacer is an essential component of spiral wound membrane elements. Feed spacers are manufactured from polymeric materials and optimized to maintain stable performance of membrane elements in a wide range of feed water composition and process parameters.

The configurations of feed channel and feed spacer net are shown schematically in Figure 3. The feed channel, shown here in unwrapped configuration, forms a rectangular opening of typically 0.7 – 0.9 mm in height. Due to the presence of spacer or netting strands in the feed channel, the actual cross section area open to the feed flow is smaller than the geometric cross section.

The length of the feed channel is about 1 m. The feed spacer net, filling the feed channel, has filaments or strands positioned bi-planarly. The bi-planar characteristic causes the feed stream to change flow direction as it flows above and below the subsequent filaments. The objective of the feed spacer, in addition to keeping the feed channel open, is to promote turbulence of the feed stream.

The need for turbulence in the feed stream is related to the nature of the RO desalination process. The feed water and dissolved salts flow parallel to the membrane surface, with a fraction of the feed water passing through the membrane as permeate, leaving the dissolved ions in the retained fraction of the feed water stream.

This process generates excess concentration of dissolved ions at the membrane surface, a phenomena known as concentration polarization. The feed spacer induced turbulence reduces extend of concentrate polarization, thus improving performance of the RO membranes. However, the feed spacer induced turbulence increases friction in the feed channel, which is translated into pressure drop of the feed stream between element feed and exit points.

Figure 2. Typical 8 inch RO modules as being used in many water treatment applications.

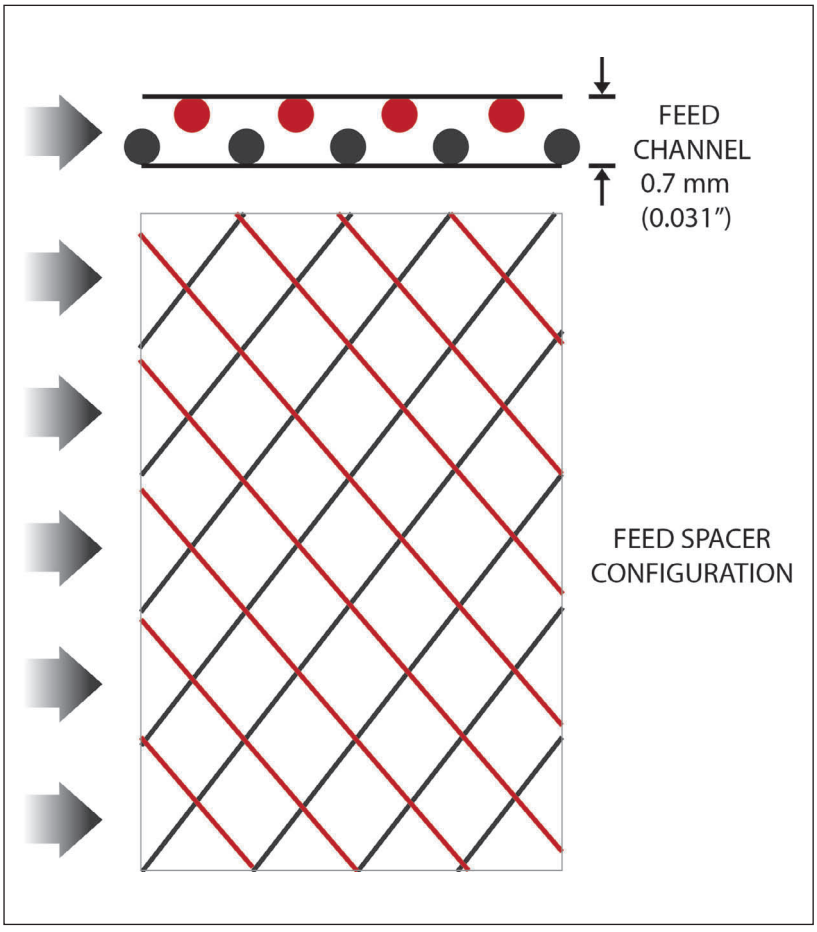

Figure 3. Schematic of a standard (equal strands) feed spacer / feed channel.

The current configurations of feed spacers, used for construction of RO spiral wound elements, have been developed based on practical experimentation and fundamental studies. The objective was to create condition of 'mixing flow' even at the low flow velocities existing in the feed channels of the spiral wound membrane elements. Subsequent R&D work demonstrated the importance of feed spacer filaments' geometry, angular configuration as well as alignment of feed spacer with the direction of feed flow.

Based on experimental results and hydraulic modelling, the configuration of feed spacer for RO applications evolved into a bi-planar net with square