ISTC Fact Sheet
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Recovery of Steam Condensate Utilizing Membrane Technology at Carlisle SynTec Inc., Greenville, Illinois

The Challenge

Carlisle SynTec manufactures single-ply roofing systems primarily for commercial and industrial applications. In most situations, return of boiler steam condensate is a viable and often utilized energy recovery and water conservation practice. However at Carlisle SynTec, the return and reuse of steam condensate has not been feasible due to its use of a mica coating in the manufacture of EPDM (ethylene propylene diene monomer), a type of synthetic rubber.

After the EPDM is mixed and rolled into sheets, a water-mica solution is applied to the EPDM sheet to prevent adhesion upon itself during vulcanization. The vulcanization process involves 1) winding the sheets onto large mandrels, 2) loading the mandrels of mica-coated product into six 8' x 60' autoclaves, 2) curing with direct contact steam for 4-6 hours, and then 3) unloading the mandrels to cool.

During vulcanization, steam condenses on the product, the mandrel and autoclave's interior walls. This steam condensate is not returned to the boiler due to the suspended mica particulates that render the condensate unusable. Prior attempts to remove the mica with traditional cartridge filtration had been ineffective, causing immediate boiler pump seal wear & failure, coating of internal boiler surfaces and even internal boiler component blockages. This required subsequent repairs, system downtime and parts and labor costs. No further attempts to filter the condensate were pursued.

An Opportunity

Seeing an opportunity, Carlisle Syntec requested assistance from the Illinois Sustainable Technology Center (ISTC) to investigate the feasibility of producing a steam condensate suitable for return to its boiler, saving natural gas, chemicals and water.

ISTC staff, Carlisle Engineer Chris Ziemba, and Cory Hurst-Thomas, Illinois Environmental Protection Agency summer intern, began collecting preliminary information.

A condensate sample and a mica raw material sample were collected. ISTC's Laboratory Services sized the samples using a Coulter LS Particle Size Analyzer.

Sizing results indicated that the mica particles had a broad range of particle sizes (from 0.2 micron to 200 microns) which most likely would render standard bag or cartridge filtration ineffective. With this in mind, ISTC set up a portable ultrafiltration membrane unit on-site, and successfully processed a small sample batch of heated condensate.

Condensate volumes and temperatures were recorded and determined 1.2 million gallons of 160º F condensate were being discharged annually with 100º F ΔT (temperature differential of incoming makeup water vs. heated condensate). Boiler efficiency was calculated and natural gas pricing was collected. Preliminary projections indicated a potential $40,000 annual savings.

From initial particle sizing results and the portable membrane system demonstration, Carlisle Syntec and ISTC believed that membrane (ultrafiltration) technology may be an effective tool in producing a mica-free, heated condensate suitable for return to the boiler.

Membrane Technology Application and Theory

Membranes are semi-permeable barriers capable of separating feed stream components that have a particle size relative to the pore sizes of the membrane. Feed stream components that have a particle size larger than the pore sizes of the membrane are retained (retentate) while components that are smaller than the pore sizes of the membrane are allowed to pass through (permeate).

A major difference between conventional filtration practice and “membrane” filtration is with respect to the mechanism of contaminant capture. Conventional filters operate by capturing particles within the filter matrix, a process termed depth filtration. The filters cannot be regenerated after use, as the particles accumulate within the filter matrix. Membrane filters are usually sized to have pores that are too small for particles to enter. Therefore, the bulk of the filtration occurs at the surface of the filter. Membrane filters can, therefore, be reused by removing the particulate matter from the surface by flushing or cleaning. Figure 1 below illustrates the common mode of operation employed in ultrafiltration.

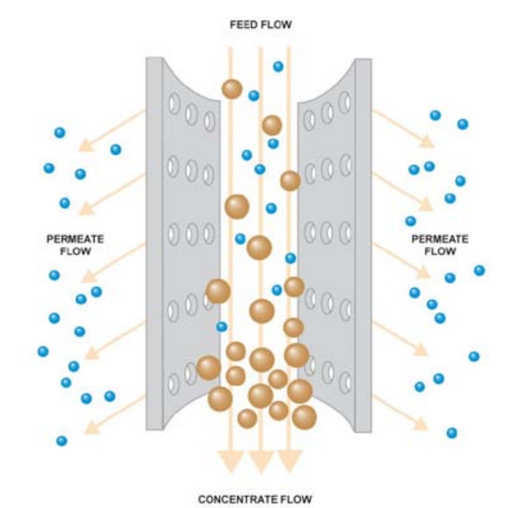

Figure 1 – UF Cross-section

This mode, termed “cross-flow” filtration, describes the flow of the feed solution in a direction parallel to the membrane surface or filter. This facilitates the “sweeping” of the membrane surface and limits filter cake buildup and allows for longer periods of operation without having to clean the membrane. A small portion of the solution is forced through the membrane by the applied pressure and recovered as “permeate.”

The Ultrafiltration Pilot- Initial Setup

ISTC and Carlisle SynTec agreed that a small-scale, short term pilot would evaluate the effectiveness of a select membrane system at removing suspended mica from the hot condensate for potential reuse in the boiler. The feasibility pilot would be completed in June-July 2009 due to the availability of Carlisle SynTec’s IEPA summer intern.

Carlisle SynTec provided the location, utility connections and plumbing, availability of Cory Hurst-

Thomas, its summer intern, and maintenance personnel support. ISTC provided an ultrafiltration pilot system fitted with five (5) 0.1 micron sintered stainless steel membranes, plus technical assistance in the system setup, operation, data collection, sampling protocol and analytical analysis.

The Ultrafiltration Pilot- Base Line Information

The ultrafiltration system (Figure 5) was thoroughly cleaned before use and water fluxes (permeate flow rates) were collected at multiple pressure points for establishment of a baseline for future reference. Fluxes were recorded for tap water and conditioned water as depicted below in Figures 2, 3 and 4.

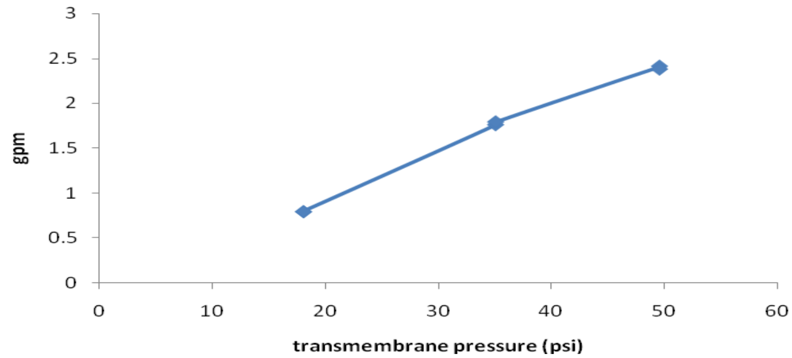

Figure 2: Ambient Tap Water Flux.

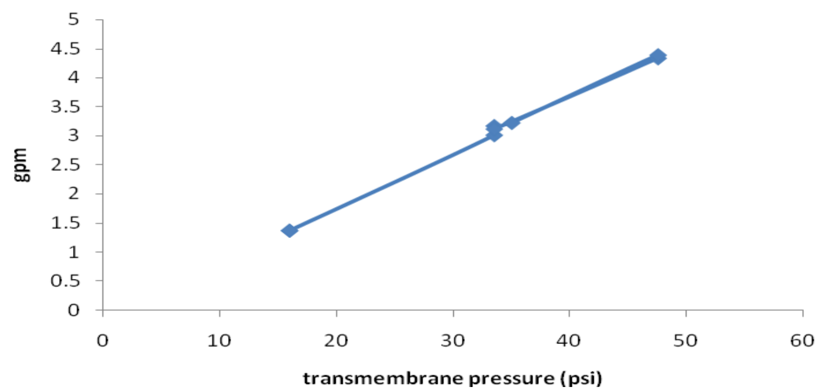

Figure 3: Warm Tap Water Flux.

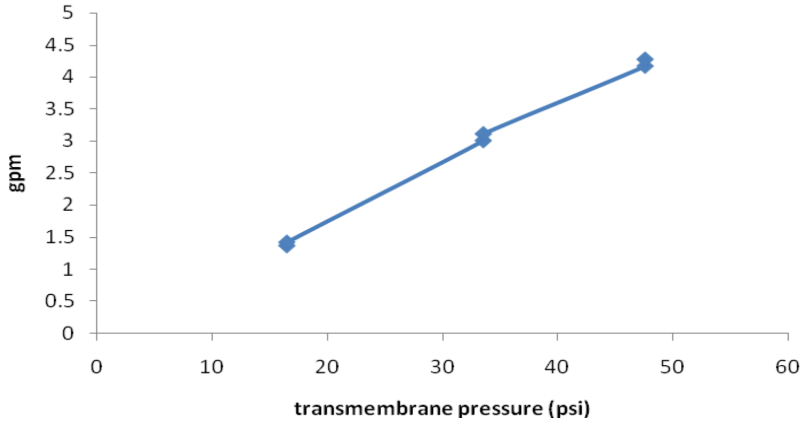

Figure 4: Warm Conditioned Water Flux.

The Ultrafiltration Pilot- Execution and Results

Figure 5 depicts the ultrafiltration pilot system (located by an autoclave), comprised of a pump, a control panel, five membranes, a process/concentration tank (retentate) and a permeate line. Not shown is the inlet line from the autoclaves. Over time, as the membrane system processes the condensate, membrane fouling occurs and flux rate declines which is typical and to be expected. Finding the rate at which this occurs is the reason for conducting the pilot.

Figure 5: UF Pilot. The stainless steel barrel (foreground) is the process/concentration tank. Condensate enters the process tank by means of a gravity-fed inlet pipe (not shown) from the autoclaves. Then it is pumped throughout the membranes (five vertical metallic pipes) and leave as either permeate (foreground red tubing) or as retentate (black vertical pipe into the process tank) where it is further concentrated and reprocessed through the system.

The pilot system ran for 142.5 hours and processed approximately 11,970 gallons of heated condensate. The permeate flux was recorded periodically from the startup through the end of the pilot. The end was determined when the flow rate leveled and remained steady (Figure 6). The system was then cleaned using physical action, followed with detergents, and then clean water fluxes were recorded and compared to the initial water fluxes to determine the best cleaning methodology.

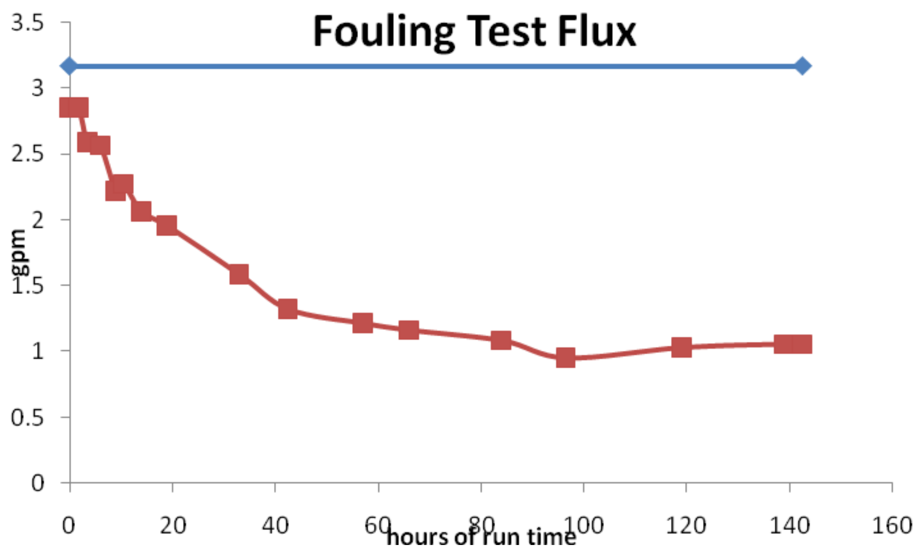

Figure 6: Fouling Test Flux- the blue line is the conditioned water flux (control) and the red line is the condensate permeate flux rate over time.

A sample of conditioned water (control) was collected and samples of the initial condensate feed, permeate, and retentate were collected throughout the trial (Figure 7).

Figure 7: (Left to Right) Samples of conditioned water, initial feed, end retentate, and end permeate.

ISTC's Laboratory Services analyzed the samples for Total Suspended Solids (TSS). Table 8 results indicate significant removal of contaminants from the condensate, even at elevated retentate concentrations.

Sample Number	Total Suspended Solids (mg/L)
Control Conditioned Water	0.75
Condensate Feed Startup	47
Permeate- Startup	1.8
Permeate- Mid	2.3
Permeate- End	1.8
Retentate End	1500

Table 8: Total suspended solids concentrations

Conclusion

The pilot conducted at Carlisle SynTec has shown ultrafiltration membrane technology to be a feasible methodology for removing its mica particulate from steam condensate making it suitable for reclamation and reuse in the boiler. Reclaiming this condensate will save water, chemicals and energy, an opportunity that Carlisle SynTec would like to further investigate with ISTC's assistance.

For more information about membrane technology, additional ISTC Fact Sheets are available at www.istc.illinois.edu. You may also contact:

Dan Marsch
ISTC- Peoria Office
P.O. Box 697
Peoria, IL 61652
Work: 309 671-3196
Fax: 309 671-3106
dmarsch@istc.illinois.edu

Special Thanks To:
Chris Ziemba
Electrical Project Engineer
Carlisle SynTec, Inc.

Cory Hurst-Thomas
University of Illinois- UIUC
IEPA Intern
Carlisle SynTec, Inc.

Richard Reese, CEM, CEA
Intern Program Coordinator
Illinois EPA- Office of Pollution Prevention
P.O. Box 19276
1021 N. Grand Avenue East

Springfield, IL 62794-9276
(217) 557-8671
richard.reese@illinois.gov
www.epa.state.il.us/p2/internships/

About the Company

Carlisle has been a leader in roofing and waterproofing for more than 40 years. Carlisle SynTec has manufacturing facilities in Carlisle, PA; Greenville, IL; Senatobia, MS; and Tooele, UT.

In October 2008, Carlisle SynTec received an Illinois Governor's Pollution Prevention Award for its environmental achievements.

This case study was developed as part of the Strategic Energy and Water Reduction project, funded by a grant from the U.S. Environmental Protection Agency. Photos courtesy of Carlisle SynTec Incorporated.