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IMPACT OF A ROTARY MICROFILTER ON THE SAVANNAH RIVER SITE HIGH LEVEL WASTE SYSTEM

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Introduction

The rotary microfilter is an alternative filter technology that offers increased filter flux over conventional filtration technologies. The filter system combines centrifugation with membrane filtration. Solids are removed from the liquid at the membrane surface, and the centrifugal force acts to keep the surface clean, minimizing the formation of a filter cake. The centrifugal force minimizes solids buildup, allowing more flow through the filter membrane. The effect is the same as increasing the axial velocity of a crossflow filter without increasing system pressure requirements.

Centrifugal filter systems are commercially available (from Spintek, ASPECT USA, Pall, and Canzler) and have been used in radioactive service both at Los Alamos National Laboratory (LANL) (i.e., for Low-Level Waste) and in Russia (for High-Level Waste). The technology has been tested with actual SRS High-Level Waste at the SRTC Shielded Cells.

SRTC 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 (ARP). The data show significant improvement in filter flux with the rotary microfilter over the crossflow filter.[1,2,3]

As part of the development of the rotary microfilter, the author investigated the impact of the technology on the Savannah River Site High Level Waste system. This report documents that investigation.

Discussion

The rotary microfilter technology adds no new chemicals to the actinide removal process. With the technology, the feed to 512-S is contacted with monosodium titanate (MST) for as long as 24 hours, and filtered to remove the strontium and actinide species that sorb to the MST.

The rotary microfilter produces higher filtrate throughput, so it will facilitate faster treatment of the SRS High Level Waste that needs alpha removal. The flowsheet for the rotary microfilter shows that replacing the 0.5 micron crossflow filter in 512-S with two 25 disk rotary microfilters (50 ft^2 filter area total) would increase the annual throughput of 512-S by 25% (assuming a 24 hr MST strike).[4] If the MST contact, or strike, time is reduced, the degree of improved throughput with the rotary microfilter increases further. Two 25 disk rotary filter (50 ft^2 filter area total) would produce the same annual throughput as a 230 ft^2 0.1 micron crossflow filter.

Since the rotary microfilter produces higher filter flux than the baseline crossflow filter technology, it will likely require less frequent chemical cleaning, and add fewer cleaning chemicals, such as oxalic acid, to the SRS High Level Waste System. Prior experience in Russia shows this type of equipment may operate for extended periods [e.g., 4000 hours] without any need of chemical cleaning.[6] Since the cycle time with the rotary filter is 34.3 hours and the filtration time is 5 hours, 4000 hours of filtration corresponds to 31,000 hours of ARP operation (~ 3.5 years). The feed streams to this process will vary widely, and some will be more challenging than the feed to the Russian unit. One can conservatively assume the rotary filter would require chemical cleaning once per year versus eight times per year with the crossflow filter.

In addition, the rotary filter has a smaller holdup volume (4 gallons for a 25-disk unit and 8 gallons for two 25-disk units). The crossflow filter in 512-S has a holdup volume of 92 gallons. If we base the volume of cleaning chemicals on the holdup volume of the filter housing, the rotary filter requires 90% less cleaning chemicals than the crossflow filter. If we base the amount of cleaning chemicals on the filter surface area (50 ft^2 for rotary filter and 230 ft^2 for crossflow filter), the rotary filter requires 80% less cleaning chemicals than the crossflow filter.

Cleaning the crossflow filter requires five 425-gallon batches of oxalic acid. If the crossflow filter is cleaned eight times per year, the annual oxalic acid requirement is 17,000 gallons. Assuming an 80% reduction in cleaning chemicals, the rotary microfilter requires five 85-gallon batches of oxalic acid for chemical cleaning. If the rotary filter is cleaned once per year, the annual oxalic acid requirement is 425 gallons, a 97% reduction.

Because of the rotating parts, the system may require more frequent maintenance and replacement than the baseline crossflow filters. SRTC and CBU personnel performed a risk assessment of the rotary microfilter technology.[5] The risk assessment assumed a lifetime of two years for an "off the shelf" rotary microfilter and five years for a "Rad hardened" rotary microfilter.[6] Russia has deployed rotary filters in High Level Radioactive Waste treatment applications.[6] Their units have operated for over four years and are still in service. Based on the Russian experience and design improvements identified by the authors[7], we believe a "Rad hardened" unit could operate for five years.

Because multiple rotary filter units would be deployed (two in 512-S or four in 241-96H), the failure of one unit would not cause the ARP to shut down. If the rotary filter required replacement after two years of service and the replacement took two weeks, the throughput reduction would be < 2%. If the rotary filter required replacement after five years of service and the replacement took two weeks, the throughput reduction would be < 1%. The cost of replacing the rotary filter is described in the cost-benefit analysis report.[8]

Testing shows the rotary microfilter can concentrate sludge and MST slurries to 11 – 13 wt % with negligible change in filter flux, still providing a throughput nearly 10X that of the design target.[2] Such behavior will allow SRS to concentrate the slurry to a higher solids loading, reducing the amount of water sent to DWPF.

Steve Phillips of DWPF evaluated the impact of increasing the solids concentration from 5 wt % to 12 wt % (see Attachment 1). If SRS concentrated the slurry to 12 wt % insoluble solids rather than 5 wt %, it would reduce the SRAT boiling cycle by 1.3 hours and the amount of recycle generated by 14,000 gallons per year. Until coupled operations begin, the reduced SRAT cycle does not affect DWPF throughput. The annual reduction in recycle (14,000 gallons) is approximately 1%.

Conclusions

The rotary microfilter has the following positive impacts to the SRS High Level Waste System:

- The rotary microfilter technology adds no new chemicals to the actinide removal process.
- The rotary microfilter requires less frequent chemical cleaning and less oxalic acid, so it adds fewer cleaning chemicals to the SRS High Level Waste System (estimated as 97%, or 16,000 gal per year, reduction).
- The rotary microfilter produces higher filtrate throughput, so it will allow faster treatment of the SRS High Level Waste needing actinide removal. Replacing the crossflow filter in 512-S with two 25-disk rotary filters would increase the throughput of that facility by

25%. Two 25 disk rotary filter (50 ft^2 filter area total) would produce the same throughput as a 230 ft^2 0.1 micron crossflow filter.

- The ARP could concentrate the waste slurries to 12 wt % rather than 5 wt %, with no adverse impact on filter flux. Increasing the insoluble solids loading would reduce the SRAT cycle time by 1.3 hours and the annual recycle generation by 14,000 gallons.

The rotary microfilter has the following negative impacts to the SRS High Level Waste System:

- Because of the rotating parts, the system may require more frequent maintenance and replacement than the baseline crossflow filters. Because multiple rotary filter units would be deployed (two in 512-S or four in 241-96H), the failure of one unit would not cause the ARP to shut down. The impact of more frequent replacement on the ARP is less than 2%. The cost of replacing the rotary filter is described in the cost-benefit analysis report.[8]

References

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2. D. T. Herman, M. R. Poirier, and S. D. Fink, "Testing of the SpinTek Rotary Microfilter Using Actual Waste", WSRC-TR-2003-00030, Rev. 1, December 2003.
3. M. R. Poirier, "Filtration Systems, Inc., Report for SRS SpinTek Rotary Microfilter Testing", WSRC-TR-2001-00214, Rev. 1, May 4, 2001.
4. K. B. Martin, D. T. Herman, M. R. Poirier, and S. D. Fink, "ARP Alternative Filtration Options Material Balance", WSRC-RP-2003-01013, October 2003.
5. G. C. Winship and M. R. Poirier, "Rotary Microfilter Risk Assessment Report", WSRC-RP-2003-01004, December 1, 2003.
6. M. R. Poirier, D. T. Herman, and S. D. Fink, "Evaluation of Alternative Rotary Microfilter Manufacturers", WSRC-RP-2003-01097, November 24, 2003.
7. D. T. Herman, M. R. Poirier, and S. D. Fink, "Recommendations for Additional Design Development of Components for the SpinTek Rotary Microfilter Prior to Radioactive Service", WSRC-RP-2003-00605, October 2003.
8. J. L. Siler, M. R. Poirier, K. B. Martin, D. T. Herman, and S. D. Fink, "Cost Benefit Analysis for using a Rotary Microfilter Unit in the 512-S/241-96H Facility", WSRC-TR-2003-0058, October 31, 2003.

Attachment 1
Impact on DWPF of Concentration Insoluble Solids to 12 wt %

January 8, 2004

To: Michael Poirier

From: Steve Phillips, 704-27S
8-7165

Re: 12% vs. 5% Solids in ARP Process

The following information was developed using the ARP material balance developed by Mark Drumm. I selected Case 2 Appendix A from calculation X-CLC-S-00113 Rev. C.

The input for this case is as follows:

- The incoming feed is 6.44 M Sodium and is diluted to 5.6 M Sodium with 1.66 M caustic.
- Concentration of solids to 5%. This requires 27 batches in a tank with a 3800 gallon working volume and a 1600 gallon heel.
- Concentrate pump out to DWPF is from 1600 gallons to 650 gallons.
- 2125 gallons of cleaning chemicals are then used to clean the cross-flow filter and are pumped to DWPF as a line flush.
- The incoming salt has 600 mg/l entrained sludge.
- Baseline receive, react with MST, and filter cycle time is 42 hours.
- Each concentrate batch is washed with the combined time for cleaning and washing of 36 hours.

This results in a DWPF input of 0.044 gpm of washed ARP solids and cleaning chemicals. This is equivalent to 25,300 gallons including additional pump priming water per year. At 250 cans/yr, DWPF will process 44 SRAT batches so the ARP addition is 575 gallons per batch. At a 2000 lb/hr boilup rate the ARP addition extends each SRAT boiling cycle by 2.4 hours (105 hours per year.). At present and until coupled feed begins, the additional boilup time does not significantly affect DWPF throughput since the SRAT cycle is not the DWPF limiting step.

Increasing the solids to 12% would result in 67 batches before washing and chemical cleaning. This results in a DWPF input stream of 0.018 gpm of ARP washed solids and cleaning chemicals. At 250 cans/yr the ARP addition would be 265 gallons per batch including pump priming water. At a 2000 lb/hr boilup rate the ARP addition would add 1.1 hours to the SRAT cycle a saving of 1.3 hours per batch (57 hours/year). As mentioned above, this would not significantly increase the DWPF throughput.

At present DWPF recycles about 1.4 million gallons per year. The total processing cost is about $2.00/gallon. The ARP stream would add 25,300 gallons at 5% solids and only 11,600 gallons at 12% solids or a saving of 13,700 gallons or $27,400 per year.