REAL-TIME IN-LINE STICKIES, DIRT AND CONTAMINANT DETECTION IN RECYCLED PULP

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ABSTRACT

A real-time in-line stickies, dirt and contaminant detection sensor suitable for mill environment is presented in this work. Stickies, in this context, are defined as contaminants in a pulp sample with at least one image attribute (such as translucency, hue, saturation, etc.) different from the overall sample. Measurement trends from the in-line sensor were validated against existing stickies measurements in multiple paper mills before operating decisions were made entirely based on this real-time measurement. Mills where in-line stickies measurements have been implemented have, on average, been able to make process decisions 8-10 hours faster than laboratory measurements. ANDRITZ PulpVision is an in-line sensor, built on a machine learning algorithm to detect and classify contaminants in a pulp stream. Another mode of PulpVision is to measure fiber morphology and shives in pulp. This application is essential for monitoring pulp quality and performance of unit operations such as refiners. Detection accuracy is not affected by the presence of bubbles, flocculation, and consistency variation in pulp samples.

A trial using PulpVision was conducted throughout an old corrugated container (OCC) plant to generate profiles of stickies and dirt. It was found that in this specific recycling line, Primary fine screens (PFS) were tested to be inefficient for stickies removal, while cleaners did not play a positive role in dirt removal. This stickies sensor is tested to be powerful to provide real-time feedback of the equipment performance in paper recycling plants.

Keywords: dirt, fiber morphology, recycling, shives, stickies.

INTRODUCTION

One strategy to increase utilization rate of recovered paper is to remove contaminants. Among all kinds of contaminants in recovered paper, stickies have been identified as the most detrimental component in recycling recovered paper (Miranda et al., 2008). Stickies are generally considered as organic contaminants in recovered paper from various sources such as wood derivatives, ink residues, deinking chemicals, adhesives, coating binders, sizing agents, etc. (Blanco Suárez et al., 2007). In terms of chemical compositions, polyvinyl acetate, polyacrylates, styrene butadiene rubber, and derivatives of fatty acids/resin acids have been identified as the main components in stickies deposit (Miranda et al., 2008).

Stickies negatively affect the paper making process by forming deposits which introduces sheet breaks and reduces the quality of the final product. It also reduces the efficiency of the drying section by clogging press felt (Monte et al., 2004). Higher temperature can render stickies tackier, and therefore more likely to form deposits (Hubbe et al., 2006).

Paper furnish generally contains 1%-5% (w/w) sticky materials. There are various testing methods in both lab/academic settings and mill environment (Hubbe et al., 2006). In lab scale, stickies can be measured by spectroscopic analysis at certain wavelengths and microscopic method by counting objectives consistent with the shape of stickies (Vahasalo e Holmbomh, 2005). An analytical procedure based on scanning electron microscopy-electron dispersive X-ray and consecutive solvent extraction steps with Fourier-transform infrared spectroscopy (FTIR) analyses has also been developed to examine different fractions of stickies (Miranda et al., 2008). In addition, solvent extraction and screening have been studied to quantify stickies content in recovered paper (Blanco Suárez et al., 2007).

In mills, “coupons”, consisting of metal or plastic plates, are used and exposed to steady stream flow for stickies deposition. The mass of stickies is measured by drying the plates and calculating the weight difference (Hubbe et al., 2006). In addition, transparent biofilm was utilized in paper machine system to monitor the reduction of light transmission caused by stickies deposit (Flemming et al., 2001).

The testing methods mentioned above are either time consuming or appropriate for stickies problems that have already occurred. There is enormous potential for developing an on-line monitoring technique which can provide rapid quantification of even trace amounts of stickies.

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METHODS

The PulpVision system includes one or more online sensors and a computer workstation. Pulp flows through an observation cell where up to 25 images per second are recorded by a high speed video camera synchronized with a strobe light, Figure 1. The video images are then transferred to the workstation for real-time analysis. PulpVision can detect and analyze any contrasted particles, including ink, dirt, shives and stickies. It detects particles as small as 25 microns—or one thousandth of an inch—nearly invisible to the human eye.

Setup and Principle

Pulp streams having a consistency of 1.5% or lower are directly connected to the measurement unit. For higher consistency samples, a dilution water connection is mounted at the inlet of the unit to bring down the consistency to less than 1.5%. The outlet of the unit is always sent to an open collector/tank without any back pressure. The sensor has a built-in consistency indicator and automatically corrects for changes in consistency. The measurement unit consists of a high-resolution imaging hardware that is capable of taking real-time pictures of moving pulp flowing through a viewing cell. Images of the moving pulp is acquired and processed according to the steps outlined in Figure 2.

Real-time imaging of a flowing pulp suspension generally results in blurred images, and post processing is necessary for meaningful conclusions (Laaksonen et al., 2011). The in-line stickies sensor uses proprietary image processing algorithms to filter acquired images. The processing algorithm not only improves image sharpness, it also eliminates bubbles and flocculation. Figure 3(a) shows an example of a typical raw image, and a processed/filtered image is shown in Figure 3(b). Contaminants and bubbles are clearly visible in the processed image, which helps in subsequent detection and classification.

A sticky or dirt imbedded in the stream is shown having contrasting reflectance and/or its translucence compared to the rest of the sample. The measurement principle in the stickies sensor is based on the composite of multiple attributes such as color, reflectance, translucence, etc. It is tested using image analysis to track stickies since they are represented due to brighter color, higher reflectance, higher translucence compared to other contaminants such as dirt and styrofoam.

Stickies and dirt levels are automatically tracked for their trend over time. Data is saved to a hard drive for later retrieval and analysis. In mill environments, in all cases/installations so far, existing lab measurements were subjective to human evaluations. Due to the overwhelming dependence on operator bias, every installation required specific perceptron training. Generally, this is achieved within two weeks of continuous operation. Figure 4 depicts data from an OCC line. The continuous trend shows in-line stickies sensor data with round dots showing lab data (human perception).

Depending on the mills’ need, this stickies sensor can be...
converted to another mode for fiber morphology (fiber length, width, coarseness, fines content) and shives measurement. Higher dilution and lower consistency of the pulp is required in this mode in order for the sensor to analyze individual fibers, Figure 5.

**OCC Plant Trial**

A mobile version of a stickies sensor was developed and utilized for a mill trial to evaluate the efficiencies of the major pieces of equipment in an old corrugated container (OCC) plant. Each pulp sample was diluted to 4g/L to achieve the optimum measurement for stickies and dirt. Each sample was pumped through the mobile analyzer for 3 min for contaminants measurement. A total volume of 15 gallons of pulp suspension was made to ensure the accuracy of the measurement. The sampling points of the OCC plant were listed in Table 1. The unit operations in the OCC plant that has been evaluated were primary coarse screen (PCS), primary fine screen (PFS), fractionator, primary cleaner and secondary cleaner.

### RESULTS AND DISCUSSION

A simplified OCC plant flow sheet was sketched and sampling points for PulpVision measurements are marked as red stars. Stickies was reported in counts per gram and dirt was reported in PPM (parts per million). They were reported in both total content and in different sizes (0.08 mm², 0.2 mm², 0.4 mm²). Consistency of each sample was measured in lab to act as controls.

**Figure 6** shows a stickies profile of the OCC plant. The initial stickies content was measurement to be 43 count/g in the primary coarse screens (PCS) feed. Based on the data for the accept of PCS (25 count/g), 42% (in quantity) of the stickies was removed by primary coarse screens. It is also shown that primary fine screen (PFS) was inefficient in terms of stickies removal. Although the stickies in count/g in the PCS feed is higher than that of the final accept secondary cleaner. The total area of the stickies was reduced, i.e. a majority of the stickies with larger surface area was removed from the system (data not shown).

In general, accepts of the screens and fractionators showed lower

### Table 1. Sampling points for contaminants analysis in the OCC plant

<table>
<thead>
<tr>
<th>Sampling points</th>
<th>Feed</th>
<th>Accept</th>
<th>Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary coarse screen</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Primary fine screen</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Fractionator</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Primary cleaner</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Secondary cleaner</td>
<td>✓</td>
<td></td>
<td></td>
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</tbody>
</table>

**Figure 5.** A part of the image captured by the analyzer in the fiber morphology mode

**Figure 6.** Profile of stickies count throughout the OCC plant
consistencies. In terms of dirt removal, it is shown in Figure 7 that PCS was not efficient in removing dirt but fractionators are capable of removing ~50% of the dirt. A secondary cleaner shows nearly zero efficiency for dirt removal. Overall, most dirt accepted in the final pulp stream has a surface area less than 0.08 mm².

CONCLUSIONS

The in-line stickies sensor is a powerful tool detecting contaminants such as stickies and dirt in the recycled pulp. It is also capable of measuring fiber morphology and shives in pulp with a different settings and higher dilutions. An OCC plant trial using a mobile version of the sensor was conducted to evaluate the efficiencies of the equipment in terms of contaminant removal. For this specific plant, most of the contaminants were removed by primary coarse screens (PCS). Screens and fractionators reduced the overall size of stickies and dirt. Primary fine screens (PFS) were tested to be inefficient for stickies removal, while cleaners did not play a positive role in stickies removal.

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REFERENCES