ISTC

Fact Sheet

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Forward Progress in Reducing Oily-Wastewater

A forward osmosis, small-scale pilot at a metal fabricator

Abstract

Forward osmosis is the natural diffusion of water through a semi-permeable membrane from a solution of a lower solute concentration to a solution with a higher solute concentration. Taking advantage of this natural process, Illinois Sustainable Technology Center (ISTC) research staff successfully reduced volumes of three (3) common water-based industrial process waste streams at a small metal fabricator. Instead of conventional energy-intensive alternatives, researchers employed fledgling forward osmosis technology, using chemistry instead of energy to remove water from common process fluids.

The Theory

In solutions, high concentrations and low concentrations attempt to establish equilibrium. Forward osmosis involves using a drawing solution (a solution with a high solute concentration) to remove water from waste streams with a lower solute concentration by separating the two solutions with a semi-permeable membrane. The semi-permeable membrane acts as a barrier that allows small molecules such as water to pass through while blocking larger molecules. During this process, the drawing solution is diluted. Once the drawing solution has been sufficiently diluted, disposal or re-concentration is necessary. This process occurs at ambient temperature and pressure, without the need for external energy input. Because water is a major component in most common process fluids, low energy alternatives to dewatering these fluids are desirable because it would allow industrial facilities to reduce energy and the volume of waste they transport and dispose, which in turn reduces associated energy and disposal costs.

The Pilot

In ISTC's laboratory, researchers fabricated a simple, small-scale forward osmosis pilot system which could be easily transported and set up at a host industrial facility. A field pilot was performed in order to test the viability of the system in a real world environment. Once the system was ready, a small metal fabricator was selected for field testing in real-world conditions. Highland Machine, located in Highland, Illinois, volunteered to be the pilot host. Like many small manufacturing facilities, Highland Machine utilizes a natural gas evaporator to remove excess water from water-based waste streams prior to disposal via a licensed waste hauler. Removing the water from the waste reduces their disposal costs.

During a 10-day field test, researchers successfully processed 12 sample batches, comprised of three (3) waste process fluids (metalworking fluid, compressor condensate and degreaser/cleaner solution). Samples of all fluids were collected at the beginning, midpoint and end of each batch run for analysis at ISTC.

Equipment and Materials List
Container- (2) 5 gallon plastic with 31/2" dia. hole centered in lid
Drawing Solution- tap water with salt (NaCl)
Concentrations: 9-12%
Motor with Stirring Paddle- (2) 100-watt TLine Laboratory Stirrers
Membrane Housing-(2) 3" dia. 18 gauge 409 stainless steel perforated tubing
Membrane- Hydration Technology Innovations, cellulose triacetate
Sample Bottles
Waste Process Fluids
Master Chemical, Trim E216 Metalworking Fluid
Ingersoll Rand Air Compressor Condensate
Aqueous Degreaser/Cleaner- Troy 1163

Table 1: Pilot Bill of Materials

The Results

Analytical results of these samples indicate that the salt solution drew pure water (through osmosis) from the spent process fluids through the selectively permeable membrane without transference of chemical constituents or contaminants. The volume of water removed varied by waste stream. These differences are attributed to the waste streams containing different compounds at various concentrations. Trim E216 was processed in six of the tests, while the air compressor condensate and Troy 1163 were each processed in two of the tests. Each test lasted for roughly the same time (~24 hours) and under similar conditions with only slight variation of salt concentration which had little effect on the results. The total volume of waste stream treated, volume of waste remaining after treatment and the percent that the volume of the reduced waste was averaged for each waste stream. The combined data is displayed in Table 2.

	Volume (Gallons)		
Waste Stream	**Initial**	**Remaining After Treatment**	**Reduction in Volume**
Trim E216	1.9	0.57	70%
Air Compressor Condensate	0.62	0.12	81%
Troy 1163	0.63	0.35	44%

Table 2: Test Results

The Future

The initial pilot findings appear to indicate that forward osmosis technology is an effective, low-energy alternative to conventional energy-intensive waste treatment systems. Forward osmosis technology has been used commercially for providing emergency drinking water and desalinization around the world. Little research has been done regarding its role in wastewater treatment, food processing, pharmaceutical products, and power generation. This technology is only beginning to be utilized and optimized for a variety of these applications. Costs could be

further reduced by repurposing waste streams as drawing solutions. For example, the discharge from water softeners could be used instead of purchasing and preparing a drawing solution. Further research is necessary to determine the scope, limits, and applications of forward osmosis technology.

Photo Gallery

Photo 1: Housing fitted with membrane

Photo 2: 5-gallon container with housing, membrane, motor, and stirrer

Photo 3: Machining center

Photo 4: Machine sump of metalworking fluid with tramp oil and other contaminants used in the pilot

Photo 5: HP Air Compressor

Photo 6: Compressor condensate

Photo 7: Multi-stage washer – Stage 1 cleaner

Photo 8: Spent aqueous cleaner

Photo 9: Metalworking fluid samples before (feed) and after (concentrated)

For More Information

Additional ISTC fact sheets covering energy efficiency, water conservation, pollution prevention and sustainability are available at http://www.istc.illinois.edu. You may also contact:

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About Highland Machine

Highland Machine is one the largest sheet metal fabricators and precision machinists serving the Midwest. Established in 1944 in rural Highland, Illinois just 40 miles east of St. Louis, this facility comprises three buildings, totaling approximately 140,000 square feet with a workforce of 130 employees. Manufacturing operations include: engineering, machining, assembly, powder-coat finishing and packing.