CONTROLLED CAVITATION CAN INCREASE RECOVERY EFFICIENCY

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Everyone knows the sound of banging water pipes. Laymen call it "water hammer," and scientists call it "cavitation." Several years of research and pilot projects have shown that the "destructive force" of cavitation can have useful purposes.

A liquid passing through a Shockwave Power™ Reactor (SPR) undergoes "controlled cavitation." In an SPR, microscopic cavitation bubbles form. When they collapse, heat transfers to the liquid without heat transfer surfaces or combustion. No scaling occurs between liquid and metal. Adding a gas, powder, or other material to a liquid cavitation causes the additive to disperse to almost microscopic size. This increases the surface contact area between materials and maximizes the process.

SPR technology offers benefits for heating liquids by preventing scale accumulation and by promoting mixing of liquids with gases (two phase fluids), powders, and other liquids at the microscopic level to increase mass transfer rate.

Chemical recovery from black liquor is an essential part of most paper mills. Because of large capital investments, operating efficiency is critical. Development of three black liquor applications helps mills achieve these goals.

WHAT YOU WILL LEARN

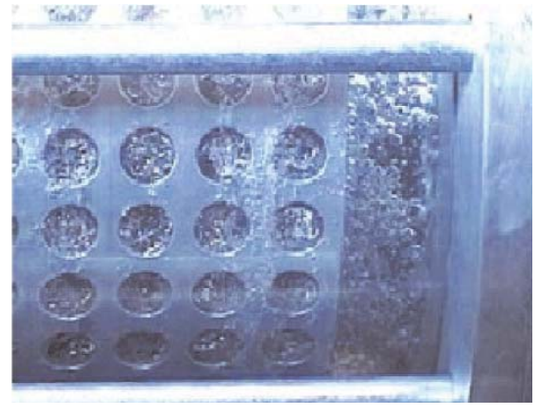
- How SPR technology offers benefits for heating liquids.
- How this technology can improve recovery boiler throughput.

ADDITIONAL RESOURCES

- Frederick, J., Armstead, D., Lien, S., Schmidl, W., and Kazem, B., "Economic Benefits of Utilizing Controlled Cavitation Technology for Black Liquor Oxidation and Heating," Proceedings of the 2001 International Chemical Recovery Conference.
- Frederick, W. J., and Grace, T. M., "A Study of Evaporator Scaling: An Evaluation of Thermal Deactivation," Project 3234, Report 4, The Institute of Paper Chemistry, Atlanta, GA, November 15, 1977.
- Hydro Dynamics Web site: www.hydrodynamics.com.

INCREASING EVAPORATOR EFFICIENCY

If evaporators are running inefficiently because of scale buildup, black liquor preheating by oxidation should eliminate this problem. Preheating a liquor before the "effect" where the scaling is occurring has shown elimination of as much as 98% of the scale. This increases uptime and significantly reduces or eliminates expensive hydro blasting, boil-outs, and mini-washes.



Still picture of clear acrylic demo showing cavitation occurring at low RPMs reducing gas bubble

Microscopic size bubbles when water and air are mixed at high RPMs in the SPG. Gas bubbles appear as a "cloud".

A SPR has had successful use in earlier tests to heat black liquor without scaling (see Frederick, et al in "Additional Resources"). In contrast to a standard heat exchanger, the SPR does not require a hot surface. Instead cavitation generates heat directly in the black liquor. Another method to heat black liquor indirectly is partial oxidation. Because sulfide oxidation is an exothermic reaction, liquor temperature will increase as oxidation

occurs. Partial oxidation of kraft liquors can combine with controlled cavitation in the SPR to increase the economic efficiency of heating. Replacing electricity with oxygen reduces the cost of heating the liquor.

A recent project used a pilot SPR unit to mix oxygen in black liquor for rapid oxidation to heat the liquor. The purpose of this work was to evaluate the fouling tendency of SPR-heated black liquor in conventional heat exchangers. Several trials used the Institute of Paper Science and Technology (IPST) annular-flow heat transfer fouling test cell (ATC) to simulate the thermal environment in a live-steam-heated black liquor evaporator. Precise control of liquor conditions and sensitive instrumentation in the ATC allowed measurement of the rate of fouling due to calcium carbonate deposition. The calculated fouling rates from two baseline tests with no SPR treatment were 0.33–0.67 mm/hr. Partial oxidation treatment using the SPR reduced the fouling rate to 0.00–0.07 in three trials.

Baseline tests performed with untreated liquor determined the rate of fouling with a 20°C temperature differential between the electrically-heated surface in the ATC and the circulating black liquor. The open symbols in **Fig. 1** show the calculated heat transfer coefficient for an unoxidized mill liquor with 44% solids content. The decrease during the first 60 minutes indicates that this liquor has a high propensity to form scale.

Other tests performed using the same initial batch of black liquor involved initial heating to more than 130°C by partial oxidation in the SPR during transfer into the ATC apparatus. In one test, the liquor was at the treatment temperature while testing in the ATC. As expected, the temperature differential of 2°C resulted in very little change in heat transfer coefficient over several hours. In this case, preheating reduced the driving force for calcium compounds to deposit on the heat transfer surface.

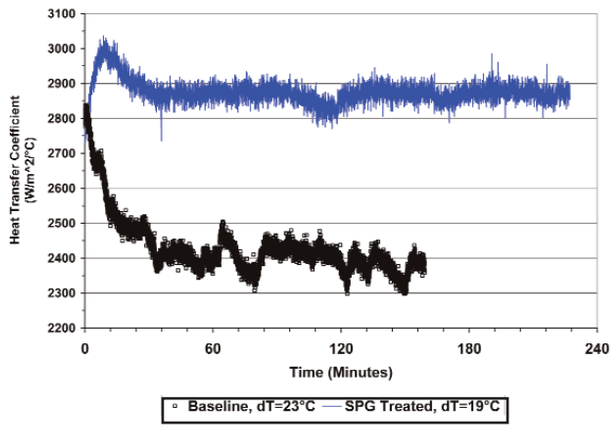


Figure 1: The impact of partial oxidation heating on calculated heat transfer coefficients versus time for a mill black liquor.

In another test, the liquor cooled as it entered the ATC flow loop after SPR heating to 130°C. This ATC test used the same 20°C temperature differential of the base line test. The line plot in **Fig. 1** shows that no significant scaling occurred during four hours. This result implies that partial oxidation treatment in the controlled-cavitation mixer imparted a sustained change to the black liquor. Based on research at IPST by Frederick and Grace (see Additional Resources), a reasonable conclusion is that heating the liquor above the maximum temperature encountered in the subsequent test may alter its chemistry and greatly reduce the fouling tendency of the liquor.

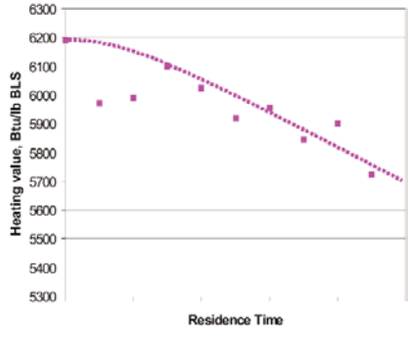


Figure 2: HVR reduction.

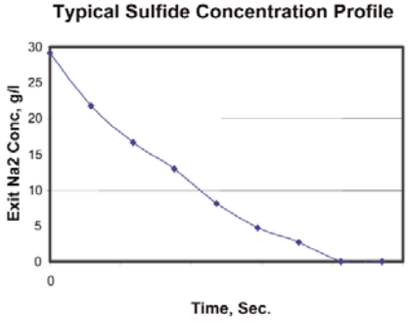


Figure Black liquor polishing.

INCREASING THROUGHPUT

Using similar oxidation chemistry when the recovery boiler is steam limited, the black liquor heat value reduction application allows a mill to efficiently increase boiler production up to 7% using a small, skid-mounted SPR. All this is possible without additional storage tanks or producing non-condensable gasses.

If a mill needs to address an environmental issue regarding sulfur emissions, the black liquor polishing application could be very economically viable. Na_2S can decrease to non-detectable levels of less than .01 grams per liter. This is far below what most technologies can deliver efficiently. The SPR can be beneficial in many areas of the recovery cycle. These include scale-free heating, heating by oxidation, polishing, and HVR. **S!**

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