A Novel Unit Operation to Remove Hydrophobic Contaminants

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Doshi & Associates, Inc.
Project Period: 4/1/2015 to 12/31/2016

Mahendra Doshi, Doshi & Associates, Inc.

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Project Objective

- To remove hydrophobic contaminants like stickies (arising from pressure sensitive adhesives, hot melts, ink and coating binders) from paper mill process streams without the use of chemicals.
- Stickies affect paper machine operation and product quality.
- Relatively small size stickies (microstickies), less than 100 μm, are not effectively removed by conventional processes like screens, hydrocyclones, dispersed air flotation and dissolved air flotation.

Technical Innovation

- Microstickies accumulate, agglomerate and deposit on paper machine wires and felts. Kerosene or other solvents and high pressure showers are used to dislodge these deposits. Pacifying additives like talc, used to stabilize microstickies are not always effective.
- Patented process was successful in laboratory and mill trials for measuring microstickies.
  - Reduction of pressure in an enclosed vessel containing process water results in the nucleation of bubbles on hydrophobic contaminants that float to the surface for easy removal. Other parameters include residence time and temperature
- Implementaion of process will reduce paper machine downtime and improve overall mill economics.

Technical Innovation

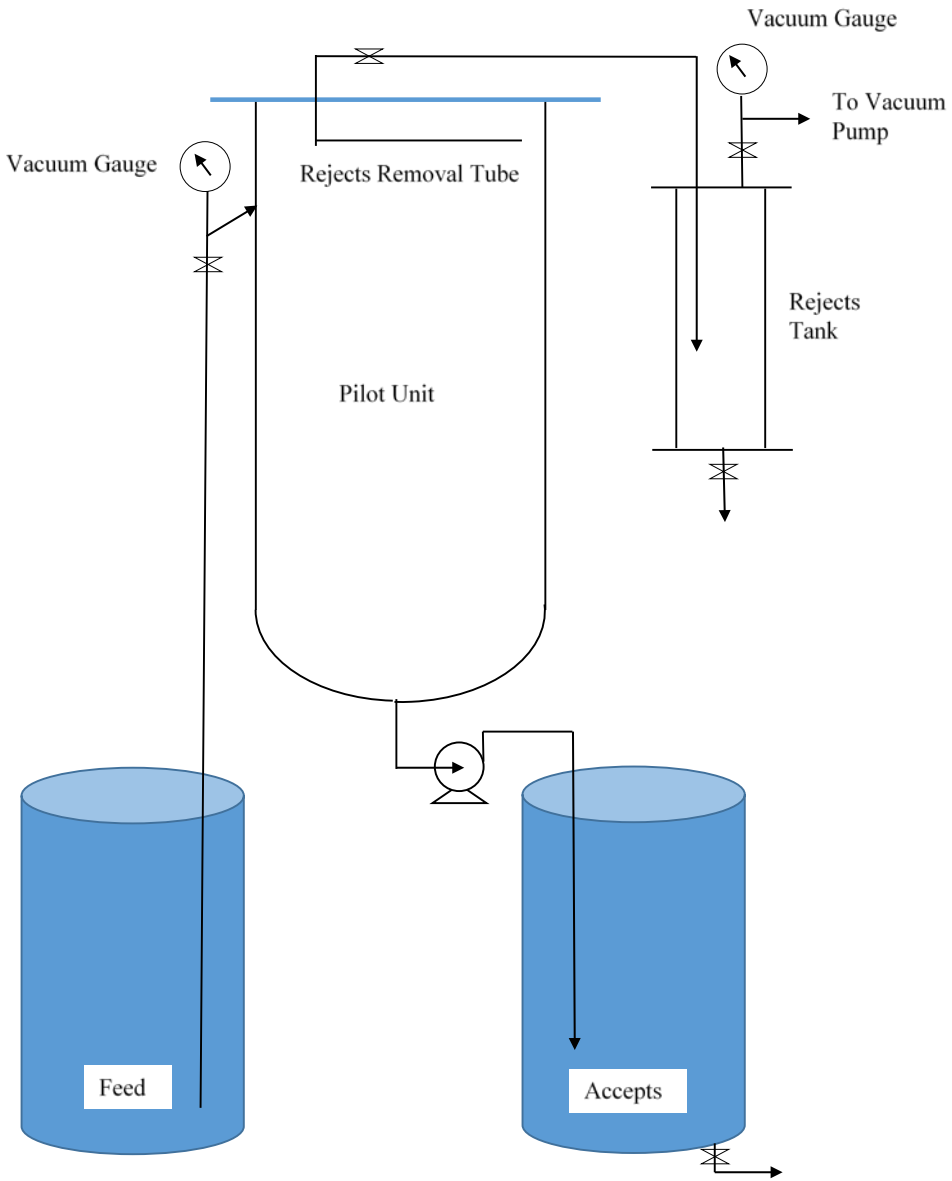
Comparison of flotation processes

	Froth Flotation	Dissolved Air Flotation	Bubble Nucleation Flotation (BNF)
Separation	Selective separation	Collective separation	Selective separation
Mechanism	Bubble attachment to hydrophobic particles	Bubble entrapment in flocks	Bubble nucleation on hydrophobic particles
Chemistry	Surfactant	Coagulation-flocculation agents	None
Bubble size	0.1 to 1.0 mm^2	0.01 to 0.1 mm^2	0.001 to 0.01 mm^2
Fluid mechanics	Controlled turbulence	Somewhat quiescent	Somewhat quiescent
Air	Introduced by mechanical dispersion	Air introduced by dissolving at elevated pressure	Removal of dissolved air and other gases.

Technical Approach

- Bubble nucleation flotation (BNF) will be tested in a batch unit using synthetic process water and mill samples. Batch testing results will be used to design and test a continuous process unit and a pilot unit.
- Participants working on all aspect of projects include Dr. Mahendra Doshi, Salman Aziz, Robert de Jong (Doshi & Associates, Inc.) and Dr. Carl Houtman from USDA Forest Products Laboratory. A tissue mill, SCA Corp. in Menasha, WI, is demonstration site.
- Achieved target stickies removal efficiency greater than 60% so there is no major risk.
- Investigators have extensive experience working with paper mills addressing problems caused by stickies.

Technical Approach



Transition and Deployment

- Attractive features of the process include low reject rate (less than 5%), no need for coagulating/flocculating chemicals or surfactants, virtually no moving parts and the removal of air from process water.
- Successful implementation of bubble nucleation flotation (BNF) in paper recycling mills will increase paper machine efficiency, improve product quality, and reduce the use of cleaning solvents.
- Currently paper mills have shown interest in reducing fresh water use. Implementation of BNF can achieve this objective.
- Plan to work with a vendor to commercialize and collaborate for further process upgrade based on input from customers.

Transition and Deployment

- Future Plans (June to December 2016)
  - Finalize pilot unit testing and controls.
  - Conduct mill trial for 2 to 3 months.
  - Apply for provisional patent
  - Develop strategy for commercialization
  - Partner with a vendor
- BNF can potentially be used to recover valuable fibers from mill reject streams while at the same time reducing the volume of waste to be disposed.
- Application of BNF to decrease stickies concentration in process streams will allow mills to increase water reuse thereby conserving energy and reducing load on the wastewater treatment processes.

Measure of Success

- Target is to achieve stickies removal efficiency greater than 60%. This has been achieved in batch unit and a continuous process. Next step is to install controls in a pilot unit between June-August 2016 time period.
- Success will be measured by mill acceptance of the pilot unit performance.
- BNF can potentially reduce paper machine downtime by at least 1 hour/week (highly conservative estimate) resulting in energy savings of 1.45 Trillion BTU/year.
- Reducing paper machine downtime by 1 hour/week will result in average savings of $50,000 or about $2.5 million per year recovering the BNF installation investment in less than 4 months.

Project Management & Budget

- Project duration: April 2015 to December 2016.
  - Task 1: Construct and test batch BNF unit (completed).
  - Task 2: Construct and test continuous BNF unit (completed).
  - Task 3: Construct and test pilot size BNF unit for mill trial and commercialization (to be completed by December 2016).
  - Mill trial with stickies removal efficiency greater than 60% will be considered successful.

Total Project Budget	
DOE Investment	$316,000
Cost Share	$79,000
Project Total	$395,000

Results and Accomplishments

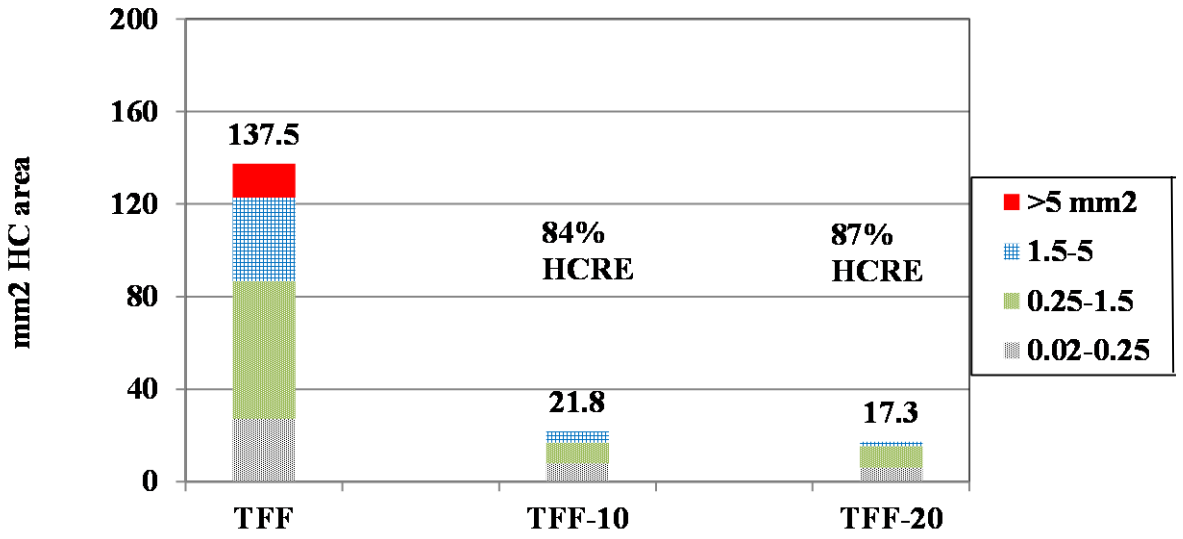
- Successful demonstration of batch and continuous process with hydrophobic contaminants removal efficiency greater than 80 % was accomplished.

Sample Source*	Cons. (%)	Flow (LPM)	Vacuum (in. Hg)	Stickies (mm^2 / liter sample)			SRE (%)
				Feed	Accepts	Rejects	
A	0.02	6.3	17	1.7	0.4	3.6	80
B	0.26	2.9	20	11.9	1.8	236	85

  - *Sample A is mill process water while sample B is hydrocyclone rejects diluted by process water.
- Parameters identified include the vacuum level, residence time and temperature.
  - Vacuum level should be controlled so as to avoid “boiling.”
  - Residence time should be greater than 3 minutes.
  - Excessive turbulence should be avoided.

Results and Accomplishments

BNF efficiency is greater than 80%



HC: Hydrophobic Contaminants; TFF: Tertiary Fine Screen Feed;

HCRE: Hydrophobic Contaminant Removal Efficiency

TFF-10 and TFF-20 correspond to 10 and 20 minutes duration in BNF.

- Task 3 work to be completed include pilot unit lab testing, controls and mill trial (June –December 2016).