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Pilot-Scale Testing of a SpinTek Rotary Microfilter with Welded Disks and Simulated Savannah River Site High Level Waste

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SUMMARY

The Department of Energy is developing processes to treat Savannah River Site (SRS) radioactive waste. In the first step, personnel contact the incoming salt solution that contains entrained sludge with monosodium titanate (MST) to adsorb strontium and select actinides. They filter the resulting slurry to remove the sludge and MST. The filtrate receives further treatment to remove cesium. 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.

The SRNL received funding from the DOE-HQ, Office of Cleanup Technologies, via the National Energy Technology Laboratory (NETL), to continue developing the rotary microfilter for SRS high level waste applications. As part of this task, the authors developed a protocol to weld stainless steel and ceramic filter disks. After they welded the disks, they placed them in the pilot-scale rotary microfilter and tested them with simulated SRS waste.

The conclusions from this work follow.

- The rotary microfilter has now operated for over 2400 hours with no significant operational problems. In particular, no operational problems occurred with the mechanical seal. The welded filter disks effectively removed solid particles from the feed slurry.
- Filter flux with the welded disks was significantly less than the flux in comparable tests with filter disks fabricated using epoxy. The differences are apparently due to changes in the spacing between the filter disks and the turbulence promoters and changes in the turbulence promoter thickness added for the current tests. These changes affected the fluid mechanics of the system and reduced the shear at the filter surface. Presumably, these changes can be reversed in the final design.
- The ceramic filter media produced the highest flux.
- The Pall filter media produced higher flux than the Mott filter media.
- MST-only feed filtered at a higher rate than sludge plus MST feed.
- The Lasaentec® data provides insight into the settling behavior of the sludge and MST particles. The settling was fastest with solids loadings of 0.29 – 4.5 wt %. At the higher concentrations, particle settling rate was reduced because of hindered settling.
- When agitation resumed, the settled particles re-suspended within a few minutes
- The MST-only solids settled more rapidly than the sludge plus MST solids.
- Particle size measurements showed a 25 – 50% median particle size reduction during the tests. Similar particle size reduction was observed during testing with a crossflow filter.
- The median particle size was as much as 35% smaller than in previous tests.

INTRODUCTION

The Department of Energy is developing processes to treat Savannah River Site radioactive waste. In the first step, personnel contact the incoming salt solution that contains entrained sludge with MST to adsorb strontium and select actinides. The process filters the resulting slurry to remove the sludge and MST. The filtrate receives further treatment to remove cesium.

Crossflow filter testing performed by SRNL and the University of South Carolina (USC) with simulated waste showed relatively low filtration rates of 0.03 – 0.08 gpm/ft^2.[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]

SRNL researchers tested the rotary microfilter as an alternative to the crossflow filters in the current baseline of the Salt Waste Processing Project and the Actinide Removal Project. Table 1 summarizes the results of scoping testing, and Figures 1 and 2 show some of the data from the actual waste testing and pilot scale testing.[7,8,9] The data show significant improvement in filter flux with the rotary microfilter over the baseline crossflow filter (2.5 – 6.5 X during the scoping tests, up to 10 X in the actual waste tests, and approximately 2 X in the pilot-scale tests).

Table 1. Comparison of SpinTek Filter with Conventional Crossflow Filter from Vendor Scoping Tests, Actual Waste Tests, and Pilot-Scale Tests[4,7]

Solids (wt %)	Rotary (gpm/ft^2, measured)	Crossflow (gpm/ft^2, predicted)	Ratio
0.05	0.21	0.08*	2.6
0.22	0.19	0.07*	2.7
1.0	0.15	0.04*	3.8
4.8	0.13	0.02*	6.5
4.5	0.40	0.04**	10
0.06	0.13	0.08*	1.6
0.29	0.10	0.07*	1.4
1.29	0.08	0.03*	2.7
4.5	0.05	0.02*	2.5

* predicted
** measured

The SRNL received funding from the DOE-HQ, Office of Cleanup Technologies, via the NETL, to continue developing the rotary microfilter for SRS high level waste applications. As part of this task, the authors developed a protocol to weld stainless steel and ceramic filter disks. After they welded the disks, they placed them in the pilot-scale rotary microfilter and tested them with simulated SRS waste. This report describes that testing.

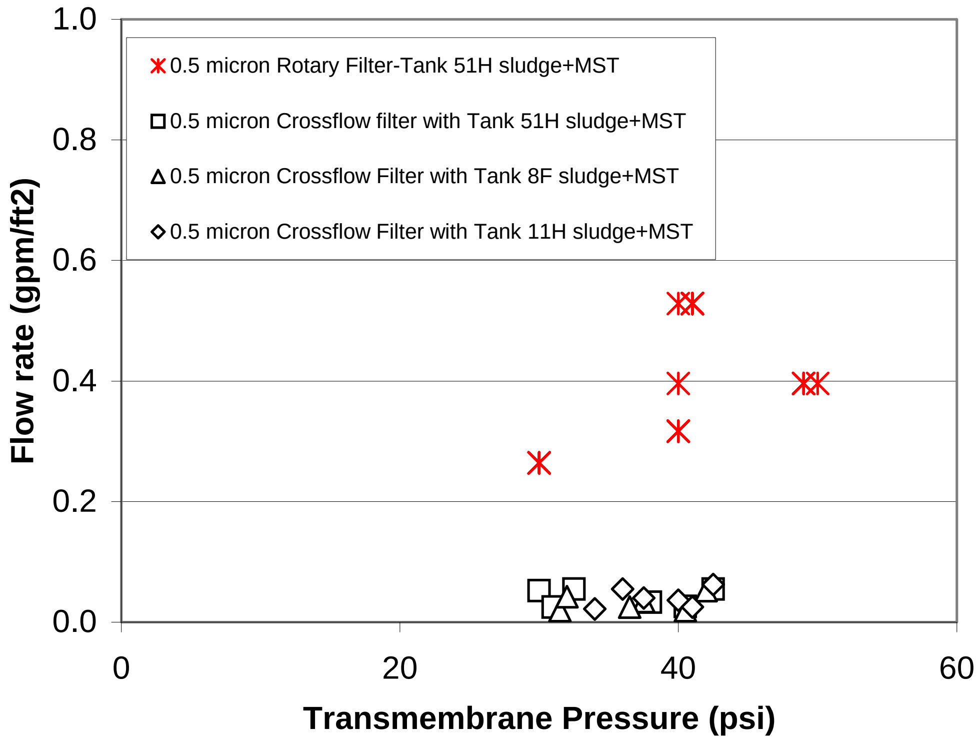

Figure 1. Rotary Microfilter Actual Waste Test Results[5,8]

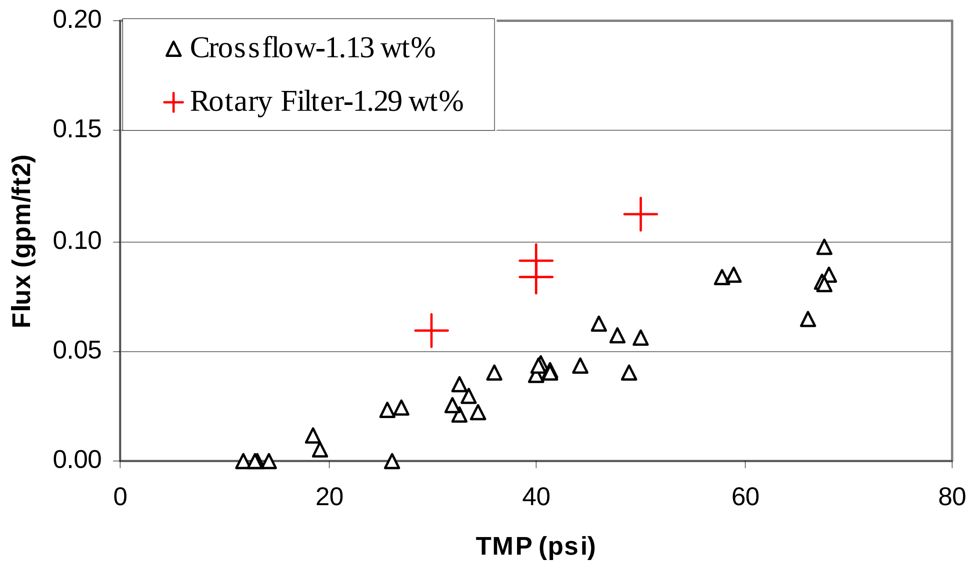

Figure 2. Rotary Microfilter Pilot-Scale Test Results[4,9]

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 ft^2 active membrane area (see Figure 3). 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 where noted.

Figure 3. Pilot-Scale SpinTek Rotary Microfilter

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

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.

Disk Development

The standard filter disk for the SpinTek rotary microfilter is constructed using a Ryton® center support plate, polypropylene mesh and sheet of filter media all joined by an epoxy bead around the outer edge. Testing of this disk configuration demonstrated that the polymers and epoxy joining would not stand up in combined caustic and radioactive service for more than a few years operation. The original design was modified to construct the filter disk using all metal parts that are attached and sealed using welding technology.

Filter disks were fabricated using three different vendor membranes. Two membranes (Mott and Pall Corp.) are 0.1 micron stainless steel membranes. The third membrane, provided by SpinTek, incorporates a thin ceramic coating on a thicker stainless steel substrate. Three disks of each membrane type were prepared for testing. One of the first welded disks using the Mott 0.1 micron stainless steel membranes was deemed unacceptable for testing. Therefore, only two filter disks were used in the testing with the Mott membranes with the third position in the filter system being occupied by a blank.

The redesign work eliminated polymers from the disks, but did not eliminate polymers from the filter unit. We have minimized the polymers where we could, but continue to use O-ring seals. The elastomer selected (EPDM), when in compression, maintains its integrity in radiation fields and should be suitable for service.

Test Protocol

Personnel conducted the tests with two feed slurries: sludge plus MST and MST only. The MST was from batch 00-QAB-417. They prepared the feed from previously used test slurries.[4,10,11] We selected these slurries to match the solids used in previous crossflow filter tests.[4,10,11]

We prepared the 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 MST drums for insoluble solids concentration and added to the feed tank to achieve the target solids loading.

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.

Once the feed tank contained the desired slurry (nominal 0.06 wt % insoluble solids), personnel mixed the feed slurry for two hours. In the tests with Mott filter media (using MST-only and sludge plus MST feed), personnel allowed the slurry to settle for four hours and measured particle changes with the Lasentec® probe. After four hours, they restarted the agitator and mixed the tank for an hour. (No settling was conducted in the tests with the ceramic or Pall filter media.) Personnel then started the rotary microfilter. After a specified time, they added additional solid particles, mixed the slurry, and continued the filtration test. Table 2 shows the conditions and time of each test segment.

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

Filter Media	Feed	Nominal Insoluble Solids (wt %)	TMP (psi)	Rotor Speed (rpm)	Time (h)
0.1 µ Mott	MST	0.06	40	1170	60
0.1 µ Mott	MST	0.29	40	1170	50
0.1 µ Mott	MST	1.29	40	1170	50
0.1 µ Mott	MST	4.5	40	1170	17
0.1 µ Mott	MST	4.5	40	950	17
0.1 µ Mott	MST	4.5	40	700	16
0.1 µ Mott	MST	7.5	40	1170	17
0.1 µ Mott	MST	7.5	40	950	17
0.1 µ Mott	MST	7.5	40	700	16
0.1 µ Mott	MST	12.5	40	1170	17
0.1 µ Mott	MST	12.5	40	950	17
0.1 µ Mott	MST	12.5	40	700	16
0.1 µ Mott	Sludge + MST	0.06	40	1170	21
0.1 µ Mott	Sludge + MST	0.06	40	950	20
0.1 µ Mott	Sludge + MST	0.06	40	700	20
0.1 µ Mott	Sludge + MST	0.29	40	1170	50
0.1 µ Mott	Sludge + MST	1.29	40	1170	50
0.1 µ Mott	Sludge + MST	4.5	40	1170	50
0.1 µ Mott	Sludge + MST	7.5	40	1170	50
0.1 µ Mott	Sludge + MST	12.5	40	1170	19
0.1 µ Mott	Sludge + MST	12.5	40	950	18
0.1 µ Mott	Sludge + MST	12.5	40	700	3
0.1 µ Ceramic	Sludge + MST	0.06	40	1170	10
0.1 µ Ceramic	Sludge + MST	0.06	40	950	13
0.1 µ Ceramic	Sludge + MST	0.06	40	700	10
0.1 µ Ceramic	Sludge + MST	0.29	40	1170	25
0.1 µ Ceramic	Sludge + MST	1.29	40	1170	26
0.1 µ Ceramic	Sludge + MST	4.5	40	1170	10
0.1 µ Ceramic	Sludge + MST	4.5	40	950	10
0.1 µ Ceramic	Sludge + MST	4.5	40	700	10
0.1 µ Ceramic	Sludge + MST	7.5	40	1170	10
0.1 µ Ceramic	Sludge + MST	12.5	40	1170	13
0.1 µ Pall	Sludge + MST	0.06	40	1170	10
0.1 µ Pall	Sludge + MST	0.06	40	950	10
0.1 µ Pall	Sludge + MST	0.06	40	700	10
0.1 µ Pall	Sludge + MST	0.29	40	1170	25
0.1 µ Pall	Sludge + MST	1.29	40	1170	25
0.1 µ Pall	Sludge + MST	4.5	40	1170	10
0.1 µ Pall	Sludge + MST	4.5	40	950	10
0.1 µ Pall	Sludge + MST	4.5	40	700	10

Because of warpage of the Mott filter disks from the welding process, personnel changed the spacing between the disks and the turbulence promoters to prevent rubbing. [As development of the welding protocol, the amount of warping decreased markedly and hence this concern will be lessened in the final design.] They also reduced the thickness of the turbulence promoters from ¼ inch to 1/8 inch. In the MST-only test, two filter disks were used rather than three. The ceramic and Pall filter disks contained a stainless steel support structure rather than Ryton®.

Because the thickness of the stainless steel support was reduced to keep the disk weight constant, the spacing between the filter disk and turbulence promoters was changed.

RESULTS

Filter Flux Data

Figure 4 shows the filter flux plotted as a function of time during the test performed with a 0.1 μ Mott filter and using MST-only feed slurry. The initial flux (at 0.06 wt % measured 0.09 gpm/ft^2, and decreased to 0.04 gpm/ft^2 after 60 hours. This flux is less than measured during the 2002 rotary microfilter test (~ 0.12 gpm/ft^2). At 4.5 wt % solids and 1170 rpm rotor speed, the flux measured 0.017 gpm/ft2 versus 0.05 gpm/ft^2 in the 2002 test. The flux continued to decline during the remainder of the test, and measured 0.01 gpm/ft^2 at 12.5 wt %.

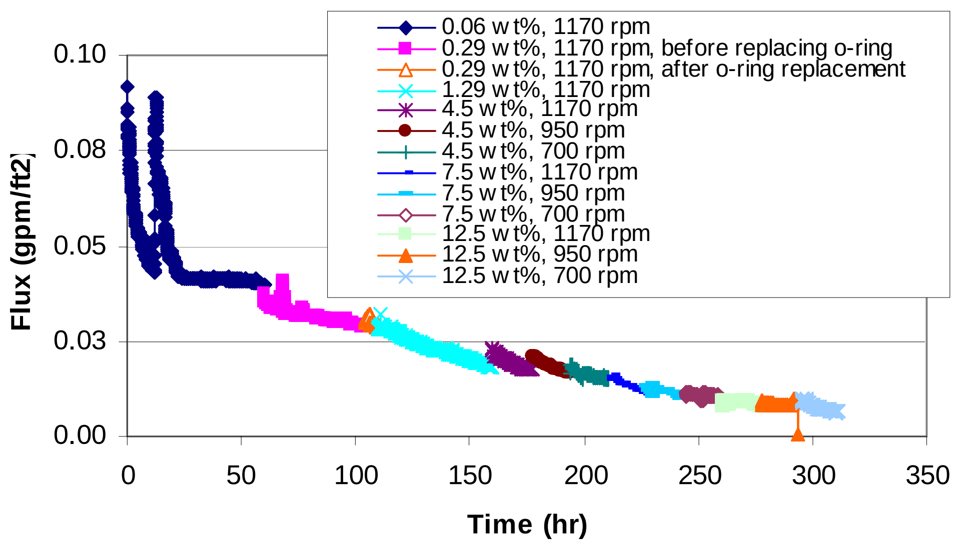

Figure 4. SpinTek Flux with MST Slurry

The flux is much less than measured during the 2002 and 2003 pilot-scale rotary microfilter tests. Plausible explanations are warping of the filter disks, changing of the spacing between the disks and turbulence promoters, and changes in particle size of the feed slurry. These causes will be discussed later.

During the tests with 0.06 and 0.29 wt % MST slurry, personnel measured high turbidity (~ 200 NTU) in the filtrate. They disassembled the unit and observed that an O-ring had not been installed. They installed the O-ring, and reassembled the unit. No high turbidity (> 5 NTU) filtrate was observed during the remainder of the test.

Figure 5 shows the filter flux during the test with a 0.1 micron Mott filter and sludge plus MST feed slurry. The initial flux (at 0.06 wt %) measured 0.034 gpm/ft^2, which is less than the flux during the MST only test, and less than the flux in previous pilot-scale rotary microfilter tests (0.12 gpm/ft^2). At 0.06 wt % solids, the flux increased with decreasing rotor speed. Because of the short duration of the tests (~ 20 hours) and the flux not reaching steady state, we are uncertain whether reducing the rotor speed will produce an overall higher flux. Future testing should investigate the impact of rotor speed on filter flux in more detail. At 4.5 wt % solids, the flux measured 0.016 gpm/ft^2 versus 0.5 gpm/ft^2 in the 2002 test.

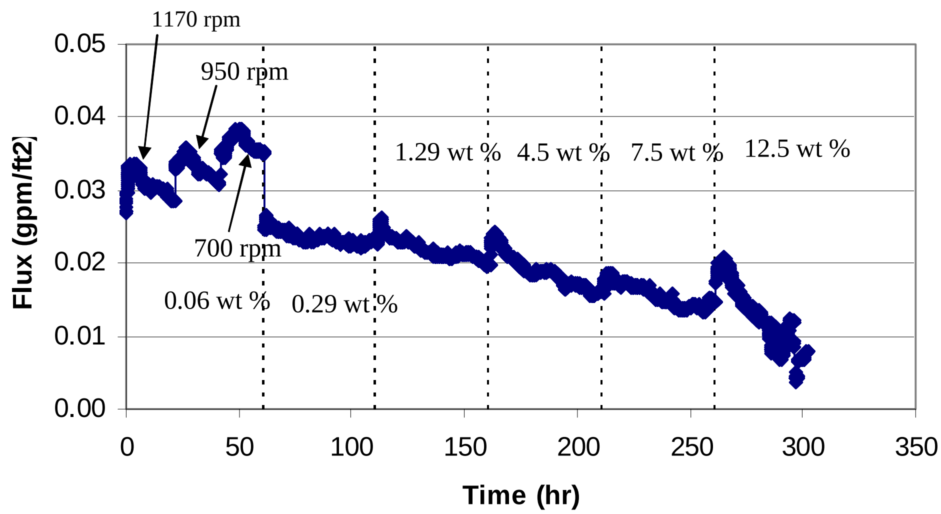

Figure 5. SpinTek Flux with 0.1 micron Mott Filter and Sludge/MST Slurry

The test results show the MST-only feed produced a higher filter flux that the sludge plus MST feed. Given that the MST has a larger median particle size and less particle size variability than simulated sludge, one would expect an MST-only feed to have higher flux. This result is also consistent with filter testing that showed sludge-only feed had a lower flux than sludge plus MST feed.[12]

Figure 6 shows the filter flux measured during the test with a 0.1 micron ceramic filter using sludge plus MST feed slurry. The initial flux measured ~ 0.07 gpm/ft^2 and decreased to 0.06 gpm/ft^2 after 33 hours. When the rotor speed was decreased, the flux increased. Little change occurred in the flux as the solids loading was increased to 0.29 and 1.29 wt %. When the solids loading increased to 4.5, 7.5, and 12.5 wt %, the flux increased and then decayed. The increase is likely due to changes in supernate viscosity from the large amount of dilute supernate added with the sludge and MST solids. The flux is 0 – 25 % lower than the flux measured during the 2003 test. The impact of changing rotor speed is less dramatic at 4.5 wt % than at 0.06 wt % solids. The flux produced by the ceramic filter media is greater than the flux produced by the Mott stainless steel media with the same feed slurry. This result is consistent with the 2003 pilot-scale rotary microfilter test results.[11]

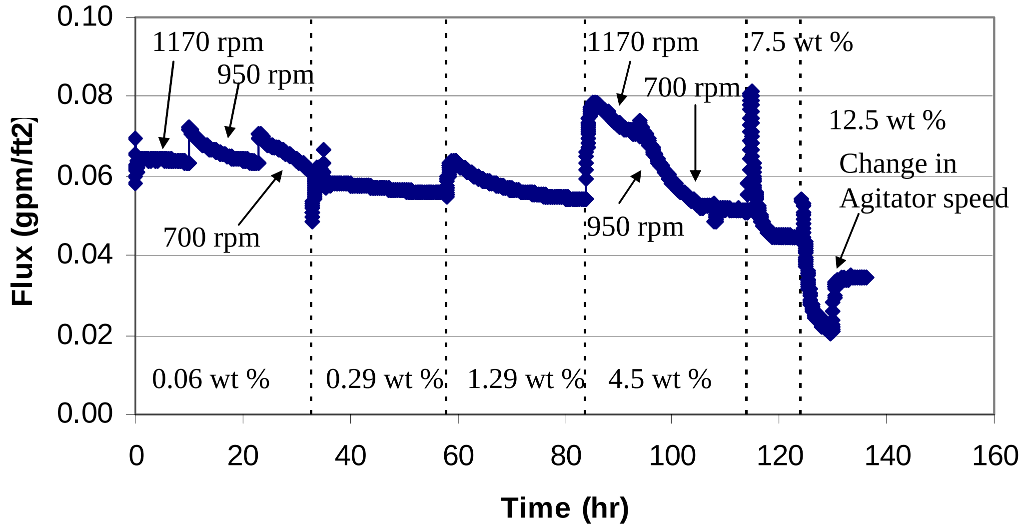

Figure 6. SpinTek Flux with 0.1 micron Ceramic Media and Sludge/MST Slurry

Figure 7 shows the flux measured during the test with Pall filter media. The flux is ~ 30 % higher than the flux measured during tests with the Mott filter media. This result is consistent with testing conducted at INEEL to compare alternative filter media for SRS filtration applications.[13]

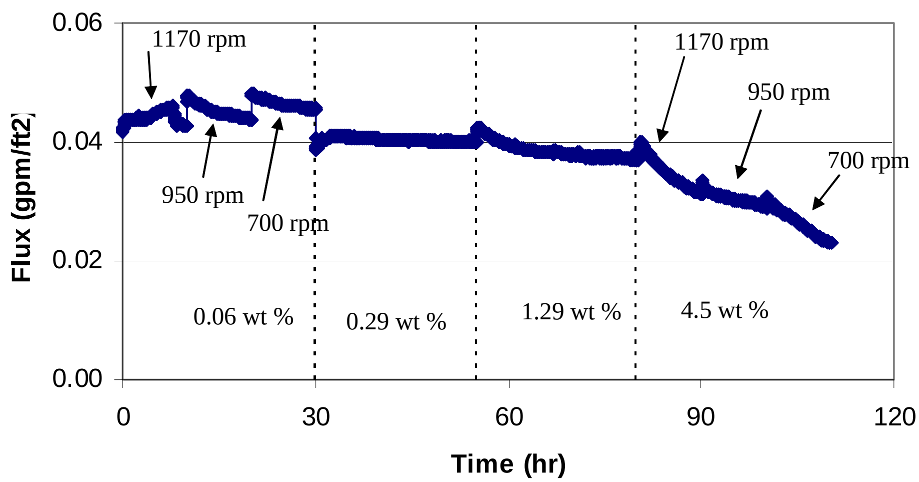

Figure 7. SpinTek Flux with 0.1 micron Pall Media and Sludge/MST Slurry

The filter flux during these tests was less than the flux measured in previous rotary microfilter tests. Plausible explanations for the lower flux are warping of the filter disks, changes in spacing between the filter disks and the turbulence promoters, and changes in particle size (see next section).

The initial batch of welded disks (Mott filter media) showed a great deal of warping. The warping will affect the fluid mechanics of the slurry that is transported through the filter. This warping caused the disks to rub against the turbulence promoters when the disks were spun. To resolve this problem, we fabricated new turbulence promoters that were 1/8 inch thick rather than ¼ inch thick. Previous researchers found the filter flux to decrease with increasing gap between the filter media and turbulence promoters.[14] They also found the flux to decrease with decreasing turbulence promoter thickness.[15]

Figure 8 shows pictures of rotary filter disks following testing. The top row shows disks from previous tests.[8,9,11] In each of the disks, the cake occupies a small fraction of the disk surface. The outer diameter of the cake is approximately the same in all of those disks. The bottom row shows disks from the current test. The outer diameter of the cake is different on each disk for the current testing. Because the spacing between the disks and the turbulence promoters was different for each disk surface, the fluid dynamics was different across each disk surface. The differing fluid dynamics led to differing filter cakes and differing filter flux. The cake outer diameter being larger shows that the shear stress at the filter surface were lower than in the previous tests. The lower shear stress leads to lower flux. Once the distance between the filter disks and the turbulence promoters and the turbulence promoter thickness are restored to the vendor's design, the filter flux should return to the levels seen in previous testing. SRNL should conduct additional testing with welded disks using the SpinTek design spacing to verify that the flux will achieve the target when the disks are optimally spaced.

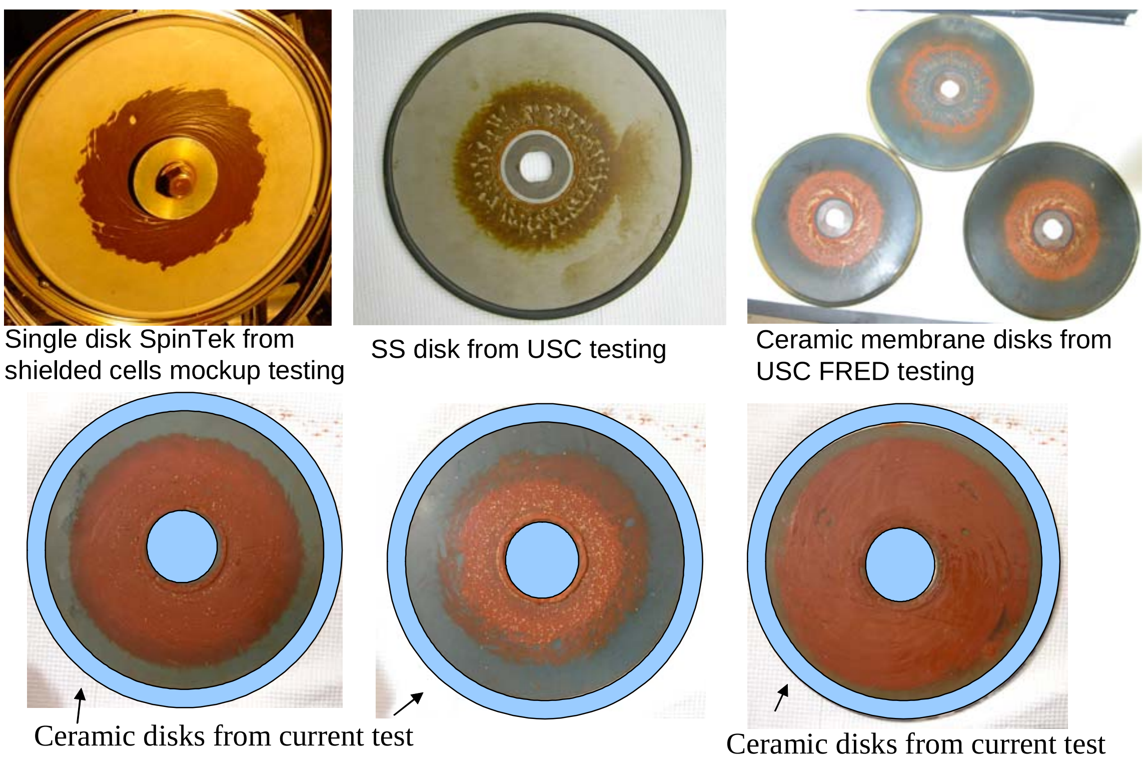

Figure 8. Rotary Filter Disks Following Testing

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 9 – 14 show data collected from the FBRM. Figure 9 shows the particle counts near the probe (located in the top quarter of the tank) during the settling and re-suspension tests with MST-only feed slurry. With the lowest solids loading, the particle count dropped by about 5X while the slurry was mixing. We are unsure of the reason. The drop could be caused by particles adhering the feed vessel. When the agitation stopped, the particle counts decreased by ~ 2X. No significant increase in particle count was observed when the agitator was turned back on. At the intermediate solids loadings (0.29, 1.29, and 4.5 wt %), the solids concentration decreased by about an order of magnitude when the agitation stopped. When the agitation was restarted, the particles were re-suspended within a few minutes. At 7.5 wt % solids, the particle count decreased by two orders of magnitude when the agitator was stopped, but the settling occurred over two hours rather than a few minutes. When the agitator was turned back on, the particles re-suspended within a few minutes. No significant settling was observed with the 12.5 wt % slurry over four hours.

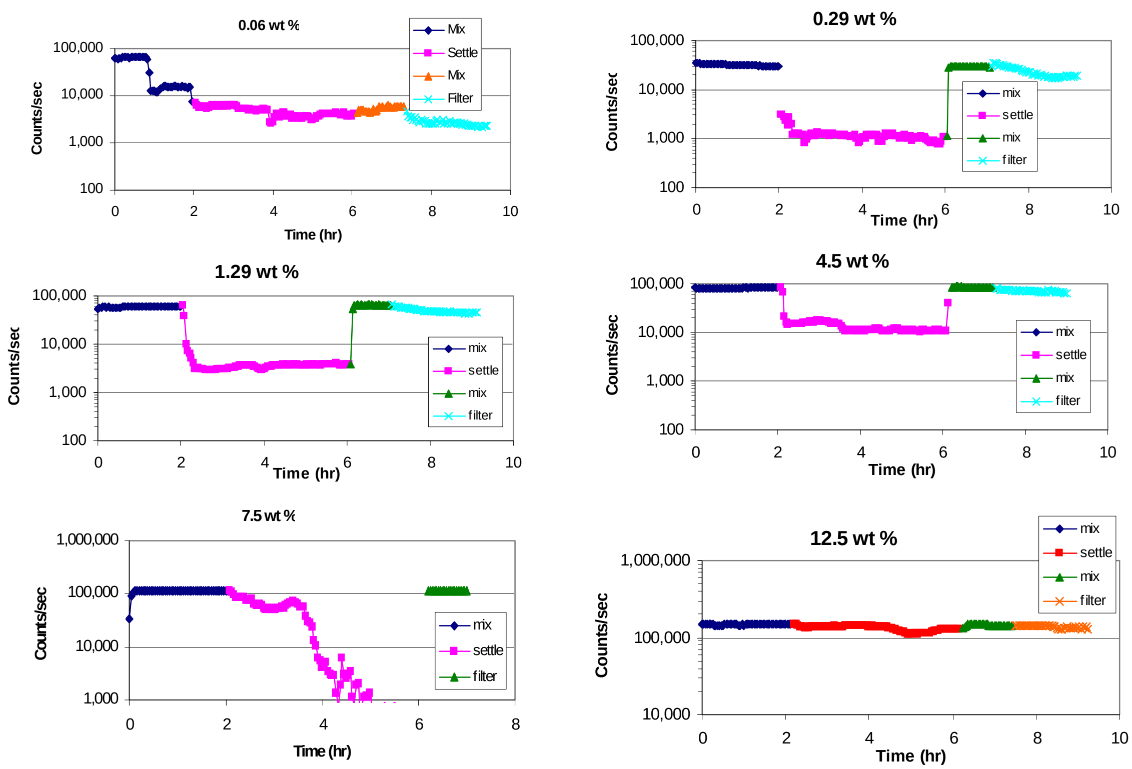

Figure 9. Particles counts during Settling Tests with MST-Only Feed

Figure 10 shows the particle counts near the probe (located in the top quarter of the tank) during the settling and re-suspension tests with sludge and MST feed slurry. With the lowest solids loading, the particle count dropped by about 5X while the slurry was mixing. We are unsure of the reason. The drop could be caused by particles adhering the feed vessel. When the agitation stopped, the particle count decreased by ~ 5X and then slowly increased by 4X. No significant increase in particle count was observed when the agitator was turned back on. When the filtration process started, a large increase in particle count was measured ~ 8X. This increase could be due to particles in the filtration system that were not removed during chemical cleaning.

With the 0.29 wt % slurry, the particle count dropped by about 5X while the slurry was settling. When the agitation restarted, the particles were re-suspended within a few minutes. With the 1.29 wt % slurry, the particle count dropped by about 2X while the slurry was settling. When the agitation restarted, the particles were re-suspended within a few minutes. With the 4.5 wt % slurry, the particle count dropped by about three orders of magnitude in four hours while the slurry was settling. This result is surprising, since one would expect more hindered settling as the solids loading increases. When the agitation restarted, the particles were re-suspended within a few minutes. No significant settling was observed with the 7.5 wt % slurry over four hours. The particles in the 12.5 wt % slurry settled. The settling occurred over four hours and produced an order of magnitude reduction in particle count at the top of the tank. This result is also surprising, since a 12.5 wt % slurry would likely have a significant yield stress and hindered settling. When the agitation was restarted, the particles re-suspended within a few minutes.

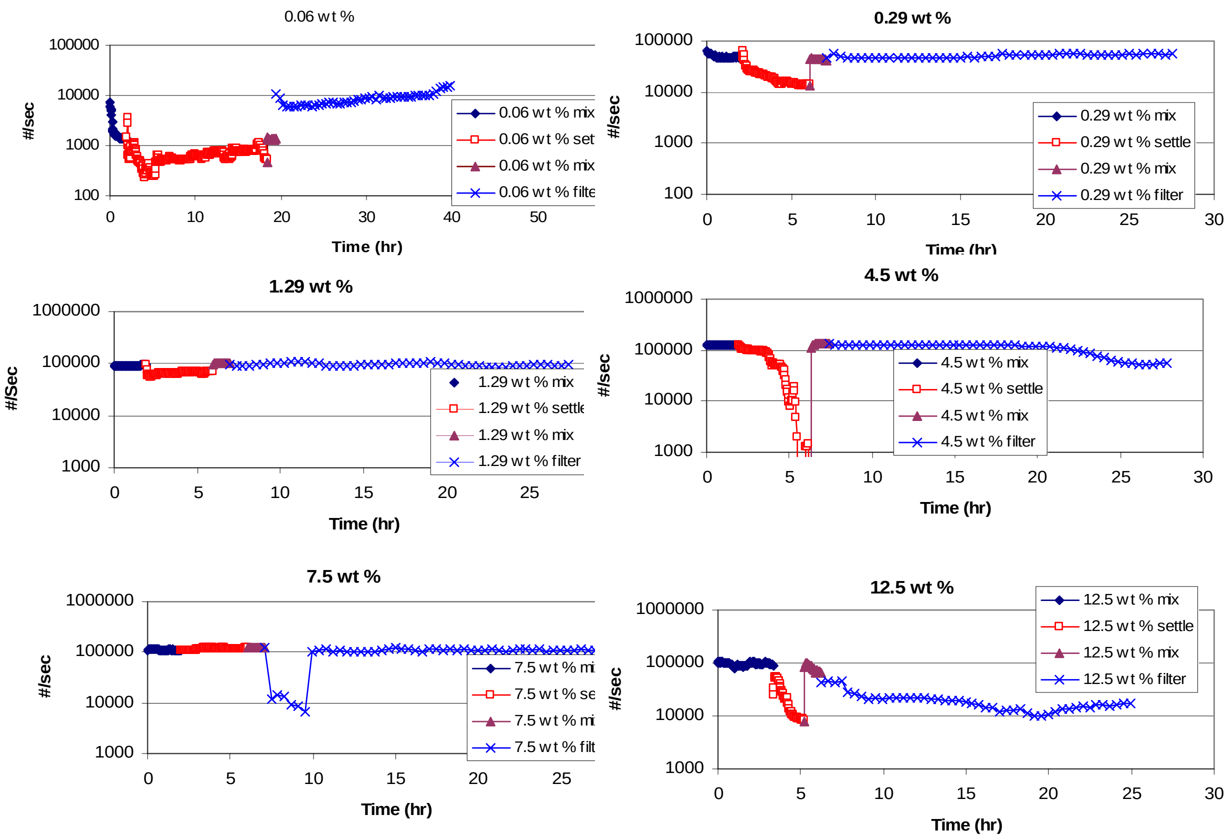

Figure 10. Particles counts during Settling Tests with Sludge/MST Feed

Figure 11 shows the particle size distribution (i.e., chord length distribution) during MST-only testing. The particle size distribution shows a decrease between the start of the test (12 micron median particle size) and the end of the test (9 micron median particle size). This decrease is likely caused by the feed pump or the rotating disks shearing the solid particles in the feed slurry. Similar decreases in particle size occurred during crossflow filter tests.[18] The median particle in this test is 25 – 35% less than the median particle size measured during the 2002 test.[9]

Equation [1] describes the effect of particle size on filter flux

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

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.[16] Since theory predicts filter flux to be proportional to particle size squared, a 30% decrease in median particle size would produce a 50% decrease in filter flux. The particle size in this test is approximately the same as the particle size in the 2003 rotary filter test.[11]

Figure 12 shows the particle size distribution (i.e., chord length distribution) during sludge plus MST testing. The particle size distribution shows a decrease between the start of the test (16 micron median particle size) and the 4.5 wt % test (9 micron median particle size). This decrease is likely caused by the feed pump or the rotating disks shearing the solid particles in the feed slurry. The median particle size increased following testing at 7.5 wt % and 12.5 wt %. The median particle in this test is 10 – 25% less than the median particle size measured during the 2002 test.[9] Since theory predicts filter flux to be proportional to particle size squared, a 25% decrease in median particle size would produce a 45% decrease in filter flux. The particle size in this test is approximately the same as the particle size in the 2003 rotary filter test.[11]

Figure 13 shows the particle size distribution (i.e., chord length distribution) during ceramic media testing. The particle size distribution shows a decrease between the start of the test (14 micron median particle size) and the end of the 4.5 wt % test (10 micron median particle size). This decrease is likely caused by the feed pump or the rotating disks shearing the solid particles in the feed slurry. The median particle size increased following testing at 7.5 wt % and 12.5 wt %. The particle size in this test is approximately the same as in the 2003 rotary filter test with ceramic disks.

Figure 14 shows the particle size distribution (i.e., chord length distribution) during Pall media testing. The particle size distribution shows a decrease between the start of the test (17 micron median particle size) and the end of the test (9 micron median particle size). This decrease is likely caused by the feed pump or the rotating disks shearing the solid particles in the feed slurry. The particle size in this test is approximately 20% less than in the 2002 test.

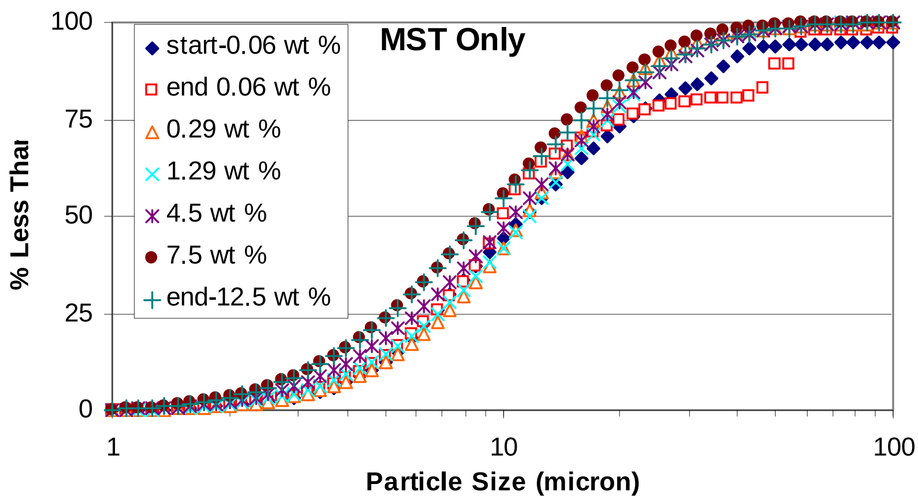

Figure 11. Particle size data from the SpinTek Test with 0.1 micron Mott Filter and MST-Only Slurry

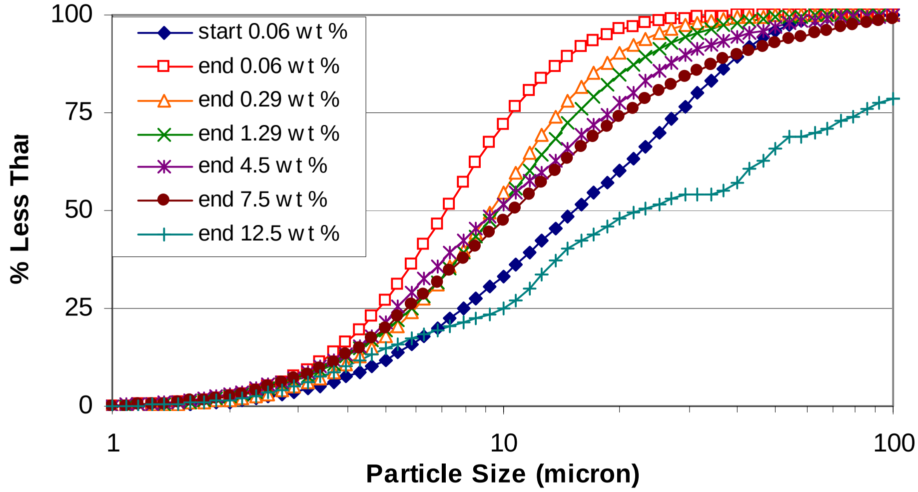

Figure 12. Particle size data from the SpinTek Test with 0.1 micron Mott Filter and Sludge/MST Slurry

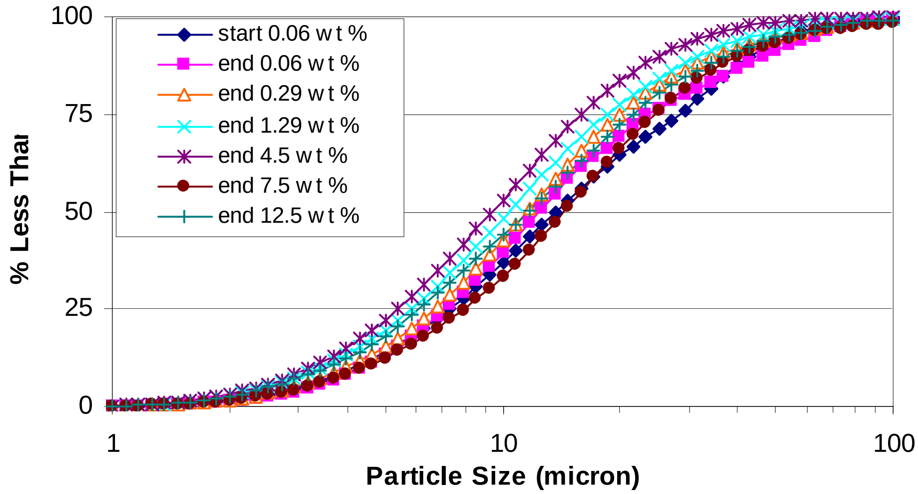

Figure 13. Particle size data from the SpinTek Test with 0.1 micron Ceramic Filter and Sludge/MST Slurry

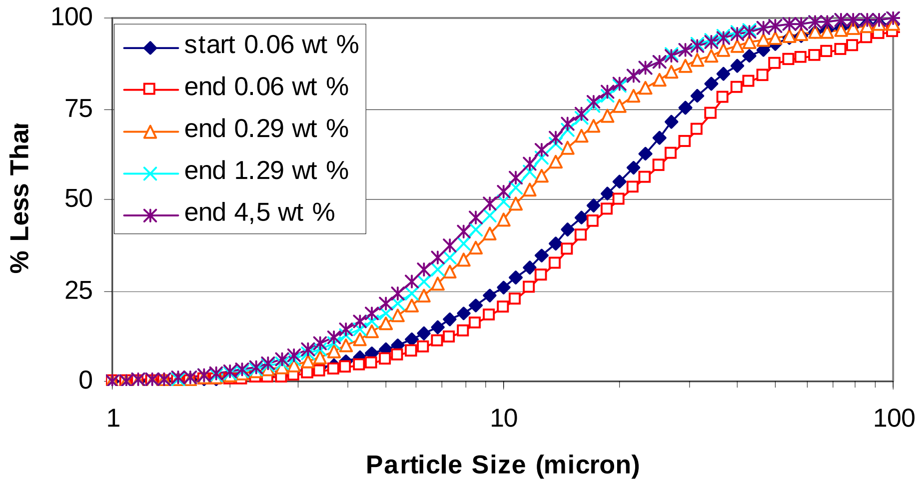

Figure 14. Particle size data from the SpinTek Test with 0.1 micron Pall Filter and Sludge/MST Slurry

Reliability

The rotary microfilter has operated for over 2400 hours with no significant operational problems. In particular, there have been no operational problems with the mechanical seal. The welded filter disks effectively removed solid particles from the feed slurry.

During this test, several filtrate samples early in one test showed high turbidity; investigation of the occurrence identified a missing O-ring as the cause of the high turbidity.

During this test, a rotary union on the filtrate side of the rotary filter failed. An investigation of the failure showed the seal face was mounted with acrylate which is not compatible with the feed slurry. The corrective action is to have the vendor silver solder the seal faces to the rotary joint.

CONCLUSIONS

The conclusions from this work follow.

- The rotary microfilter has now operated for over 2400 hours with no significant operational problems. In particular, no operational problems occurred with the mechanical seal. The welded filter disks effectively removed solid particles from the feed slurry.
- Filter flux with the welded disks was significantly less than the flux in comparable tests with filter disks fabricated using epoxy. The differences are apparently due to changes in the spacing between the filter disks and the turbulence promoters and changes in the turbulence promoter thickness added for the current tests. These changes affected the fluid mechanics of the system and reduced the shear at the filter surface. Presumably, these changes can be reversed in the final design.
- The ceramic filter media produced the highest flux.
- The Pall filter media produced higher flux than the Mott filter media.
- MST-only feed filtered at a higher rate than sludge plus MST feed.

- The Lasentec® data provides insight into the settling behavior of the sludge and MST particles. The settling was fastest with solids loadings of 0.29 – 4.5 wt %. At the higher concentrations, particle settling rate was reduced because of hindered settling.
- When agitation resumed, the settled particles re-suspended within a few minutes
- The MST-only solids settled more rapidly than the sludge plus MST solids.
- Particle size measurements showed a 25 – 50% median particle size reduction during the tests.
- The median particle size was as much as 35% smaller than in previous tests.

FUTURE WORK

SRNL plans to perform additional rotary microfilter testing to confirm that returning the disk spacing to the manufacturer's design returns the filter flux to the values measured in previous tests, to optimize the disk spacing, and to optimize the rotor speed. In addition, SRNL plans to procure a 50 ft^2 rotary filter that will be integrated with the small column ion exchange process.[17]

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QUALITY ASSURANCE

The FRED facility follows ISO-9000 guidelines. Prior to performing the 2002 rotary microfilter test, SRS personnel completed an operational readiness review. SRNL Quality Assurance performs periodic audits of the FRED facility. FRED personnel prepared and followed a test procedure, which includes calibration checks of the thermocouples, pressure gauges, and flow meters. The uncertainty of the temperature measurements was ± 0.4 °F. The uncertainty of the pressure measurements was ± 2 psi. The uncertainty of the feed flow rate measurement was ± 0.5 %. The uncertainty of the filtrate flow rate measurement was ± 0.009 gpm. FRED personnel performed calibration checks of the instruments following the completion of each test.