By Emily Gilbert & Kate Koerber

Ultrafiltration Gains Performance Edge

The XIGA dead-end filtration concept provides for a wide dynamic operating range, requiring fewer flow controls and operating modes

Ultrafiltration (UF) and microfiltration (MF) hollow-fiber membranes are rapidly gaining acceptance as module design has improved and prices have decreased. This dynamic market has produced a broad array of membrane configurations with variations in materials of construction, membrane module geometry and philosophies of operation.

The XIGA hollow-fiber UF process is of particular significance because of its new module configuration, straightforward automated operation and low cost of ownership. The two main parameters that determine the operating philosophy for hollow-fiber MF and UF are the direction of flow through the hollow fiber during production and the operating mode.

Operating Mode

Three operating modes are available: dead-end, cross-flow and quasi-dead-end. With cross-flow membranes, the suspension to be filtered is pumped across the membrane surface at high velocity to promote turbulence. This turbulence prevents solids accumulation on the membrane surface. In cross-flow operating mode, only a portion of the feed stream passes through the membrane while the rest leaves the system as a continuous waste stream.

With dead-end operation, all of the feed passes through the membrane material, thus becoming filtrate. As a result, there is no waste stream during filtration. All solids in the feed stream will be retained on the membrane surface during operation.

Quasi-dead-end operation falls somewhere between these two extremes. Similar to cross-flow, there is a continuous waste stream during the service cycle; however, velocity across the surface of the membrane is so low that a significant amount of solids will accumulate on the membrane surface. A periodic backwash is necessary in dead-end and quasi-dead-end and is sometimes employed in cross-flow.

The major advantage of dead-end membranes is lower energy consumption because there is no cross-flow stream to recirculate. As long as fouling can be avoided, this leads to lower energy consumption per volume of treated water and, consequently, a lower cost to the end user.

Flow Direction

The flow direction of hollow-fiber membranes is either outside to inside (outside-in) or inside to outside (inside-out). With outside-in operation, feedwater is presented to the shell side of the hollow fiber, and filtrate collects on the tube side (commonly referred to as the lumen) of the fiber. With inside-out operation, feedwater is pumped to the lumen of the fiber, and filtrate is collected on the shell side. The XIGA process operates in dead-end filtration mode with an inside-out flow direction.

One advantage of the XIGA process is that air is not required in the membrane backwashes performed between service cycles. This is certainly not the case for the outside-in membranes on the market. Using only water to backwash eliminates the need for blowers dedicated to a membrane air scrub and simplifies process valving.

Dead-End Filtration

The combination of dead-end filtration, inside-out flow and a membrane element with highly specialized internals is the basis of the XIGA dead-end filtration concept, developed by Norit X-Flow.

In early 2007, Kruger, Inc. and Norit X-Flow signed an agreement to supply the XIGA membranes to the U.S. market. Kruger will supply membrane filtration equipment utilizing the XIGA process concept not only as a stand-alone solution but also as a combined solution with other Kruger processes such as ACTIFLO high-rate clarification (ACTIMEM) and a final polishing step following its biological systems to provide guaranteed overall process performance.

The XIGA technology is well-suited for large-scale surface water, wastewater treatment plant effluent, well water and seawater treatment projects with a suspended solids content of the feed typically less than 50 mg/L.

The XIGA concept uses multiple membrane elements inside horizontally oriented, standard 8-in. reverse osmosis (RO) pressure vessels. Each membrane element hydraulically operates in parallel, regardless of its position in the system.

The SXL225 Membrane

The XIGA dead-end filtration concept uses SXL225 inserts, which have an 8-in. filtration element diameter containing permanently hydrophilic capillary membranes, each with an internal diameter of typically 0.8 mm (Figure 1). The polyethersulfone membrane fibers have a high

Figure 1: XIGA dead-end filtration concept

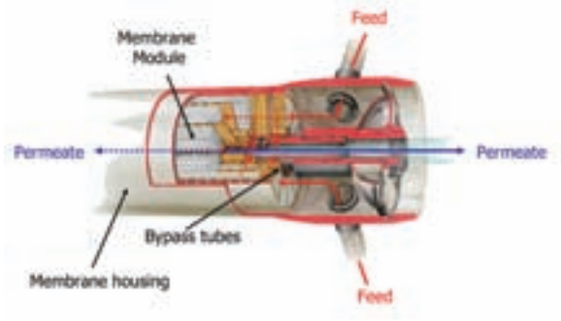
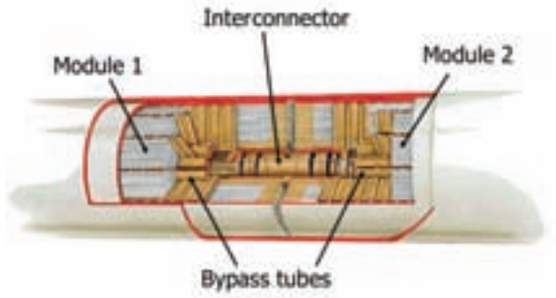


Figure 2: Module bypass tubes



temperature and chemical resistance (pH:1 to 13, 250,000 ppm-hr oxidant life) and mechanical strength. Because the membrane is constantly hydrophilic, it can handle certain levels of oil and grease.

FSFC Internals

The insert is equipped with Norit's patented free surface flow collector (FSFC) internals, which optimize the hydraulic efficiency of the membrane. This unique system of internal flow distribution channels ensures the filtrate production is evenly divided between all of the hollow-fiber membranes in the module. These flow collectors also ensure that each fiber is efficiently flushed during backwash.

Module Bypass Tubes

Module bypass tubes are built into each module and allow a high percentage of feedwater to flow "around" a module and into the next module in the array (Figure 2). These tubes also allow feedwater to feed each fiber's lumen from the upstream and downstream side of the module simultaneously. This creates a uniform flow distribution along the length of the module by effectively halving the length of the fiber. During backwash, the bypass tubes also allow waste from modules in the center of a pressure vessel to flow "around" out modules the same way feed can bypass during service cycles.

The unique FSFC flow distributors and bypass tubes inside the element ensure:

- The lowest possible pressure drop in the insert, minimizing power consumption.
- Effective and even distribution of water over the entire length of the element and the membrane housing.
- The highest possible water production rate.
- A short-duration, high-reverse-flux backwash at fixed intervals that will effectively lift foulants accumulated on the membrane surface.
- Economical dead-end operation at low trans-membrane pressure and low energy consumption are possible.

The SXL225 membrane element is the successor to the S225 element introduced in 1994. The SXL225 element maintains the identical material composition for the previous element, but as a result of more efficient bundling of the membrane fibers, the SXL element has 15% greater surface area (40 sq meters instead of 35 sq meters); greater porosity, resulting in 100% higher permeability; 100% lower TMP (typically 0.15 to 0.3 bar); fewer chemicals required during cleaning; higher water recovery rates; longer life expectancy; and low operating pressures in combination with low fiber breakage rates.

The SXL225 has a greater pore density than the previous one. This increase in the number of pores per square foot of membrane surface area is the reason behind the decreased operating pressures. Despite the improvements in hydraulics of the membrane, rejection of contaminants is still significantly high. The SXL225 received the highest virus removal credit (4-log) from the California Department of Health Services available to any membrane technology.

Up to four inserts of 1.5 meters (60 in.) length can be mounted in a standard pressure vessel, allowing for compact construction. The capability of up to four inserts mounted into a single, horizontal housing provides a major advantage compared to vertical systems, where every element must be connected to the systems headers. Existing plants that utilize the old membrane can easily be retrofitted with SXL225 modules without any modification to the membrane treatment equipment.

Benefits of retrofitting the old membrane process with new SXL membrane include:

Increase in system output. If all ancillary equipment permits, the system output can be increased while still maintaining identical operating fluxes.

Reduction in membrane fluxes. This lowers the load of fouling on the membranes.

Reduction in number of membranes to be installed (at identical fluxes and identical output). This can result either in reduction of the number of units or reduction of the number of membrane elements (housings) and modules per unit.

Reduction in operating costs. This is due to higher permeability or lower operating fluxes.

The XIGA membrane is Title 22-approved and has been proven in numerous applications worldwide to be an effective treatment for potable water, wastewater reuse, secondary effluent and pretreatment to RO. The membrane also allows for direct coagulation with inorganic coagulants, providing short retention times, high removal of organics and phosphate removal. MT

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