A Novel Unit Operation to Remove Hydrophobic Contaminants

Bubble Nucleation Process separates and removes stickies and pitch in papermaking operations

Recovered paper entering paper recycling mills contain hydrophobic contaminants called "stickies" that significantly hinder paper making productivity. These contaminants are pressure sensitive adhesives (PSA), wax, polyvinyl acetate, and plastics found in recycled paper. The sources of these contaminants include address labels, postage stamps, envelopes, book bindings, and binders used in inks and coatings.

Stickies and pitch (resins from wood) accumulate in the pulp white water and eventually agglomerate and form deposits on papermaking machine rolls, wires, felts and dryer surfaces. Expensive chemicals to coagulate particles, screens, and other processes used today are not very effective at removing particles less than 100 microns in size. Periodically, the paper machine has to be shut down to remove the deposits with toxic cleaning solvents. In addition, residual stickies cause holes in paper boards and tissue, reduced paper quality, and problems in the machines that print on the paper.

This project will develop a new unit operation called Bubble Nucleation Process (BNP) to remove hydrophobic contaminants from paper mill process streams without the use of expensive chemicals. When the pressure is reduced to the slurry containing fibers, water, and hydrophobic contaminants, dissolved gas nucleate on the hydrophobic contaminants, form bubbles that float to the surface, and the foam containing the particles can be selectively removed.

Benefits for Our Industry and Our Nation

Broad use of the BNP in U.S. paper mills could significantly improve papermaking machine productivity and product quality. Key benefits include the following:

- Stickies and pitch-related problems result in paper machine downtime, lost production, and product quality issues. BNP use could significantly reduce the costs of papermaking from recovered paper.
- The potential energy savings is estimated to be 7 Trillion Btu per year if all U.S. recycling mills implement the BNP.
- BNP could eliminate the use of polluting chemical solvents and high pressure showers used to clean deposits from wires and felts in papermaking machines. Other environmental benefits include a reduction in water consumption and sludge production.
- An economical means to remove stickies could lead to increased recovery of paper by U.S. paper mills. It could also reduce the volume of rejected contaminated paper products.

Applications in Our Nation's Industry

BNP could offer significant advantages over other methods and flotation processes used commercially today to remove hydrophobic contaminants (e.g., dissolved air flotation (DAF), dispersed air flotation or froth flotation, cavitation air flotation, electro-flotation, centrifugal flotation). BNP does not have many moving parts so it should be relatively easy to install and operate. A small scale unit could be used to monitor paper machine white water and provide a visual online warning of the build of hydrophobic particles. A commercial VAF unit could be useful to many paper mills, increasing the efficiency and competitiveness of the U.S. paper industry.

Hydrophobic contaminants from a brown stock mill water sample floating near the surface of the Bubble Nucleation Process Tube. *Photograph courtesy of Doshi & Associates, Inc. and the USDA Forest Products Laboratory*

Project Description

Project partners will develop a novel unit operation, BNP, to selectively agglomerate pitch and stickies particles without the use of any toxic chemicals (thus reducing costs and the environmental footprint of this process). Researchers will design and build both a batch and a continuous unit for laboratory testing and mill trials. Diverse parameters will be evaluated to calibrate the magnitude and duration of

vacuum, retention time in the vessel, and the flow rate to maximize agglomeration and removal of hydrophobic particles. Results will be used to design a commercial unit that will be useful for many paper mills as well as other manufacturing processes requiring the removal of hydrophobic contaminants. Outcomes will be characterized in terms of stickies removal efficiency (SRE) and paper reject ratio. The removal target is 80% of hydrophobic particles in the synthetic process water and 60% in the industrial process water.

Barriers

- Many different types of hydrophobic contaminants exist and the concentration in the pulp white water entering the papermaking machine varies.
- Dissolved air and carbon dioxide in the process water hinders paper quality by interfering with good fiber-fiber bonding and may also lead to pin holes in the finished sheet of paper.
- The presence of fibers in the process water complicates the measurement of stickies.
- Determining the amount of process water that needs to be treated to enable the smooth operation of a paper machine.
- The amount of acceptable stickies in the paper depends on the type of product.

Pathways

A batch BNP unit will be built to demonstrate the vacuum design, stickies removal in the float separator, and the remaining water. To determine the specifications for optimal performance, experiments and statistical analysis will be conducted to evaluate the effect and interaction of the following parameters: temperature, magnitude of vacuum, time, pH, filler (clay and calcium carbonate), bicarbonate concentration, turbidity, dissolved gases (air, carbon dioxide and others), and fiber content.

Results will be used to design and operate a continuous laboratory-scale unit. Removal efficiency will be tested extensively on standardized synthetic process water samples and mill samples. A pilot-scale unit with proper process controls will be constructed and installed at a mill to automate the unit to the extent possible and verify performance, including maximizing agglomeration and separation of micro stickies and other hydrophobic contaminants. A commercial unit will be designed to demonstrate performance at scale

Milestones

This two-year project began in April 2015.

- Construct a laboratory-scale batch BNP unit and complete testing of mill samples at optimized conditions (Completed).
- Design, construct, and test a laboratory-scale continuous BNP unit (Completed).
- Design, construct, and test a pilot-scale continuous BNP unit achieving contaminant removal targets (2016).

Commercialization

The continuous pilot-scale unit will be built and operated at the USDA Forest Products Laboratory in compliance with U.S. mill regulations and needs. Commercial vendors will be invited to the mill to observe the operating BNP unit. Results will be used to design a full-scale commercial unit that is applicable to many paper mills as well as other manufacturing processes requiring the removal of hydrophobic contaminants from water streams.

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