EQUILIBAR
PRECISION PRESSURE CONTROL

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Water Purification Research: MIT's Reverse Osmosis Membrane Study Benefits from Stable Pressure Control Using Equilibar Back Pressure Regulator

Summary

Researchers at MIT implemented an Equilibar® Back Pressure Regulator to control pressure on a membrane used in reverse osmosis fouling research. The unit helped to eliminate noise in the data collected and allowed for automation of testing to incrase the efficiency in the research testing. The research is part of an effort to improve the desalination and remediation of water.

Background

In the face of population growth and climate change, the problem of water scarcity is gaining urgency throughout the world. The need to find practical, cost-effective methods of purifying waste water and salt water has become critically important.

Reverse osmosis (RO) is one of the most energy-efficient processes for purifying water, but it is not without complications. The process involves passing water through semi-permeable membranes to remove ions, molecules and other large particles. Unfortunately, these delicate membranes often become fouled, particularly in low-energy applications such as wastewater reclamation.

At the Massachusetts Institute of Technology in Cambridge, MA, doctoral candidate Emily Tow and other researchers are developing a model to predict membrane fouling in order to find solutions to the problem. Understanding the fouling of the membrane used in RO desalination will make it possible to reduce the overall cost of water treatment and expand access to clean drinking water for people throughout the world.

As part of this effort, MIT researchers are using an Equilibar back pressure regulator to control the differential pressure across RO membranes, allowing higher resolution in fouling measurement.

The Challenge

In RO desalination, trans-membrane flux depends not only on the extent of fouling, but also on the applied pressure. Taking accurate measurements of membrane fouling in real time requires precise pressure control.

Initially, MIT's research was performed using a needle valve to create back pressures of roughly 70 bar on a 150 cc/min flow of potentially high-fouling saltwater. Since needle valves act as flow controllers, the pressure was indirectly controlled by varying the flow. Researchers hoped the pressure would remain constant at relatively fixed flow rates with small variations in solution viscosity and orifice size. In practice, however, the nearly closed needle valve was highly susceptible to clogging and required constant adjustment. The clogging caused flow to vary, which resulted in unacceptable changes in pressure control.

The Solution

In order to address the pressure control problem in MIT's research application, Equilibar engineers recommended a research series LF1 model back pressure regulator made of SS316L with a PTFE/Glass Laminate diaphragm (PGL10.3) and a FKM O-ring. Unlike traditional back pressure regulators, the Equilibar ® relies on a novel technology featuring a dome-loaded design and multiple orifices. A key advantage of the Equilibar® is that it directly controls pressure over a wide range of flow rates. In the MIT application, this allows upstream pressure to remain constant even as the system flow changes due to fouling and other experimental conditions. Another advantage of the Equilibar® is that the multiple orifice design allows particles to pass to prevent clogging.

For MIT, using the Equilibar provided accurate pressure control for the RO research and vastly reduced measurement error. Most importantly, installing the Equilibar unit allowed the experiment to run reliably without supervision or adjustment. The unit is in service with salt solutions up to 4% NaCl, with no sign of corrosion.

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The Test Fixture

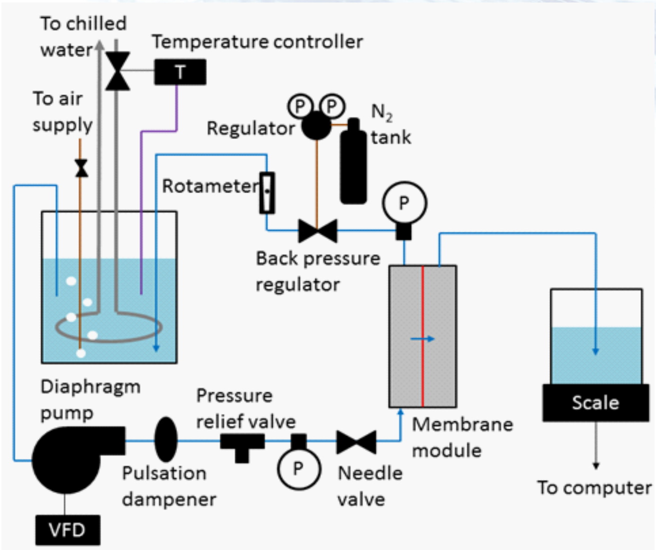

Figure 1: Schematic of RO fouling Test System

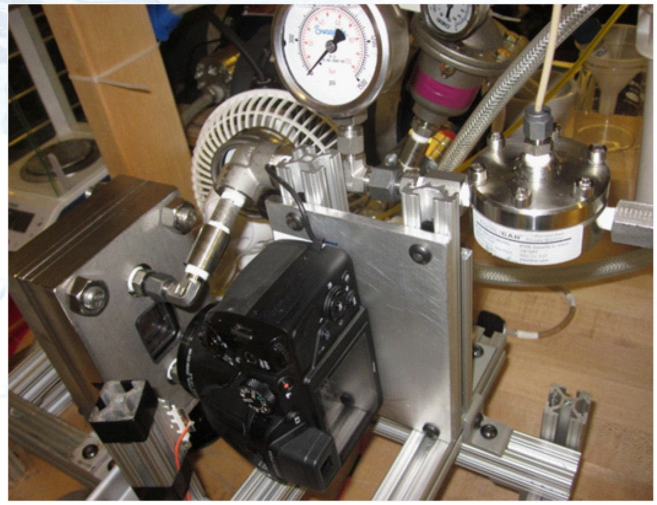

Figure 2: In the picture above, provided by Emily Tow, the Equilibar back pressure regulator is shown at work in the actual system.

Figure 1, above, is a schematic of the RO fouling test system used by researchers at MIT. The Equilibar LF back pressure regulator is shown controlling the upstream pressure on the membrane. The outlet flow of the back pressure regulator is recirculated to the pump supply

Conditions of the Test

MIT's research requires exposure to sodium chloride solutions up to a saturation level of 26% for periods of less than 24 hours. It also requires saturation levels of 3.5% sodium chloride for much longer time frames. The test is run with pressures as high as 1000 psi and average flow range of 100-600 cc/min of process fluid. Additional test conditions include solutions with sodium alginate, both dissolved and as gel particulates.

Results

While the original needle valve required constant supervision, the Equilibar unit precisely controls pressure with both long and short-term (>1 Hz) fluctuations. It allows for tests to be run unsupervised, greatly increasing productivity.

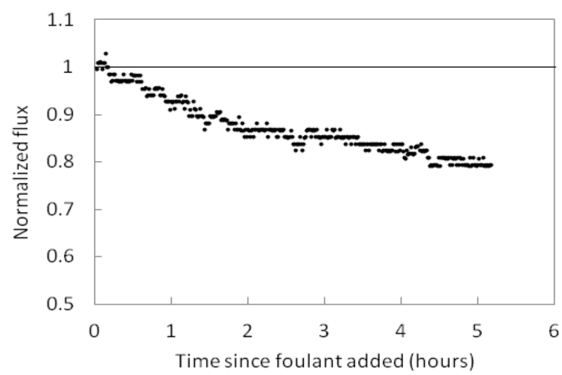

Figure 3: Above, Figure 3 shows a sample plot of measured flux decline due to fouling using the needle valve prior to installing the Equilibar LF

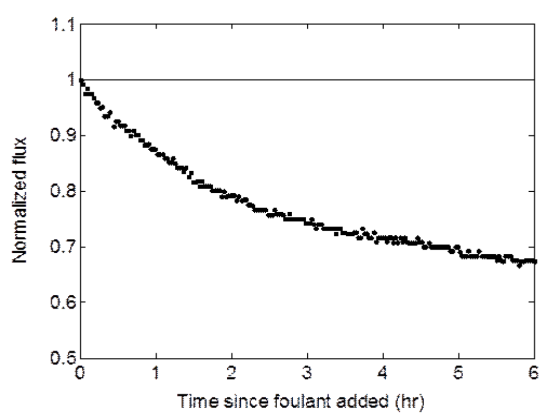

Figure 4: Right, Figure 4 shows a sample plot of the measured flux decline due to fouling using the Equilibar LF to control the back pressure

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Conclusion

MIT's research requires exposure to sodium chloride solutions up The back pressure regulator from Equilibar was installed with the goal to eliminate adjustments required to the needle valve due to clogging and to avoid resulting pressure changes in the system. The Equilibar was able to eliminate the pressure fluctuations on the sensitive diaphragm for more accurate and smoother flux decline. In addition, researchers found that the overall system was more robust and reliable as tests could be run without the supervision the needle valve required.

The Equilibar allowed for more efficient testing and more accurate testing of this vital research, which is being conducted by the Lienhard Research Group in the MIT Department of Mechanical Engineering. The group's focus is on technologies for desalination and remediation of water.

Quote from researcher Emily Tow:

"Equilibar has been the most helpful out of all the suppliers I worked with while building this experimental apparatus. I contacted them several times with technical questions while incorporating the Equilibar unit into my system, and they were knowledgeable and helpful. When a diaphragm ruptured at one point, they even overnighted replacements so that my work was not impacted."

More information on the research performed by this group can be found here: http://lienhard.scripts.mit.edu/research/

Contact Equilibar

Equilibar is a provider for unique and innovative pressure control solutions based in Fletcher, North Carolina. The patented back pressure technology is used in a wide array of processes including catalyst, petrochemical, supercritical and other industrial applications. For more information please contact an Equilibar applications specialist at www.equilibar.com, info@equilibar.com or 828.650.6590.

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