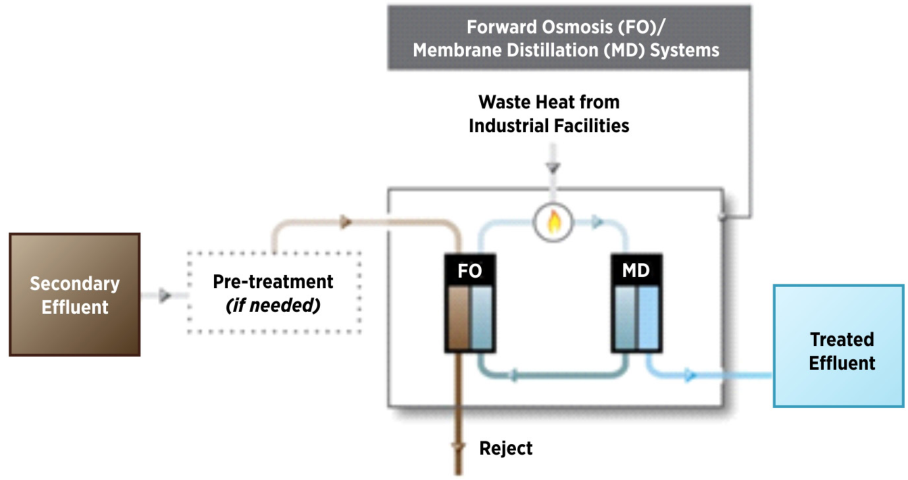
Hybrid Membrane System for Industrial Water Reuse

New Advanced System Utilizes Industrial Waste Heat to Power Water Purification



Hybrid FO/MD membrane system being developed in this project for industrial water reuse utilizing process waste heat. *Photo credit Research Triangle Institute.*

Introduction

As population growth and associated factors stress water availability, the ability of U.S. manufacturers to move toward sustainable, efficient, and low-cost water management practices is crucial to ensuring their status as global competitors. Currently, most industries treat water to meet standards for direct discharge to surface water. The process includes a primary treatment to remove free oils and solids and secondary treatment to remove biodegradable organics and nutrients. The water must be treated further if it is to be reused for cooling tower makeup, boiler feed, or process streams. Reverse osmosis (RO) is considered the current state-of-the-art for manufacturers wishing to reuse water, but this technique is also limited by a number of factors. Extensive pre-treatment of industrial wastewater is required for RO to be successful, and residual dissolved organics and solids can degrade and foul the RO membrane. In addition, energy is required to force water through the semi-permeable RO membrane.

This project is developing a robust, low-energy, dual hybrid membrane system that can provide water quality comparable to RO and be powered by waste heat. The hybrid system synergistically combines a forward osmosis (FO) system with membrane distillation (MD) technology. Minimally treated wastewater is sent to an FO system containing a salt "draw" solution on the permeate side of the membrane. The higher osmotic potential in the salt solution drives the FO process. The resulting permeated water, consisting of mainly dissolved solids with little organic content, is then passed through to the MD system. This water evaporates due to moderate heating by industrial waste heat, and the vapor is transported across the MD membrane for collection by condensation. The quality of the product water is comparable to distilled water and is suitable for direct reuse. The remaining, non-permeated solution containing non-volatile solutes and salt is sent back to the FO system as "draw" solution.

Benefits for Our Industry and Our Nation

Based on current industrial wastewater practices and preliminary analysis, this technology has the potential to provide the following benefits:

- Reduction in electricity costs associated with advanced wastewater treatment by more than 90%
- Reduction in water treatment costs by 20% or more
- Reduction in carbon emissions by more than 90%
- Reduction in wastewater discharge volumes by up to 94%
- Reduction in external industrial water withdrawal requirements by up to 34%

The proposed technology can potentially enable the U.S. manufacturing sector to become more water sustainable and move toward zero liquid discharge operations.

Applications in Our Nation's Industry

Opportunities to recover waste heat to operate a hybrid membrane system for treating wastewater exist in a number of industries, including petroleum refining, pulp and paper, and chemical manufacturing. The sustainable low-energy approach to water management has also generated interest from leaders in other application areas, including shale gas extraction and biofuels production.

Project Description

The project objective is to demonstrate an advanced water treatment and reuse process in a single hybrid system that combines forward osmosis (FO) with membrane distillation (MD) to achieve greater efficiency and increased water reuse. The technology uses recovered waste thermal energy and is applicable across all manufacturing facilities for a wide range of wastewater streams.

Barriers

- Attaining a suitable MD membrane with adequate flux performance.
- Attaining a suitable draw solution that produces minimal scaling on the MD membrane and inhibits biofilm growth on both the FO and MD membranes.
- Poor rejection of organic and inorganic contaminants in the industrial waste stream.
- Stability of membranes upon exposure to industrial waste streams.

Pathways

Researchers will take advantage of commercially available membranes suitable for FO and MD for various industrial waste streams and optimize them for the hybrid system. Appropriate draw solutions will be developed to determine the most suitable FO membrane. Ceramic membranes will be developed as advanced, next-generation MD membranes and benchmarked against those membranes conventionally used for MD. A bench-scale integrated FO/MD system will then be developed for high-fidelity performance testing. Once performance has been verified, a prototype integrated system will be field-tested with a real wastewater slipstream at an industrial facility.

Milestones

This project began in 2012.

- Development of a suitable ceramic membrane for an MD unit (Completed).
- Optimized FO membrane process with suitable FO draw solution (Completed).
- Construction and commission of a bench-scale, integrated FO/MD test system and initiation of performance testing using industrial effluents (Completed).
- Construction, installation, and initial testing of the prototype in a relevant industrial environment (2015).

Commercialization

The project team includes a leading non-profit research institution specializing in developing technology from bench-scale through commercialization as well as an industrial partner that is a global leader in water treatment and reuse technology with access to potential testing sites. The industrial partner also provides technical solutions with design-build-operate (DBO) capabilities. The DBO business model will be used to introduce the new technology into the marketplace. The technology has already attracted interest across industry and it is expected that the technology could achieve a high degree of market penetration within existing treatment plants that require upgrading and in new facilities that are expected to begin operations after 2016.

Project Partners

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