University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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"The Potential Use of Bar Force Sensor Measurements for Control in Low Consistency Refining"

Department of Mechanical Engineering

Tuesday, January 9, 2018
9:00 A. M.
Clearihue Building
Room B021

Supervisory Committee:
Dr. Peter Wild, Department of Mechanical Engineering, University of Victoria (Supervisor)
Dr. Ned Djilali, Department of Mechanical Engineering, UVic (Member)
Dr. Jens Bornemann, Department of Electrical and Computer Engineering, UVic (Outside Member)

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Dr. Judith Clarke, Department of Economics, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

A crucial parameter in the production of mechanical pulp though refining is energy consumption. Although low consistency (LC) refining has been shown to be more energy efficient than conventional high consistency refining, the degradation of mechanical properties of the end-product paper due to fiber cutting has limited the widespread adoption of LC refining. In conventional control strategies, the onset of fiber cutting is determined by post-refining measurement of pulp properties which does not enable rapid in-process adjustment of refiner operation in response to the onset of fiber cutting.

In this dissertation, we exploit a piezoelectric force sensor to detect the onset of fiber cutting in real time. Detection of the onset of fiber cutting is potentially beneficial in low consistency refining as part of a control system to reduce fiber cutting and increase energy efficiency. The sensor has a probe which replaces a short length of a refiner bar, enabling measurement of normal and shear forces applied to pulp fibers by the refiner bars. The custom-designed sensors are installed in an AIKAWA pilot-scale 16-in. single-disc refiner at the Pulp and Paper Centre at the University of British Columbia. Trials were run using different pulp furnishes and refiner plate patterns at differing rotational speeds and a wide range of plate gaps. Pulp samples were collected at regular intervals and the pulp and paper properties were measured.

We observe distinct transitions in the parameters that characterize the distributions of peak normal and shear forces which consistently correspond to the onset of fiber cutting.

In addition, the analysis of the power spectrum of the sensor data shows that the magnitude of the dominant frequency can be used as an indicator of fiber cutting.

The power of the time domain signal of the normal force is shown to be the most reliable and consistent indication of the onset of fiber cutting. This parameter consistently identifies the onset of fiber cutting, as determined by fiber length data, for all tested pulp furnishes and plate patterns.

In addition, we investigate the effect of pulp furnish and plate pattern on bar forces in LC refining. For tested pulp furnishes and at all plate gaps, the plate with higher bar edge length (which has smaller bar width and groove width) results in lower mean peak normal and shear forces but higher mean coefficient of friction. Moreover, at the onset of fiber cutting, the mean peak normal force of softwood pulp is higher than for the hardwood pulp. Our results also show that the mean coefficient of friction at the onset of fiber cutting is a function of plate gap, pulp furnish, and plate pattern.