

Pilot-Scale Testing of a SpinTek Rotary Microfilter with SRS Simulated High Level Waste

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SUMMARY

The Department of Energy selected caustic side solvent extraction (CSSX) as the preferred cesium removal technology for Savannah River Site waste. A pretreatment step for CSSX adds monosodium titanate (MST) for alpha sorption and uses crossflow filtration to remove MST and entrained sludge. Previously, personnel conducted a review of solid-liquid separation technologies and identified the rotary microfilter as a plausible improvement over the tubular crossflow filter in the current baseline. One manufacturer performed scouting tests in 2001 that showed significant improvement in filter flux from using the rotary microfilter rather than the conventional crossflow filter. We recently performed pilot-scale tests with the rotary microfilter using simulant.

The testing used a three-disk filter unit rather than a one-disk unit as used in bench-scale testing and recent actual waste studies. We conducted the tests with two feed slurries: sludge plus MST and sludge plus manganese oxide solids. The tests with each feed occurred at four solids concentrations between 0.06 wt % and 4.8 wt %. Each test lasted 125 hours, for a total operating time of 1000 hours. As such, this testing evaluated the long-term reliability of the rotary microfilter, and provides a comparison of performance of a multi-disk unit with SRS simulated waste to actual waste experiments.

The conclusions from this work follow.

- The pilot-scale rotary microfilter produced a 1.5 – 2.8 X increase in filter flux, measured as permeance (i.e., flux divided by transmembrane pressure) compared to the conventional crossflow filter with a similar sludge and MST slurry feed. The actual improvement may prove greater, since the SpinTek filter contained a 0.1 μ filter rather than the 0.5 μ filter media used in prior crossflow studies. Also, the SpinTek flux data came from operation at 8 – 57 hours rather than ~ 2 hours for the earlier crossflow study.
- The conventional crossflow filter produced higher flux than the rotary microfilter with sludge and manganese solids slurry. The difference, measured as permeance, equaled approximately 30%.
- No operational problems occurred during the tests with sludge and MST.
- Following a “rotor stop test” – performed to simulate an unplanned shutdown – using sludge and manganese oxide solids, personnel could not resume operation of the rotor. Recovery of operation required disassembly and removal of solids that packed within the equipment. Water flushing failed to dislodge these solids. The slurry packed to ~40 wt % solids during this event.
- The rotary microfilter flux with feeds containing manganese solids averaged 50% higher than the rotary microfilter flux with feeds containing MST.

INTRODUCTION

The Department of Energy selected CSSX as the preferred cesium removal technology for Savannah River Site waste. As a pretreatment step for the CSSX flowsheet, personnel contact the incoming salt solution that contains entrained sludge with MST to adsorb strontium and select actinides. They filter the resulting slurry to remove the sludge and MST. The filtrate receives further treatment in the solvent extraction system.

Testing performed by SRTC and the University of South Carolina (USC) with simulated waste showed relatively low filtration rates of 0.03 – 0.08 gpm/ft².^{1,2,3,4} Additional testing conducted with actual waste showed similar filtration rates.⁵ Personnel conducted a review of solid-liquid separation technologies and identified the rotary microfilter as a plausible improvement over the tubular crossflow filter in the current baseline.⁶

The SRTC subcontracted SpinTek to conduct a rotary micro-filter test at their facility in 2001.⁷ Table 1 shows the test results. The rotary microfilter flux shown came from the vendor tests, while we calculated the crossflow filter flux from the model developed during pilot-scale testing of the conventional configuration in 2000.⁴ The rotary microfilter demonstrated a significant improvement in performance relative to the crossflow filter. The improvement reaches approximately 2.5X at low solids loadings (0.05 – 0.22 wt %) and increases to 6.5X at 4.8 wt % insoluble solids.

Table 1. Comparison of SpinTek Filter with Conventional Crossflow Filter from Vendor Scoping Tests

<u>Solids (g/L)</u>	<u>Solids (wt %)</u>	<u>Rotary (gpm/ft², measured)</u>	<u>Crossflow (gpm/ft², predicted)</u>	<u>Ratio</u>
0.6	0.05	0.21	0.08	2.6
2.8	0.22	0.19	0.07	2.7
12.9	1.0	0.15	0.04	3.8
60.0	4.8	0.13	0.02	6.5

Based upon these results, the SRS Salt Processing Program decided to perform additional tests with the rotary microfilter using actual waste at the bench-scale and simulant at the pilot-scale.⁸

This report describes the pilot-scale testing. The testing evaluated the long-term reliability of the rotary microfilter by performing a 1000-hour test, and allows us to compare the performance of a multi-disk unit with results for actual waste with a single disk unit.

TESTING

Equipment

The Spintek rotary microfilter unit at the University of South Carolina's Filtration Research Engineering Demonstration (FRED) is a Model ST-II-3, Laboratory Test Unit with three membrane disks for a total of 3 ft² active membrane area (see Figure 1). The disks spin inside a pressurized vessel with spoked turbulence promoters above and below each disk. Personnel can manually adjust the speed of the disk rotation between 500 and 1400 rpm. Increasing the rotational speed increases the shear forces at the surface of the disk. For the purpose of this test, we kept the disk rotational speed at 1170±20 rpm except during the rotor stop portions of the test.

A valve on the concentrate exit automatically controls the pressure inside the filter housing. This pressure provides the transmembrane pressure required to force filtrate through the filter membranes. For the purpose of this test, we controlled the pressure at 30, 40, or 50 psi. The

FRED personnel added pressure sensors to the feed inlet and filtrate lines so they could collect data and calculate transmembrane pressures.

The feed slurry flows across the surface of the filter disks. A differential pressure drives the supernate through the filter membrane and into the center of the disks. The filtrate moves to the center of the disk and collects in the shaft holding the disks. The equipment provides no pressure control on the filtrate line, with only a solenoid valve to stop filtrate flow when desired. We measured filtrate flow by use of a magnetic flow meter.



Figure 1. Pilot-Scale SpinTek Rotary Microfilter

Personnel manually controlled feed flow by adjusting the speed of the feed pump. We measured feed flow with a magnetic flow meter. For the purposes of this testing, we maintained feed flow between 3.8 and 4.2 gpm.

The feed tank has a working capacity of 115 L. The agitator in the feed tank operates at a variable speed with a single marine blade. The feed tank includes a sensor for the Lasentec particle size analyzer.

We provided automatic temperature control for the system with a heat exchanger located on the line from the feed pump to the filter housing. Personnel supplied cooling water from a remote source and maintained the temperature with the control valve on the skid.

Materials of construction for the unit are all corrosion resistant (i.e. stainless steel, Teflon™, etc.)

The onboard Programmable Logic Controller (PLC) performs automatic control with data passed to the facility Data Control System for logging.

Test Protocol

Personnel conducted the tests with two feed slurries: sludge plus MST and sludge plus manganese oxide solids. They prepared the feed from previously used test slurries.^{4,9} Personnel produced the solids for the SpinTek test with the permanganate flowsheet by contacting simulated sludge with sodium permanganate. Since the sludge preparation did not include strontium nitrate, these solids differ from the current baseline. We selected these slurries to match the solids used in previous crossflow filter tests.^{4,9}

We prepared the sludge plus MST slurry in the following manner. Personnel decanted the supernate (i.e., 5.6 M sodium, “average” salt solution) from drums containing sludge and MST. We analyzed the supernate for insoluble solids to determine the mass of solids needed to achieve the target concentrations. We analyzed settled solids from the drums for insoluble solids concentration and added to the feed tank to achieve the target solids loading. We prepared the sludge plus manganese oxide solids slurry in the same manner.

Once the feed tank contained the desired slurry (nominal 0.06 wt % insoluble solids), personnel started the rotary microfilter and circulated the feed for 125 hours. They varied the transmembrane pressure between 30 psi and 50 psi to determine its impact on filter flux. After the 125-hour test, personnel increased the solids loading to nominal 0.29 wt % and operated another 125 hours. Similarly, they performed 125-hour tests using nominal 1.29 and 4.5 wt % slurries. Near the end of the fourth experiment, personnel stopped the rotor for two hours while circulating the feed slurry to investigate the impact of an unplanned shutdown on the equipment. Tables 2 and 3 summarize the test conditions. The tests with sludge and manganese oxide solids occurred in the same manner with slightly different solids concentrations to match the 2002 crossflow filter tests.⁹

Table 2. SpinTek Rotary Microfilter Test Conditions for Sludge and MST Feed

Feed	Nominal Insoluble Solids (wt %)	TMP (psi)	Rotor Speed (rpm)	Time (h)
Sludge + MST	0.06	40	1200	50
Sludge + MST	0.06	30	1200	8
Sludge + MST	0.06	50	1200	8
Sludge + MST	0.06	40	1200	59
Sludge + MST	0.29	40	1200	50
Sludge + MST	0.29	30	1200	8
Sludge + MST	0.29	50	1200	8
Sludge + MST	0.29	40	1200	59
Sludge + MST	1.29	40	1200	50
Sludge + MST	1.29	30	1200	8
Sludge + MST	1.29	50	1200	8
Sludge + MST	1.29	40	1200	59
Sludge + MST	4.5	40	1200	50
Sludge + MST	4.5	30	1200	8
Sludge + MST	4.5	50	1200	8
Sludge + MST	4.5	40	1200	40
Sludge + MST	4.5	40	0	2
Sludge + MST	4.5	40	1200	17

Table 3. SpinTek Rotary Microfilter Test Conditions for Sludge and Manganese Feed

Feed	Nominal Insoluble Solids (wt %)	TMP (psi)	Rotor Speed (rpm)	Time (h)
Sludge + MnO ₂	0.07	40	1200	50
Sludge + MnO ₂	0.07	30	1200	8
Sludge + MnO ₂	0.07	50	1200	8
Sludge + MnO ₂	0.07	40	1200	59
Sludge + MnO ₂	0.34	40	1200	50
Sludge + MnO ₂	0.34	30	1200	8
Sludge + MnO ₂	0.34	50	1200	8
Sludge + MnO ₂	0.34	40	1200	59
Sludge + MnO ₂	1.5	40	1200	50
Sludge + MnO ₂	1.5	30	1200	8
Sludge + MnO ₂	1.5	50	1200	8
Sludge + MnO ₂	1.5	40	1200	59
Sludge + MnO ₂	3.0	40	1200	50
Sludge + MnO ₂	3.0	30	1200	8
Sludge + MnO ₂	3.0	50	1200	8
Sludge + MnO ₂	3.0	40	1200	40
Sludge + MnO ₂	3.0	40	0	2
Sludge + MnO ₂	3.0	40	1200	17

RESULTS

Filter Flux Data

Figure 2 shows the filter flux plotted as a function of time during the 500-hour test performed using the sludge and MST slurry. The plot also shows the solids loading and transmembrane pressure (TMP) during each period of operation.

The data demonstrate a correlation between filter flux and TMP. Because of the high shear created by the rotating disks, one would predict an effect of TMP on filter flux. A significant decrease in flux occurred at the start of the test, and through the end of the first 125 hours. This decline is, in part, due to the filter being “new”. At the higher solids concentrations, the flux declines some initially, but steadies at the end of the 125-hour experiment. No filtrate flow occurred during the two-hour rotor stop test, because an interlock closes the solenoid valve on the filtrate line when the rotor stops. The filter flux recovered immediately after the rotor resumed spinning. The measured flux for all the testing markedly exceeds the baseline flux of 0.02 gpm/ft² specified for the Salt Waste Processing Facility.

Figures 3 – 6 show the filter flux during the tests with sludge and MST slurry. The figures also show data from conventional crossflow filter tests for comparison.⁴ At the lowest solids concentrations (nominal 0.06 and 0.29 wt %), the flux of the SpinTek equipment exceeds the crossflow data by approximately 50%. At 0.06 wt %, the average filter permeance with the rotary microfilter equaled 0.0032 gpm/ft²psi versus 0.0021 gpm/ft²psi with the crossflow filter. At 0.29 wt %, the average filter permeance with the rotary microfilter equaled 0.0026 gpm/ft²psi versus 0.0017 gpm/ft²psi with the crossflow filter. This increase is less than observed during the vendor tests in 2001.⁷ The current test data comes from the period of 8 – 57 hours after starting versus approximately two hours of operation in the crossflow filter tests used for comparison. If the crossflow filter tests continued for longer time, the improvement from the SpinTek filter

would likely be greater. Additionally, the SpinTek filter used $0.1\ \mu$ pore-size media, while the crossflow filter used $0.5\ \mu$ material. Finally, the solids loading in the SpinTek test exceeded that in the crossflow filter test.

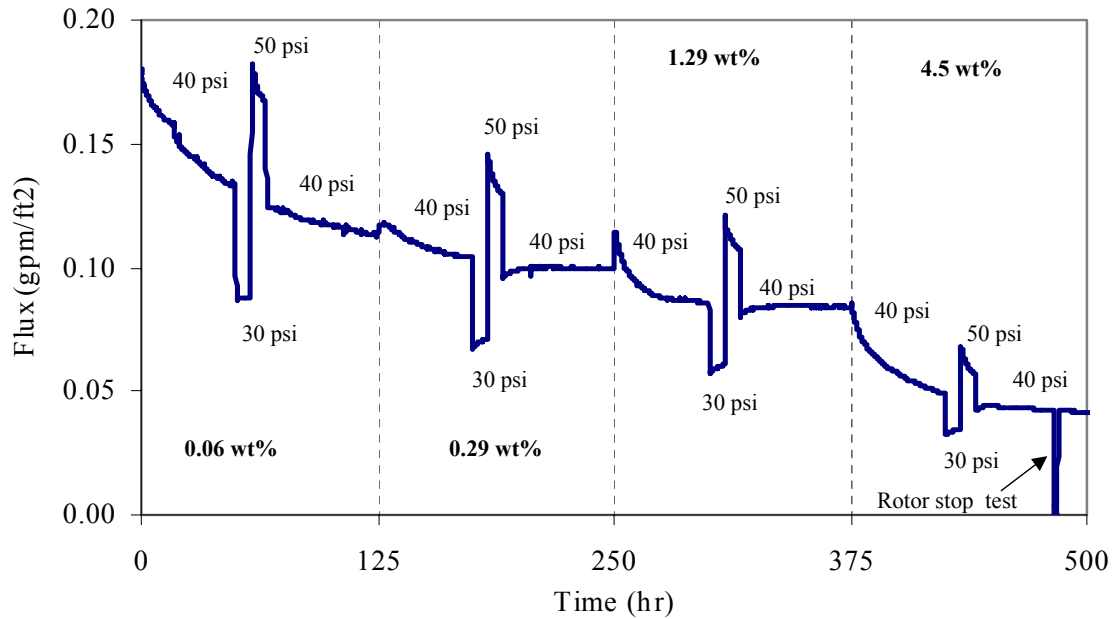


Figure 2. SpinTek Flux with Sludge and MST Slurry

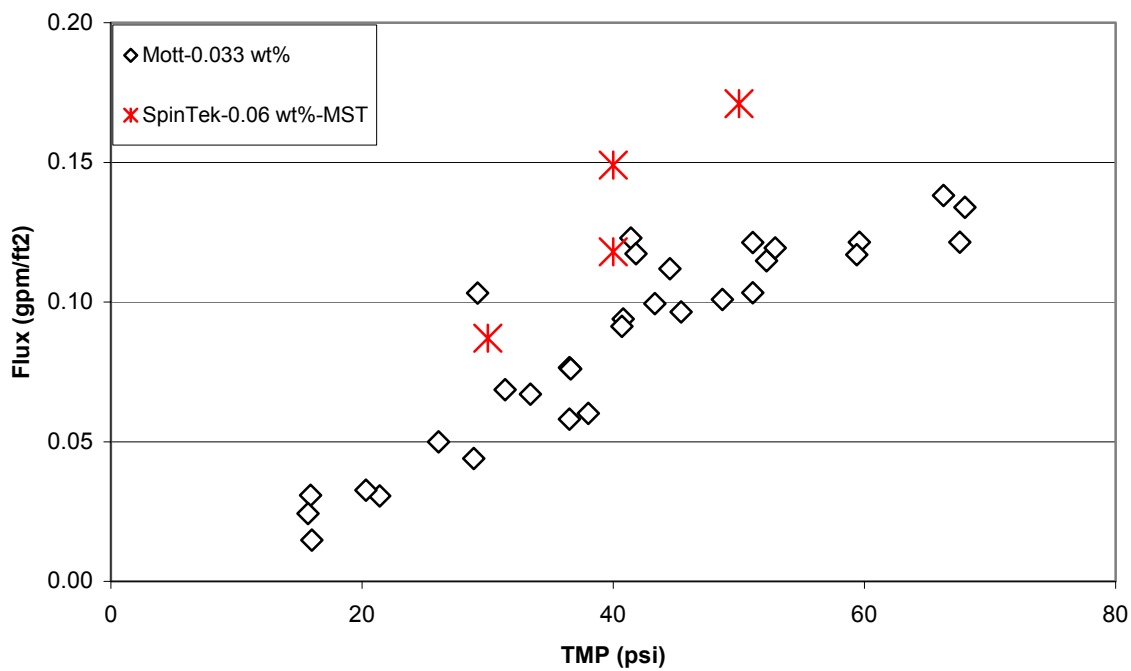


Figure 3. SpinTek versus Conventional Crossflow Filter with MST at 0.06 wt % Solids

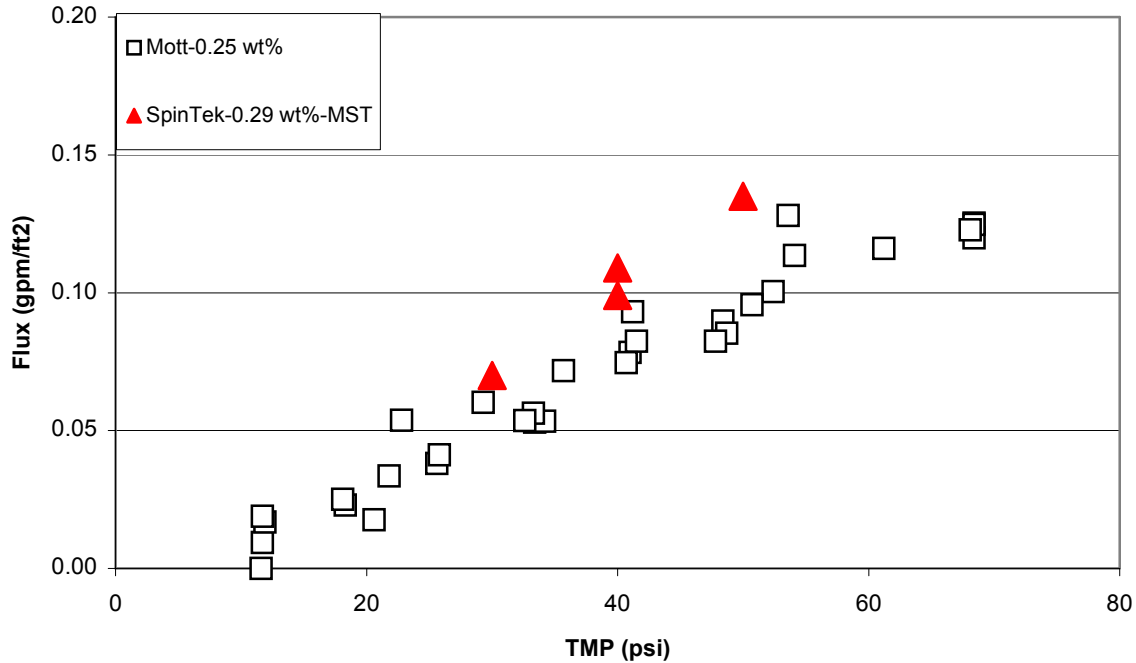


Figure 4. SpinTek versus Conventional Crossflow Filter with MST at 0.29 wt % Solids

At higher solids loadings (nominal 1.29 and 4.5 wt %), the average filter permeance with the SpinTek unit measured 0.0021 and 0.0012 gpm/ft²psi versus 0.00086 and 0.00043 gpm/ft²psi with the crossflow filter. The average increase in flux equaled approximately 2.6X. This increase exceeds that observed at the lower solids loading, but still proves less than observed during the vendor test. The rotary microfilter should produce greater improvement in filter flux at high solids loadings, because the high shear provides more benefit with a thicker filter cake.

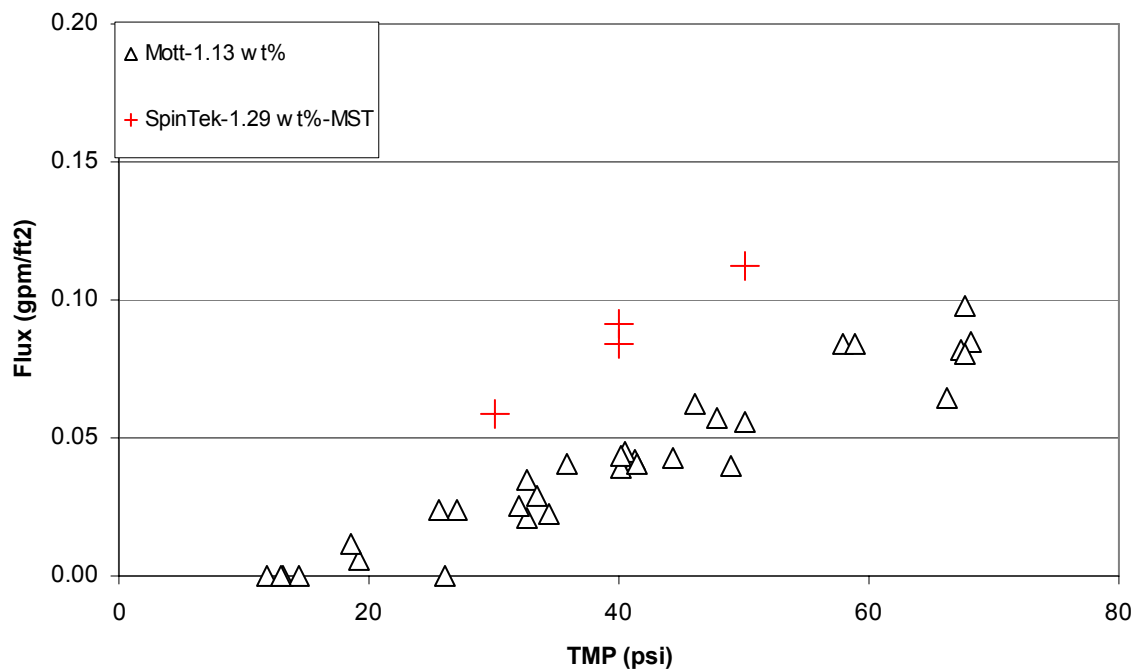


Figure 5. SpinTek versus Conventional Crossflow Filter with MST at 1.29 wt % Solids

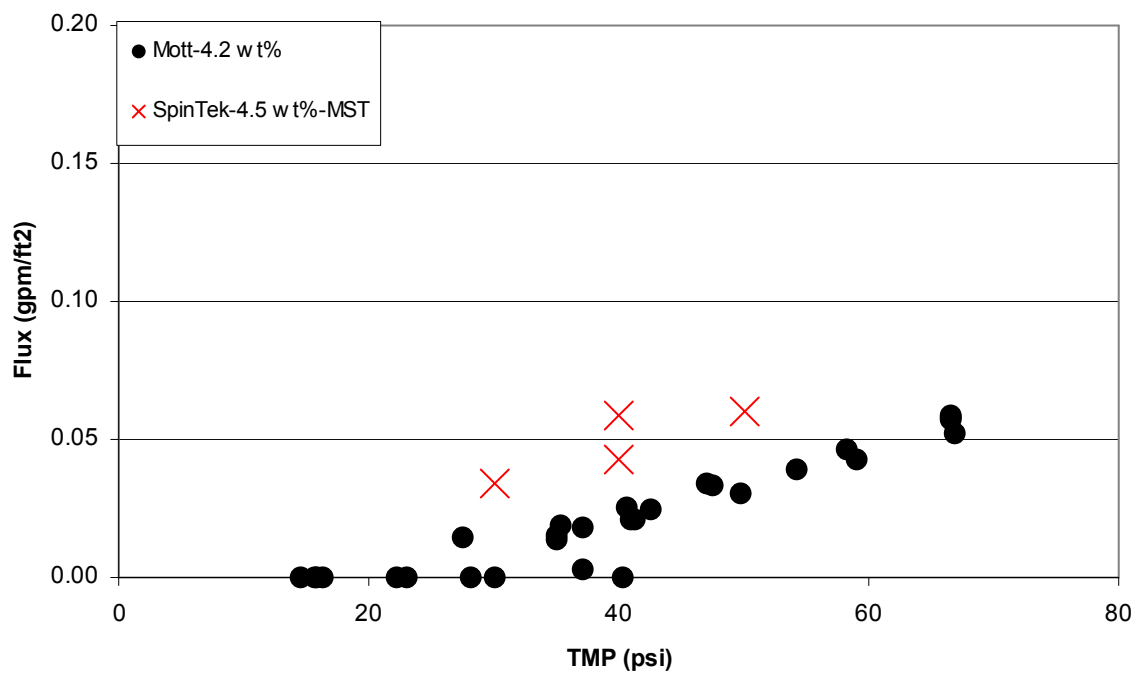


Figure 6. SpinTek versus Conventional Crossflow Filter with MST at 4.5 wt % Solids

Figure 7 shows the filter flux plotted as a function of time during the 500-hour test performed using sludge and manganese oxide slurry. The plot also shows the solids loading and TMP. A slight decrease in flux occurred at the start of each solids loading test. The flux is steady after 70 – 80 hours at each solids concentration. The data shows a strong effect of TMP on filter flux. The filter flux exceeds that measured for MST-containing slurries. The average flux during the test with sludge and manganese oxide solids equaled 0.136 gpm/ft^2 versus an average of 0.093 gpm/ft^2 during tests with sludge and MST solids.

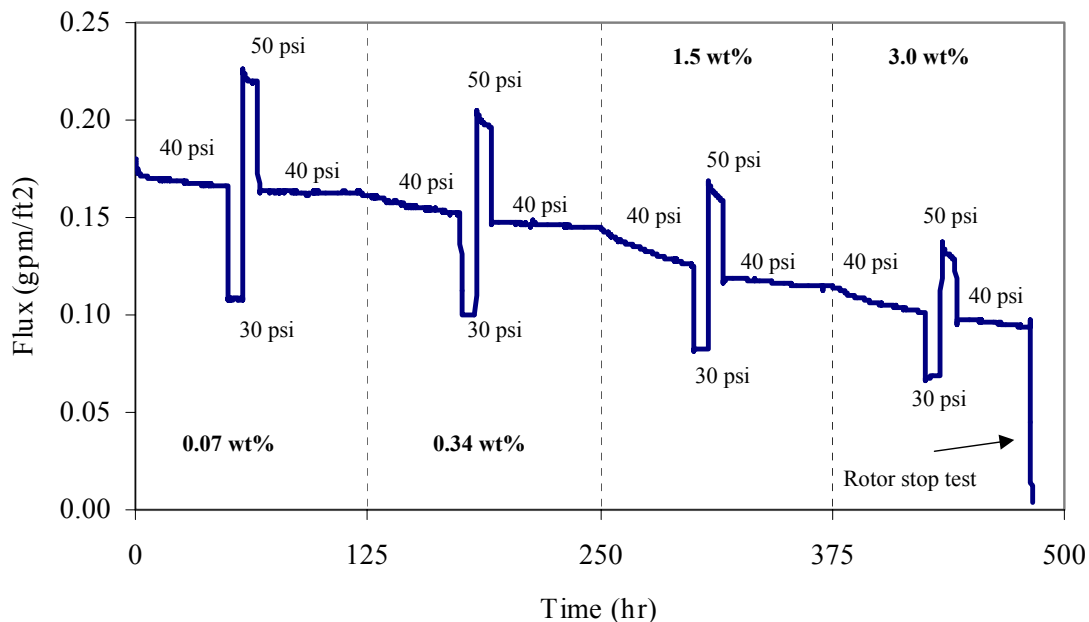


Figure 7. SpinTek Flux with Sludge and MnO₂ Slurry

Figures 8 – 11 show the filter flux during the tests using sludge and manganese slurry. The figures also show data from conventional crossflow filter tests for comparison.⁹ At 0.09 wt % solids, the average permeance with the rotary microfilter equaled $0.0041 \text{ gpm/ft}^2\text{psi}$ versus 0.0063 gpm/ft^2 with the crossflow filter. At 0.34 wt % solids, the average permeance with the rotary microfilter equaled $0.0037 \text{ gpm/ft}^2\text{psi}$ versus $0.0052 \text{ gpm/ft}^2\text{psi}$ with the crossflow filter. At 1.5 wt % solids, the average permeance with the rotary microfilter equaled $0.0031 \text{ gpm/ft}^2\text{psi}$ versus $0.0043 \text{ gpm/ft}^2\text{psi}$ with the crossflow filter. At 3.0 wt % solids, the average permeance with the rotary microfilter equaled $0.0025 \text{ gpm/ft}^2\text{psi}$ versus $0.0034 \text{ gpm/ft}^2\text{psi}$ with the crossflow filter.

At all solids loadings, the crossflow filter produces a higher flux than the rotary microfilter. The high shear of the SpinTek unit may break down the manganese oxide solids making them more difficult to filter. We discuss this phenomenon with the Lasentec particle size data later. In addition, the crossflow filter used 0.5μ pore-size media versus 0.1μ pore-size media for the rotary microfilter. A larger pore size would produce higher filter flux.¹⁰

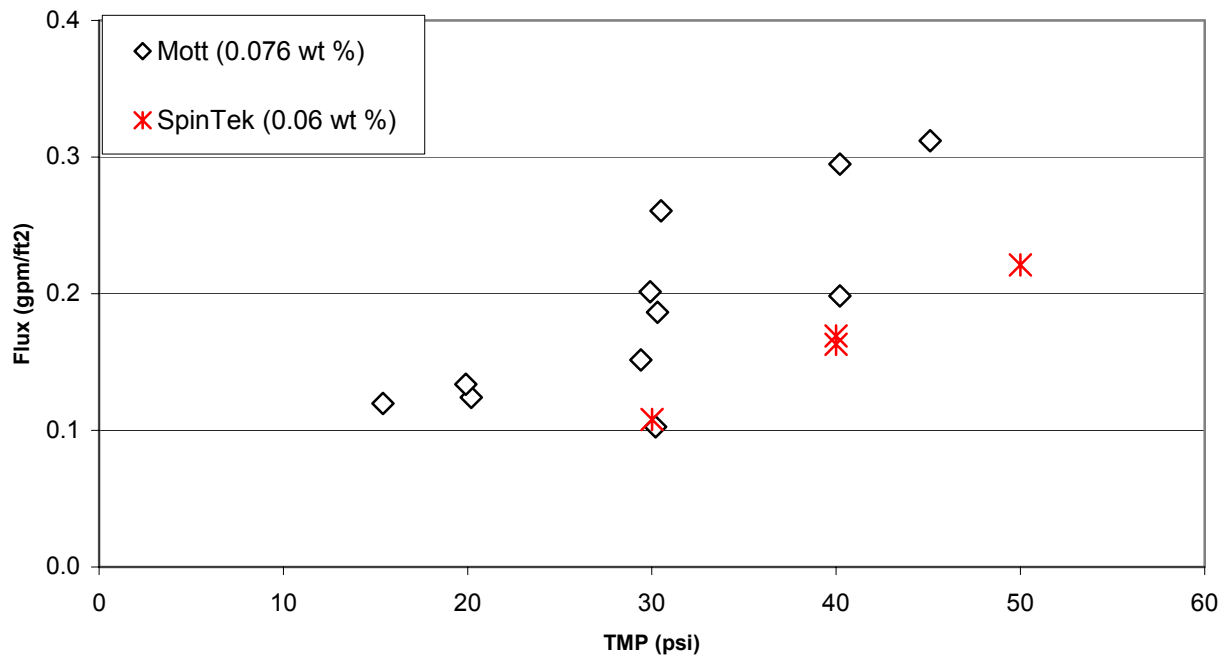


Figure 8. SpinTek versus Conventional Crossflow Filter with MnO₂ at 0.06 wt % Solids

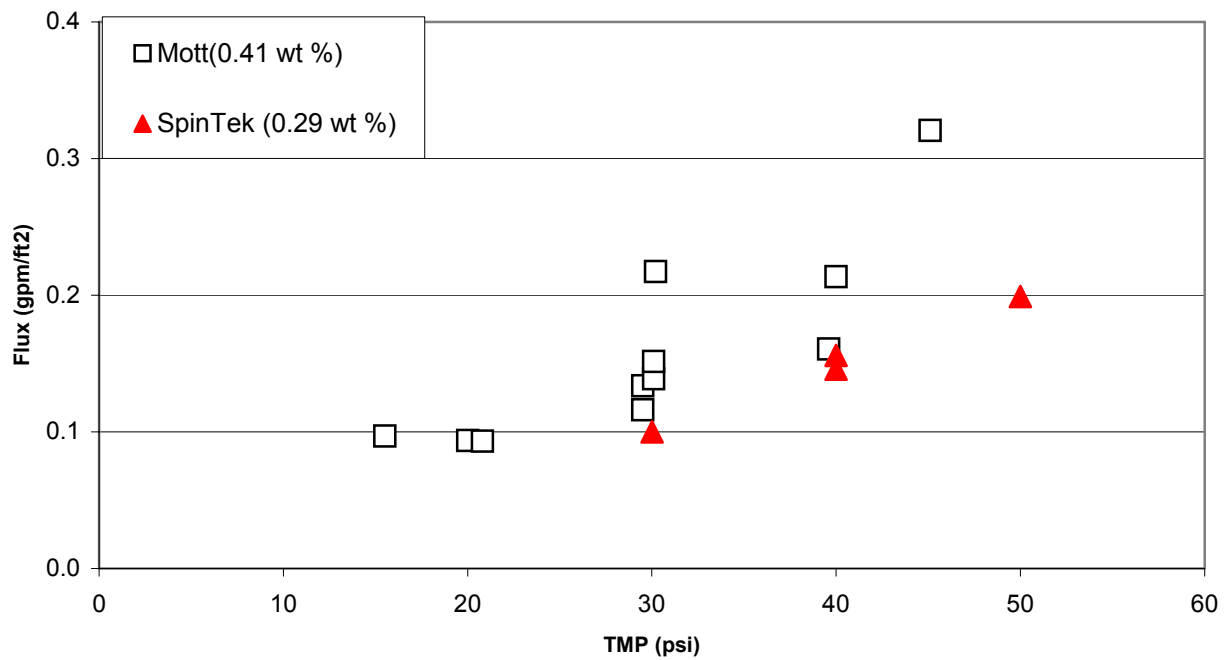


Figure 9. SpinTek versus Conventional Crossflow Filter with MnO₂ at 0.34 wt % Solids

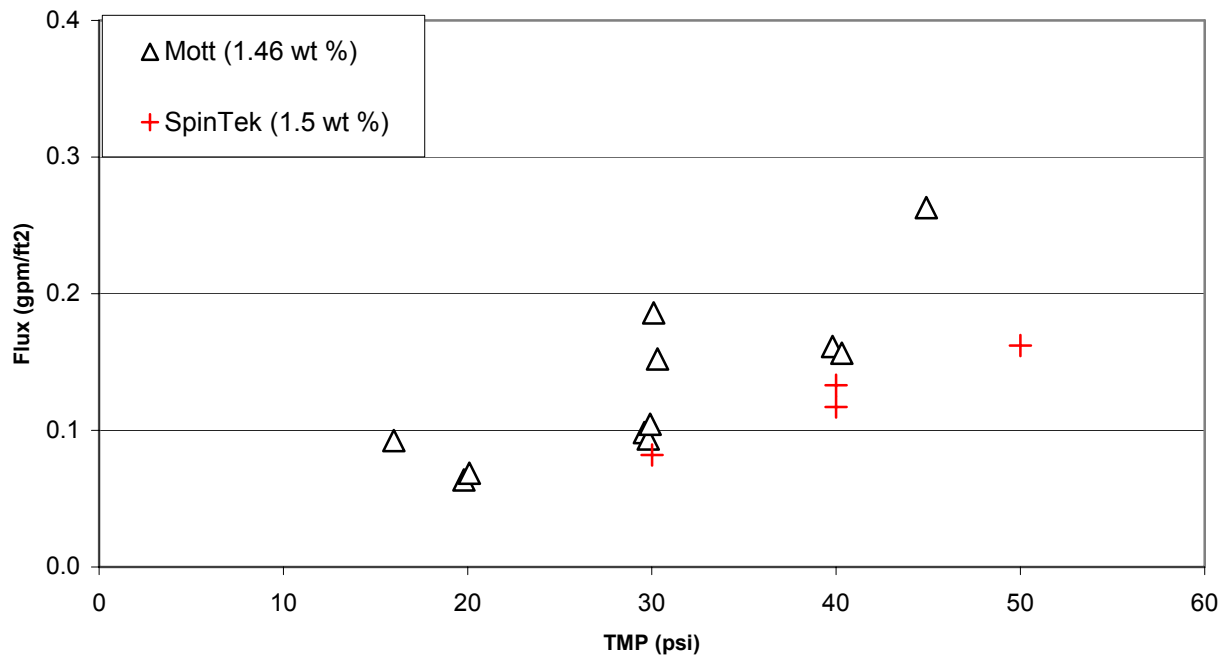


Figure 10. SpinTek versus Conventional Crossflow Filter with MnO₂ at 1.5 wt % Solids

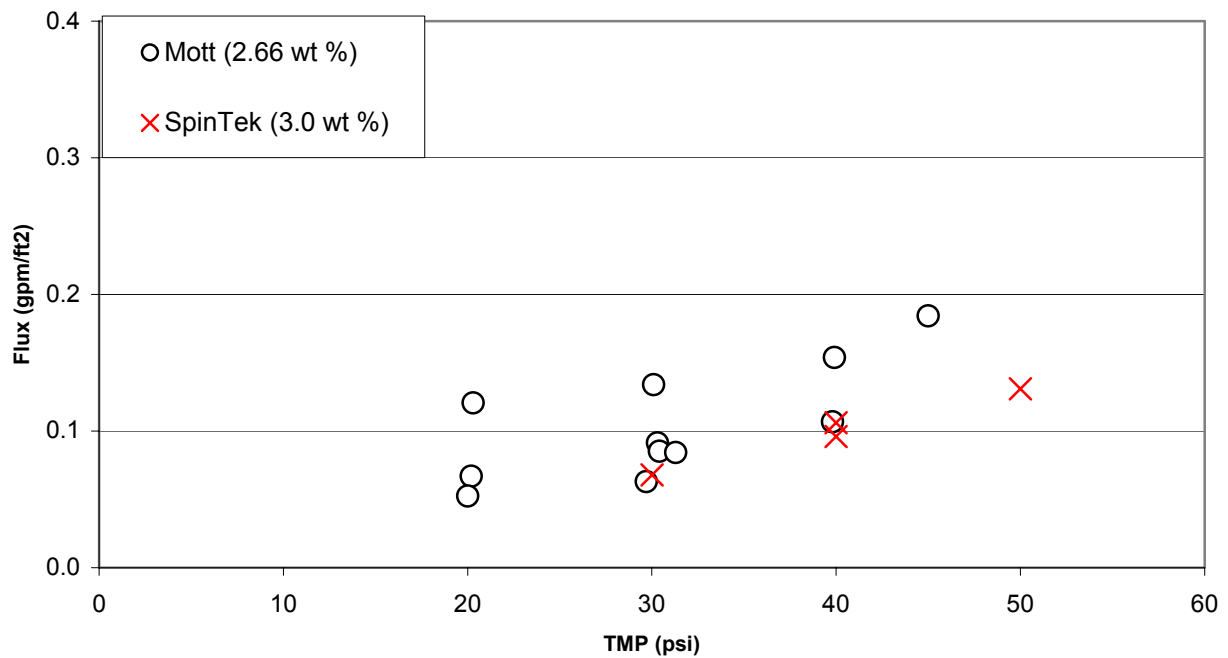


Figure 11. SpinTek versus Conventional Crossflow Filter with MnO₂ at 3.0 wt % Solids

The SpinTek rotary microfilter produced a 1.5 – 2.8X increase in filter permeance with the sludge and MST feed slurry. The sludge and manganese solids had a higher (1.5X) filter flux than the sludge and MST solids, but the flux proved less than that observed with the conventional crossflow filters.

Particle Size Data

Personnel collected particle measurements with a Focused Beam Reflectance Measurement (FBRM) probe (Lasentec®). The probe works in the following manner. Personnel installed the probe in the feed tank. The laser beam projects through the window of the FBRM probe and focuses just outside the window surface. This focused beam follows a path around the circumference of the probe window. As particles pass by the window surface, the focused beam will intersect the edge of a particle. The particle will backscatter laser light. The particle will continue to backscatter the light until the focused beam reaches the opposite edge of the particle. The instrument collects the backscattered light and converts it into an electronic signal.

The FBRM isolates the time of backscatter from one edge of an individual particle to its opposite edge. The software records the product of the time multiplied by the scan speed as a chord length. A chord length is a straight line between any two points on the edge of a particle or particle structure (agglomerate). FBRM typically measures tens of thousands of chords per second, resulting in a robust number-by-chord-length distribution.

The chord-length distribution provides a means of tracking changes in both particle dimension and particle population. The calculations do not assume a particle shape. The chord-length distribution is essentially unique for any given particle size and shape distribution. Assuming the average particle shape remains constant over millions of particles, changes to the chord-length distribution reflect solely a function of the change in particle dimension and particle number.

Figures 12 – 13 show data collected from the FBRM. Figure 12 shows the particle size distribution (i.e., chord length distribution) during sludge and MST testing. The figure shows the particle size at the start of the 500-hour test, prior to the rotor stop test (481 hours after the start), and after the rotor start test (483 hours after start of test). The particle size distribution shows a decrease between the start of the test and the beginning of the rotor stop test. This decrease is likely caused by the feed pump or the rotating disks shearing the solid particles in the feed slurry.

Figure 13 shows the particle size data from the sludge and manganese oxide slurries. The figure shows the particle size at the start of the 500-hour test, prior to the rotor stop test (481 hours after the start), and after the rotor start test (483 hours after start of test). The particle size distribution again shows a decrease between the start of the test and the beginning of the rotor stop test.

Figure 14 compares the particle size distribution between the SpinTek test with manganese oxide containing slurry and the crossflow filter test with manganese oxide containing slurry. Initially, the size of the feed particles was larger during the SpinTek test than during the crossflow test, but after both demonstrations completed the particle size distributions are approximately the same. Equation [1] describes the effect of particle size on filter flux

$$\frac{J}{TMP} = \frac{d_p^2 \varepsilon^3}{72L\mu(1 - \varepsilon)^2} \quad [1]$$

where J is filter flux, TMP is transmembrane pressure, dp is particle size, ϵ filter cake porosity, L is cake thickness, and μ is viscosity.¹¹ Filter flux has a quadratic dependence on particle size (e.g., a 14% increase in particle size produces a 30% increase in filter flux). A 7% increase in porosity from 28% to 30% increases the filter flux by 30%. The difference in flux between the crossflow filter and the rotary microfilter with manganese oxide containing feed could be due to small differences in solid packing (i.e., porosity) or small variations in the particle size.

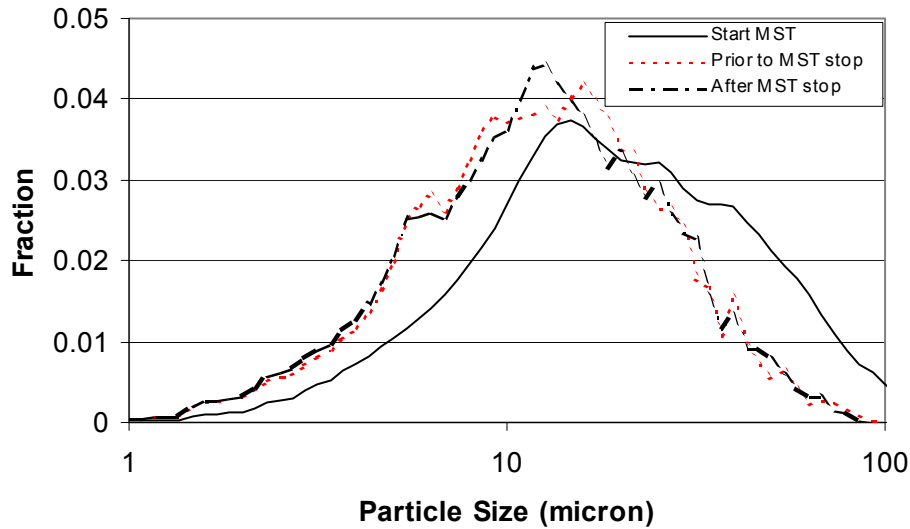


Figure 12. Particle size data from the SpinTek Test with Sludge and MST

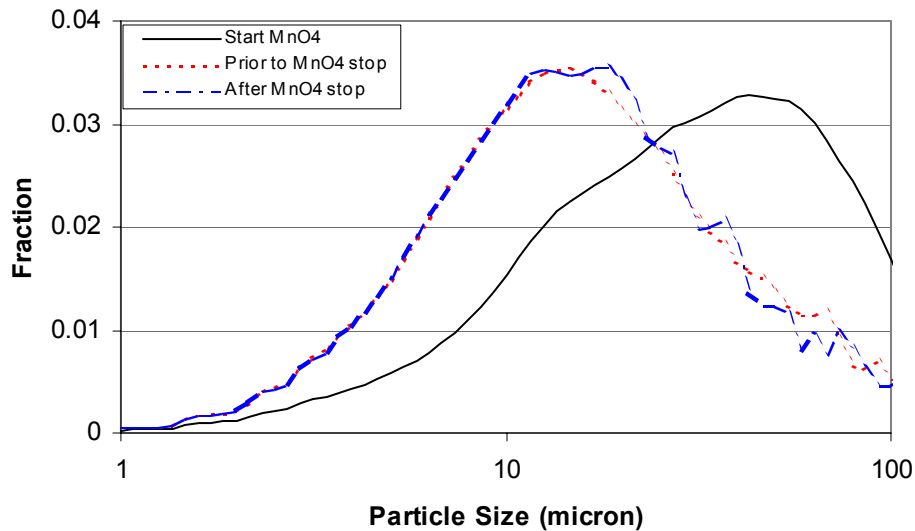


Figure 13. Particle size data from the SpinTek Test with Sludge and Manganese Oxide

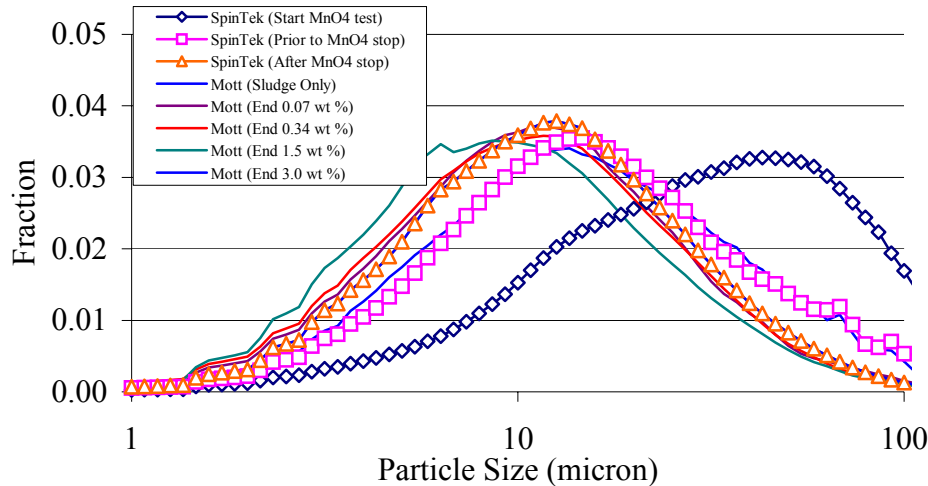


Figure 14. Comparison of Particle Data during SpinTek and Conventional Crossflow Filter Tests with Sludge and Manganese Oxide Slurry Feeds

Reliability

Sludge and MST Test

Personnel performed tests at nominal solids concentrations of 0.06, 0.28, 1.29, and 4.5 wt %, and completed the 500-hour test with no problems. They stopped the rotor for two hours and restarted it without incident. After filter cleaning, inspection of the disk revealed only a small amount of particles on surface of the filter near center of disk (see Figure 15). Personnel observed epoxy strands during disassembly of unit (see Figure 16). Visual inspection of the filter disks indicated the epoxy strands came from the upper edges of the bead that seals the outer rim of the disk. The bead apparently rubbed against the turbulence promoters. Tighter tolerances during manufacture, or a welded seam, would avoid these shavings.



Figure 15. SpinTek Filter Disk Following 500 Hour Sludge and MST Test

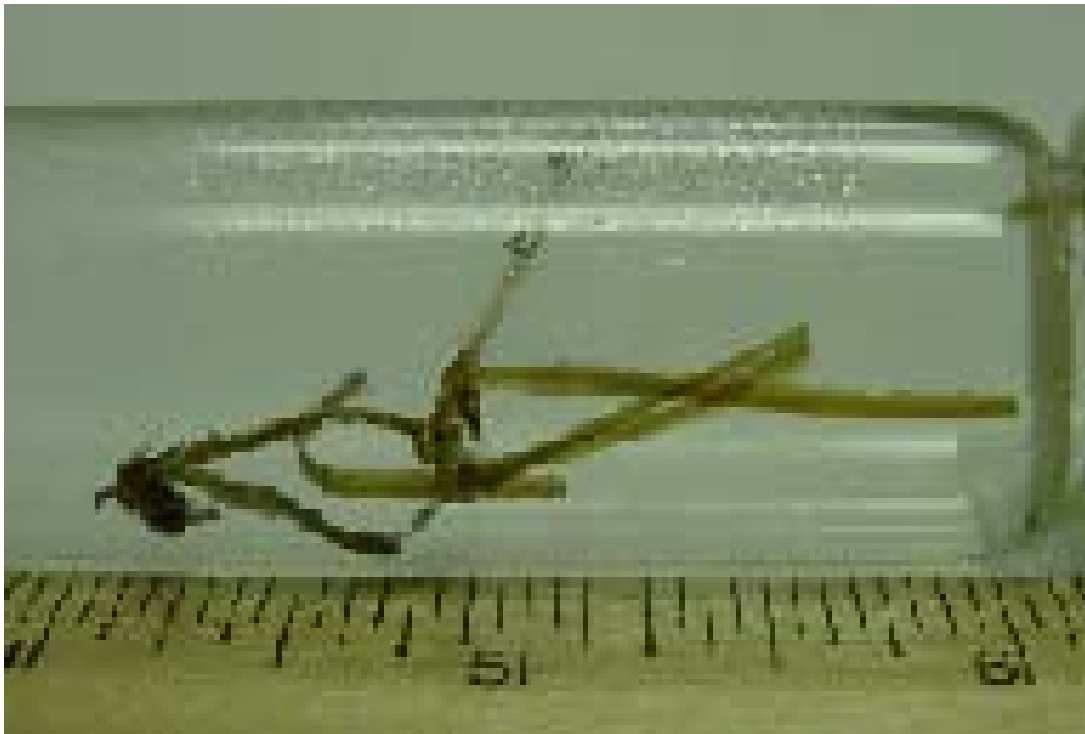


Figure 16. Epoxy Strands Observed during Disassembly of Unit

Sludge and MnO₂ Test

Personnel performed tests at nominal solids loadings of 0.07, 0.34, 1.52, and 3.04 wt %, and completed tests at the first two loadings without incident. During the 3rd loading, at about the 109th hour, personnel observed decreased filter feed flow with no change in feed pressure, which may have indicated plugging. During the 4th loading, personnel observed three additional events with decreased flow during the 40 hour, 40 psi period (just prior to rotor stop) and one at the end of the rotor stop period. Upon attempting to restart the rotor, it would not turn. Personnel attempted to manually turn the rotor. The resistance appeared “rubbery” rather than “metallic”, and the range of motion proved less than 5°.

The authors decided to attempt rotor restart after flushing the system. Personnel filled the feed tank with 25-L of deionized water, circulated it for 5 minutes, and attempted to manually turn the rotor. They repeated this action three times with no success. They then flushed the filter housing once through with water for 10 minutes and made numerous attempts to turn the rotor during flushing process with no success.

Personnel disassembled the filter and found solids packed between the filter disks and turbulence promoters (see Figures 17 – 20). Figure 17 shows the SpinTek filter internals numbered from bottom to top. Item 1 is the bottom turbulence promoter. Minimal caking occurred around the spokes of the turbulence promoter. Item 2 is the bottom filter disk, which shows minimal filter cake adhered. Item 3 is the lower middle turbulence promoter. This turbulence promoter shows solid caking around the spokes. The caking almost completely covers the openings between the spokes. Item 4 is the middle filter disk. Approximately half of the disk appears covered with a solid cake. Item 5 is the upper middle turbulence promoter, which is completely covered by solid cake. Item 6 is the top filter disk, and shows minimal solids accumulation. Item 7 is the top turbulence promoter, which is almost completely covered by a solid cake.

Figure 18 shows the upper middle turbulence promoter. Solid particles from the sludge and manganese oxide solids slurry completely fill the gaps between the spokes. If this cake has a high yield stress and is attached to the filter disk, it could prevent the filter disks from rotating.

Figure 19 shows the lower middle turbulence promoter. The solid particles formed a thick cake around the spokes of the turbulence promoter. The appearance of the solid cake suggests a high yield stress material.

Figure 20 shows a side view of one of the turbulence promoters. The cake from the sludge and manganese oxide solids is thicker than the height of the turbulence promoter. The appearance of the solid cake also indicates a high yield stress material.



Figure 17. SpinTek Filter Internals



Figure 18. Upper Middle Turbulence Promoter

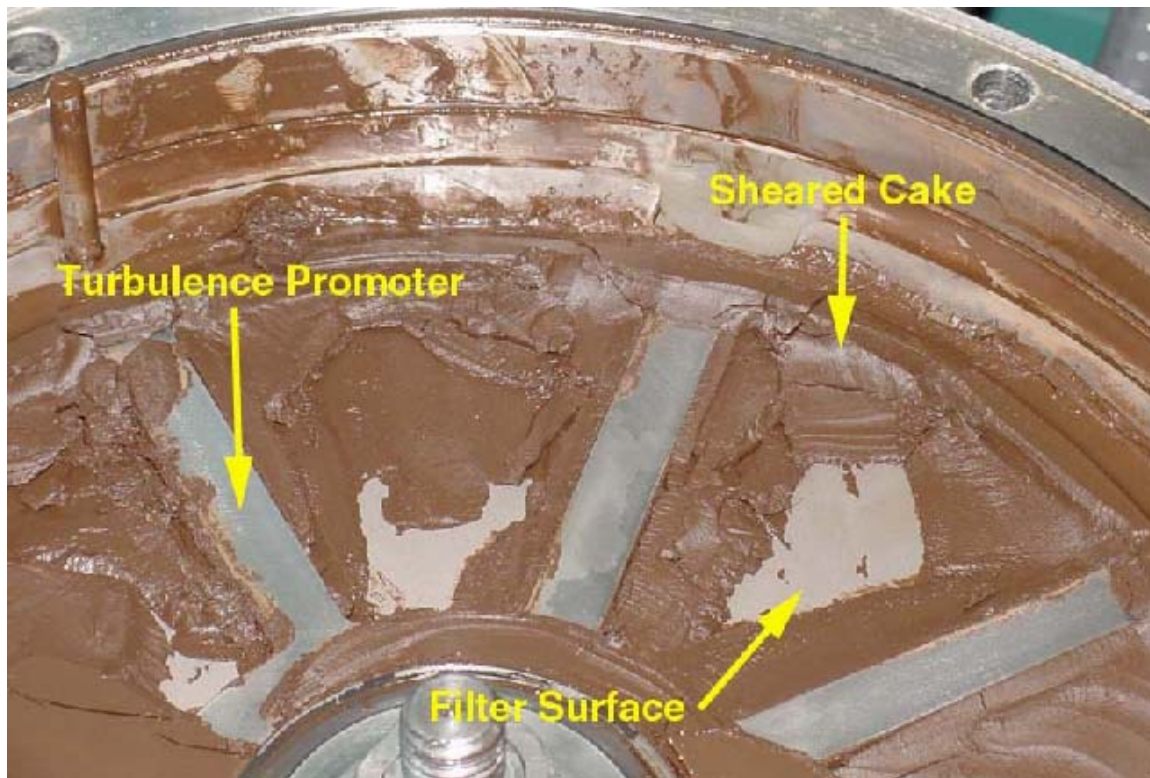


Figure 19. Installed Lower Middle Turbulence Promoter



Figure 20. Edge of Turbulence Promoter

Higher in the filter housing, the cake appeared drier. The cake appeared sticky, with a distinct tensile strength. The particles appeared to stick to each other better than to metal surfaces. The drier cake would bend slightly, then crack and crumble.

From analysis of actual solids in grab samples from the feed tank over the course of the entire 500 hours of the test, one calculates a loss of 1.09 kg of dry solids. Analysis of actual loading change for samples immediately before and after the 2-hour rotor stop indicates a loss of 0.94 kg of dry solids. Personnel collected the solids from inside the filter housing after disassembly of the filter. These solids weighed 2.62 kg, wet. Moisture analysis of one sample of these solids indicated 59 wt % water and 41 wt % solids, which corresponds to 1.07 kg dry solids. Therefore, most of the solids collected on the filter when the rotor stopped.

The manganese oxide/sludge solids appear “stickier” than the MST/sludge solids. The feed lost a negligible amount of the MST/sludge solids over the course of that test, including the rotor stop portion. Recent testing for the Waste Treatment Plant within the River Protection Program showed a 38 wt % slurry composed of strontium carbonate and manganese oxides had a yield stress in excess of 600 dynes/cm².¹² A slurry with this yield stress would prove extremely difficult to pump and could prevent rotation of the SpinTek disks if it adhered to both a disk and a turbulence promoter.

CONCLUSIONS

The conclusions from this work follow.

- The pilot-scale rotary microfilter produced a 1.5 – 2.8 X increase in filter flux, measured as permeance (i.e., flux divided by transmembrane pressure) compared to the conventional crossflow filter with a similar sludge and MST slurry feed. The actual improvement may prove greater, since the SpinTek filter contained a 0.1 μ filter rather than the 0.5 μ filter media used in prior crossflow studies. Also, the SpinTek flux data came from operation at 8 – 57 hours rather than ~ 2 hours for the earlier crossflow study.
- The conventional crossflow filter produced higher flux than the rotary microfilter with sludge and manganese solids slurry. The difference, measured as permeance, equaled approximately 30%.
- No operational problems occurred during the tests with sludge and MST.
- Following a “rotor stop test” – performed to simulate an unplanned shutdown – using sludge and manganese oxide solids, personnel could not resume operation of the rotor. Recovery of operation required disassembly and removal of solids that packed within the equipment. Water flushing failed to dislodge these solids. The slurry packed to ~40 wt % solids during this event.
- The rotary microfilter flux with feeds containing manganese solids averaged 50% higher than the rotary microfilter flux with feeds containing MST.

REFERENCES

1. H. H. Saito, M. R. Poirier, S. W. Rosencrance, J. L. Siler, "Improving Filtration Rates of Mono-Sodium Titanate (MST)-Treated Sludge Slurry with Chemical Additives", WSRC-TR-99-00343, Rev. 0, September 15, 1999.
2. H. H. Saito, M. R. Poirier, J. L. Siler, "Effect of Sludge Solids to Mono-Sodium Titanate (MST) Ratio on MST-Treated Sludge Slurry Cross-Flow Filtration Rates", WSRC-TR-99-00342, Rev. 0, September 15, 1999.
3. Ralph Haggard, Travis Deal, Carol Stork, and Vince Van Brunt, "Final Report on the Crossflow Filter Testing for the Salt Disposition Alternative", USC-FRED-PSP-RPT-09-0-010, Rev. 0, December 4, 1998.
4. M. R. Poirier, "FY2000 FRED Test Report," WSRC-TR-2001-00035, Rev. 0, January 11, 2001 and included report "Final Report on the Crossflow Filter Optimization with 5.6 M Sodium Salt Solution" (V. Van Brunt, C. Stork, T. Deal, and R. Haggard, USC-FRED-PSP-RPT-09-0-015, December 20, 2000).
5. M. R. Poirier, F. F. Fondeur, T. L. Fellingner, S. D. Fink, "Cross-Flow Filtration Demonstration for Slurries Containing High Level Waste Sludge and Monosodium Titanate", WSRC-TR-2001-00212, Rev. 0, April 11, 2001.
6. M. R. Poirier, "Evaluation of Solid-Liquid Separation Technologies to Remove Sludge and Monosodium Titanate from SRS High Level Waste", WSRC-TR-2000-00288, Rev. 0, August 16, 2000.
7. M. R. Poirier, "Filtration Systems, Inc., Report for SRS SpinTek Rotary Microfilter Testing", WSRC-TR-2001-00214, Rev. 0, May 4, 2001.
8. S. D. Fink, D. D. Walker, and M. C. Thompson, "WSRC Salt Processing," TTP SR01WT21, September 18, 2001.
9. M. R. Poirier, S. D. Fink, R. Haggard, V. Van Brunt, R. Haggard, T. Deal, and C. Stork, "Comparison of Crossflow Filtration Performance for Manganese Oxide/Sludge Mixtures and Monosodium Titanate/Sludge Mixtures", WSRC-TR-2002-00194, Rev. 0, April 19, 2002.
10. M. C. Porter, Ed., Handbook of Industrial membrane Technology, Noyes, Park Ridge, 1990, p. 77.
11. R. B. Bird, W. E. Stewart, and E. N. Lightfoot, Transport Phenomena, Wiley, New York, 1960, p. 199.
12. M. R. Duignan, "Final Report: Pilot-scale Cross-Flow Ultrafiltration Test Using a Hanford Site Tank 241-AN-107 Waste Simulant – Envelop C + Entrained Solids + Strontium-Transuranic Precipitation", BNF-003-98-0226, March 24, 2000.