

Full characterization of stickies in a newsprint mill: the need for a complementary approach

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ABSTRACT: To ensure paper machine runnability, trouble-free converting, and high quality products, stickies must be removed during stock preparation of recycled pulp. However, the stickies removal efficiency along the process is not easy to assess since there are many different types of stickies that have to be considered in a mill stickies audit. Total stickies, macro-stickies, micro-stickies, and secondary stickies are quantified by different methods.

Macro-stickies allow us to monitor the removal efficiency of the process while micro-stickies and secondary stickies predict the deposition potential of the pulp under different conditions. Micro-stickies predict calcium-soap deposits and secondary stickies predict the destabilization of the dissolved and colloidal material. Cationic demand only predicts a certain type of stickies. Therefore, an integrated approach for the full characterization of stickies throughout the papermaking process is necessary.

Application: The full characterization of stickies along the process allows papermakers to identify contaminants and to improve stickies control in the mills.

Graphic papers are bulk grades with a quality spectrum ranging from newsprint to super calendered (SC) and lightweight coated (LWC). The recovered paper content varies according to end product requirements, and only white paper recycled grades are used. Since these papers are produced on high-speed paper machines, runnability is a key factor both in the paper machine itself and in converting operations. On the other hand, the low added value of paper means operating economics also have a high priority. To ensure trouble-free economic converting and high quality printing products, all contaminants have to be removed from the stock. One of the main problems during stock preparation of recycled pulp is stickies removal.

Stickies are considered, in general, organic contaminants causing major problems in mills using recovered paper as a raw material [1]. Sources of stickies are natural furnish (wood pitch), process chemicals used in the plant (coating formulations, sizing agents, wet-end additives, etc.) and in-

coming contaminant material with the furnish (hot melts, contact adhesives, coating binders, starches, ink binders, etc.) [2]. Stickies deposits are usually formed by a mixture of acrylates, ethylene vinyl acetate, polyvinyl acetate, polyacrylates, styrene rubber, etc. [3–5]. These contaminants tend to be hydrophobic, tacky, low-surface energy, soft, and deformable materials.

The presence of stickies in recycled fibers can cause runnability problems, increasing machine downtime caused by breaks and associated clean ups. They also:

- decrease wire and felt lifetimes;
- reduce product quality due to picking, which leads to hole and spot formation and poor appearance;
- reduce efficiency of converting and printing; and
- limit levels of fiber substitution.

In summary, stickies contribute negatively to mill productivity since they increase mill downtime, lower product quality and increase chemical and maintenance costs [6,7].

Since there is a lack of an accepted

classification and definition of stickies, many different classifications have been described in previous studies. First, stickies were classified as macro-stickies and micro-stickies according to their size. Then micro-stickies, stickies that pass through 150 μm , 100 μm , or even 80 μm slotted screens, were further classified. According to Doshi et al, the following approximate classification can be considered [8]:

- Suspended stickies: 20 μm to 100 μm
- Dispersed stickies: 1 μm to 25 μm
- Colloidal stickies: 5 μm to 0.01 μm
- Dissolved stickies: < 0.01 μm .

But this classification by size is not enough. It is also necessary to consider the source of stickies generation. Stickies that carry over from the repulping process are termed native or primary stickies. Stickies that precipitate out of the pulp due to changes in pH, temperature, or the chemical environment [9] are termed potential or secondary stickies. Secondary stickies are much more complex because they result from physical or chemical changes which occur all along the paper manufacturing process.

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Because stickies are so diverse, there is no universal set of solutions to reduce their effects. The industry is focused on practical aspects of stickies, e.g., prevention, removal, and dissimulation. There are four common approaches in the mill to stickies control:

- 1) prevent the release of stickies from the raw material (e.g., controlling pulping and dispersing time, pH, and consistency),
- 2) remove stickies during stock preparation (e.g., screening, cleaning, flotation),
- 3) minimize the negative effects on paper appearance (e.g., dispersion), and
- 4) prevent deposit formation in the paper machine (e.g., detackifiers, talc, fixatives, barrier chemicals).

This set of solutions allows paper mills to live with stickies, but the only definitive solution is to remove them from the process.

Parameters affecting stickies removal efficiency can be divided into three main classes: furnish parameters, design parameters, and operating parameters. Furnish parameters can be considered to comprise of pH, temperature, fluid viscosity, fiber properties, and contaminant characteristics. The design of stock preparation systems for graphic paper grades nowadays is very similar, and the removal efficiency depends mainly on process optimization based on mill operator experience. Removal can be facilitated under certain conditions: fine slots with a gentle surface, low rotor tip speeds, low stock consistencies, low hole or slot velocities, uniform flow through the screen baskets, low shear and pressure forces, low turbulence, etc. [10]. A compromise between capacity and efficiency must be established due to the combined effect of these parameters. An overview of contaminant removal efficiency for different processes has been published by Moss [11].

Often the investment in stock preparation cannot be adequately justified through machine productivity. The paper quality improvements can be recognized,

but the correlation between the amount of stickies material in the furnish and the cleanliness of the paper is not always obvious. Great effort has been taken to evaluate the effects of process variables on stickies concentration and to study stickies removal, control, and adsorption onto the fiber material. The effects of white water recirculation and deposition of stickies are more difficult to analyze because re-agglomeration of dissolved and colloidal material can occur.

Properties of stickies can be measured in different ways, often varying with the laboratory sample preparation technique and analytical method used. Macro-stickies analysis techniques have been standardized; however this is not so for micro-stickies measurements [12]. The challenge is to quantify stickies evolution along a process and improve stickies control without a suitable method for monitoring stickies. This concern has increased in recent years due to the lower quality of the available recovered paper, which increases the amount of contaminants in the recovered paper. Another issue involves environmental concerns, which are moving the industry toward closed water circuits, thus further stimulating the accumulation of contaminants. Finally, there are the needs of the mill to be more competitive by increasing productivity and reducing costs.

This paper presents an integrated approach for full stickies characterization along a deinking line of a newsprint paper mill. Total stickies, macro-stickies, micro-stickies, and secondary stickies are quantified and their implications for the process are discussed.

MILL DESCRIPTION

PM61 of Holmen Paper Madrid produces 500 tons/day of newsprint from a mixture of recovered old newsprint (ONP), old magazines (OMG), and office paper (OP) with an average composition of 6:3:1. About 1%–3% of the furnish is considered to be undesirable material.

Figure 1 shows a simplified schematic arrangement of the deink-

ing process. The recycled paper is pulped in a high consistency batch pulper. The pulp is extracted through a perforated plate, as a first separation of plastics and coarse contaminants. Staples and other heavy contaminants are removed by high-density cleaning, a four-stage hole screening (1.2 mm), and a set of 0.25 mm slot screens. The pulp then goes through the pre-flotation unit (six primary and two secondary cells), the forward cleaners, and the fine slot screens (0.15 mm) before thickening in a disk filter and a screw press. Remaining contaminants are broken down into sub-visible particles in the disperger. If necessary the pulp can be bleached before post-flotation in a unit of 4+1 cells. Finally the pulp is thickened by means of a disk filter and screw press and stored, ready to be sent to the paper machine.

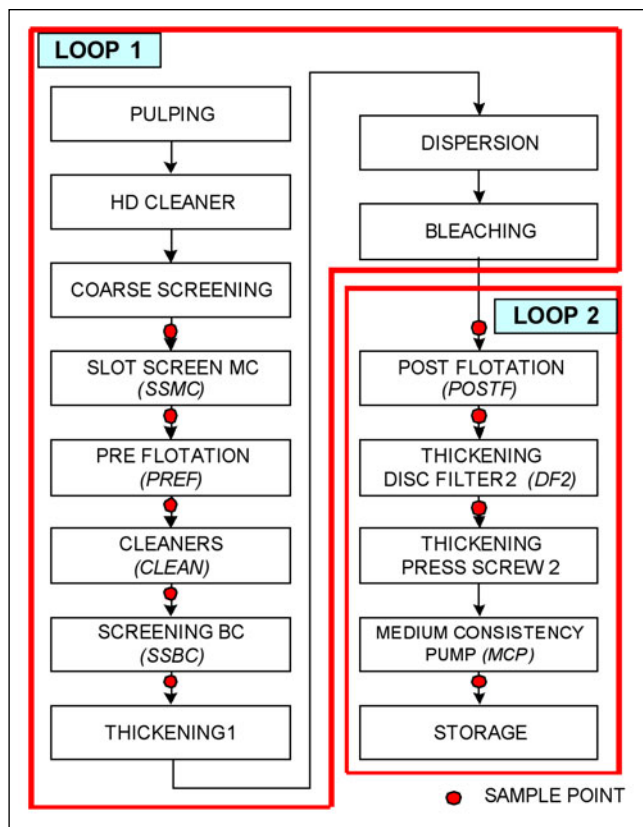
As shown in Fig. 1, nine sample points have been selected to carry out the mill stickies audit. The first sample point was the outlet of the hole screen because of the variability of the stickies level before this stage, depending on the raw material quality, but independent of the process.

Water flows are counter current to the pulp flow. Fresh water enters the system at the paper machine. Water flows back from the paper machine through loop 2 and, finally, through loop 1.

METHODS

Total stickies

Total stickies content was measured by solvent extraction with dichloromethane. The pulp samples were dried at 105°C without any pre-treatment. Extraction of 10 g of pulp was performed in a Soxhlet according to TAPPI T 204 cm-97 "Solvent extractives of wood and pulp." After the extraction the solvent was recovered and evaporated using a rotary evaporator, in a pre-weighed vessel. The residue obtained after solvent evaporation was entirely dried in an oven at 105°C and, finally, it was weighed. In accordance with the standard, all experiments were carried out in duplicate.



1. Flow diagram and sampling points along the DIP 2 deinking line.

Macro-stickies or primary stickies

Macro-stickies were considered as solid and tacky contaminants larger than 150 μm (this was the available Somerville slot screen at the mill). Contaminants were screened from the pulp following the TAPPI T 275 sp-98. The pulp, at a consistency of less than a 1% (w/w), was introduced into the Somerville vibrating screen. For each experiment the necessary amount of pulp suspension, equivalent to 75 g of dry pulp, was screened. The total screening time was 20 min. All experiments were carried out in triplicate.

Contaminants remaining on the surface of the screen were washed with pressurized water and collected. The contaminant suspension was then filtered in a Rapid-Köthen through a black filter. After dewatering a coated paper (supplied by Voith) was pressed on the black filter. Both papers were dried with vacuum for 10 min. Then the coated paper was removed and the stickies appeared as white specks on the black filter. After washing, stickies were dried again with a siliconated paper on them. After that, the remaining non-sticky material on the black filter was painted with a black pen and, finally, stickies were quantified by image analysis in a dot-counter, according to INGEDE Method 4 99-12 "Analysis of macro stickies in deinked pulp (DIP)" for analysis of macro-stickies in deinked pulp.

Micro-stickies and secondary stickies

Micro-stickies, in theory, range in size from 5 to 150 μm . However they are very difficult to isolate selectively from the stickies smaller than 5 μm . Therefore we have considered in this group all the stickies smaller than 150 μm . The UCM deposition rotor, without destabilization of the dissolved and colloidal material, was used to determine the micro-stickies content (13).

Potential stickies or secondary stickies are formed when detrimental substances, smaller than 150 μm , agglomerate and become tacky after being destabilized by their interaction with polymers, by a sudden change of pH or conductivity, by shear forces, etc. Quantification was carried out using the UCM deposition rotor with the addition of polyethyleneimine (PEI), as a destabilization agent. The amount of added PEI was the theoretical dosage needed to reach the zero current potential of the sample, determined with a Müttek PCD 03 particle charge detector used in conjunction with an automatic titrator.

The first 15 L, which passed through the Somerville experiment, were collected to determine micro-stickies and secondary stickies. The consistency was around 0.2% in all cases. These waters were filtered through a dynamic drainage jar (DDJ) with a 250 μm wire to remove the fiber fraction without removing the stickies. In both cases, 1.8 L were used for the deposition tests. Deposition experiments were carried out at 50°C for 1 h. The sticky material collected in the internal and external stainless steel film collectors were quantified by image analysis using the stickies measurement program developed by PIRA and UCM. The results obtained in these methods are the percentage of covered area by deposits collected on stainless steel films [14]. All experiments were carried out in triplicate.

Since not all micro-stickies and secondary stickies pass through the Somerville slots with the first 15 L, and since some dissolved and colloidal material may destabilize and stick together during collection and dilution of the samples, some preliminary studies were carried out to quantify this effect. It was proved that 70% of micro-stickies and secondary stickies were collected in this way with an average error below 10%.

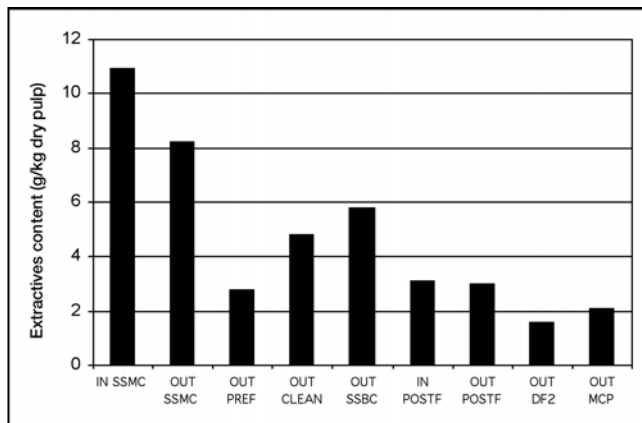
RESULTS

Solvent extraction

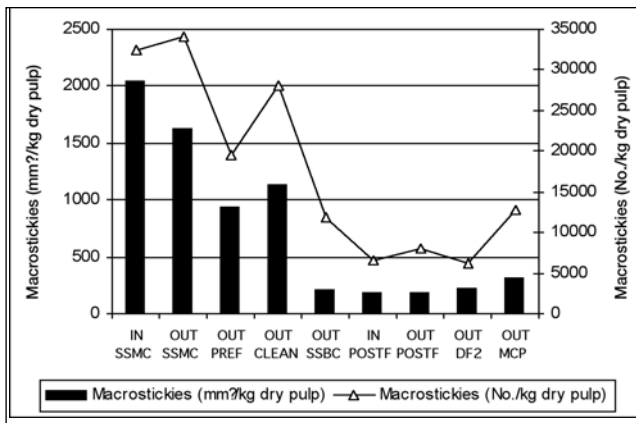
Extraction with dichloromethane of the full pulp was carried out to determine all types of extractable stickies present in the sample, independent of their size. **Figure 2** shows the average results obtained from two replicates. The average error in measurements was 10%.

Initially the extractable content is 11 g/kg dry pulp. This value is reduced along the deinking line to 2 g/kg dry pulp, which means a total removal efficiency of more than 82%. Fifty percent of this material is removed in the first loop, mainly in the flotation unit (31% of the total), while only 32% is removed in the second loop, mainly during flotation and thickening. The high efficiency removal of dichloromethane extractives achieved along the process is

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2. Extractives content evolution along the DIP2 line.



3. Macro-stickies evolution along the DIP2 line.

in agreement with the reference literature [4, 15].

Macro-stickies

The results of macro-stickies measurement along the deinking line, DIP 2, as deposited area and as number of macro-stickies are shown in **Fig. 3**.

Results show that 90% of total macro-stickies, expressed as area, are removed in the deinking line at the mill, which corresponds to 60% of the total number of stickies (always referred to the first point sampled). If hole pre-screening is considered, the total removal efficiency would be about 94%–95%. Stickies are mainly removed in loop 1. At the end of loop 1, macro-stickies level was about 200 mm²/kg, and this level increases at the end of loop 2 when the pulp is diluted with water coming from the paper machine. As was expected, fine screens were the most efficient units (82% of reduction from the inlet to the outlet), but they only remove 36% of total macro-stickies in this case, because the rest had already been removed by this stage.

The comparison of these data with reference data shows that this mill has a high removal efficiency. It has been reported that in Europe over 80% and even up to 99% of stickies can be removed [16]. This performance is due in great part to significant advances in fine screening, centrifugal cleaning, and flotation technologies during the last 20 years. The final average stickies area in

modern deinking mills varies from 200 to 400 mm²/kg. In a study carried out in 16 North American deinking ONP/OMG mills, the average stickies removal was 64.5% with upper quartile at 82%. Average DIP stickies concentration was 1310 mm²/kg, with an upper quartile at 1700 mm²/kg in coarse screen accepts. Reference data shows that deinking systems with 0.15 mm or less slot size in the primary stage had an average stickies removal efficiency of 75% while all the other systems had stickies removal efficiencies of around 55%–60% [17].

Micro-stickies and secondary stickies

The measurements of small and secondary stickies are summarized in **Fig. 4**.

The quantity of micro-stickies increased in three points along the deinking line: accepts of medium consistency slot screens, accepts of low consistency fine screening, and accepts of disk filter 2. The case of the slot screen of medium consistency outlet is the most important increase as micro-stickies are four times higher than in the inlet. Micro-stickies may be produced by a shock of calcium. The soap added to the pulp before the screening process may react with the calcium present in the dilution water, forming sticky calcium-soap micro-stickies. It is important to notice that these micro-stickies (calcium-soap) are removed by flotation.

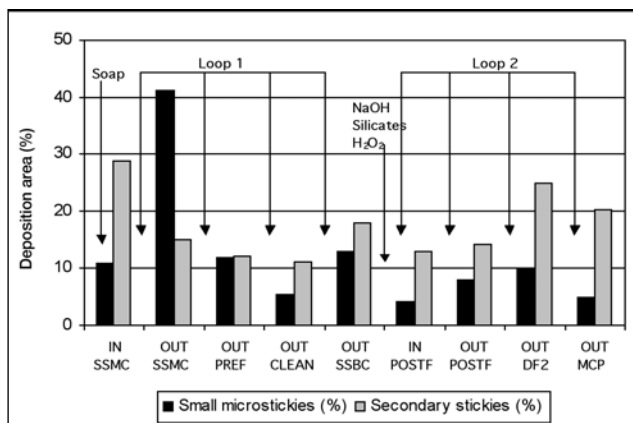
The carryover of soap was further studied under different process condi-

tions to determine if the calcium-soap deposits that are not removed during pre-flotation are removed at a later stage. Calcium-soap micro-stickies were removed before post-flotation (**Fig. 5**).

In the outlet of both the fine slot screen of low consistency and disk filter 2, the increase of micro-stickies is smaller. This could be due to the effect of dilution waters. Micro-stickies accumulate in the process water and, in consequence, dilution waters may be an important source of contaminants [18]. On the other hand, residual chemicals present in process water may also produce deposits under certain conditions.

If we consider the measurements of secondary stickies, it is observed that the trend followed by micro-stickies and secondary stickies is different. As was expected, the deposits obtained destabilizing the potential stickies are higher, because in this case both micro-stickies and secondary stickies are measured. Only the outlet of the slot screen at medium consistency presents a different behavior. When PEI is added the increase of micro-stickies after the soap addition, when the pulp is diluted, is not observed. It may be that the polymer covers the tacky material forming non-tacky aggregates.

Pre-flotation removes 70% of micro-stickies, including calcium-soap agglomerates, and 20% of potential stickies. Cleaners remove 50% of micro-stickies but, logically, they do not remove dis-



4. Micro-stickies and secondary stickies deposition along the DIP2 line.

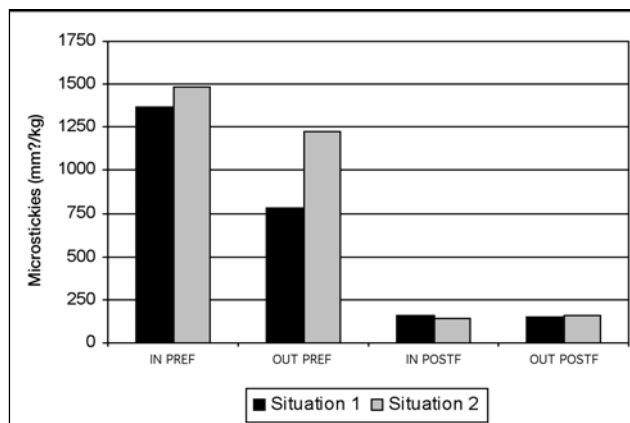
solved and colloidal material. Fine screens increase micro-stickies and secondary stickies. Post-flotation does not remove micro-stickies in this case. Finally, the level of secondary stickies increases considerably when the pulp is diluted with water from the paper machine.

Screening increases the level of stickies because the shear forces break down part of the bigger stickies that are being removed, increasing the amount of smaller stickies. Filtration steps also increase the level of micro-stickies. Since micro-stickies mainly stay in the fiber fraction, they can be released in these steps. This effect is the result of fiber thickening, and it is enhanced by the dilution of rejects at each stage with back-water. The overall effect is a wash out of micro-stickies from the rejects. On the other hand, a temperature difference between the pulp and the dilution water may also favor the destabilization of dissolved and colloidal material.

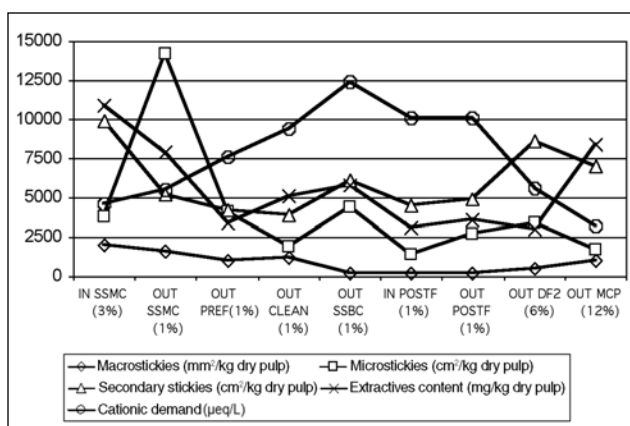
Comparison of methods

Figure 6 shows the comparison of the results obtained from the different methods used to quantify the different types of stickies indicating the sample consistency. The removal efficiency of macro-stickies and dichloromethane extractives does not present a good correlation between them, probably due to the different sizes of stickies measured in each case. Johansson et al. also observed this with the same size definition of macro-stickies [4]. There are two main differences between the two data: the efficiency in the fine slot screens and in the pre-flotation. In the reduction of macro-stickies, the most individually efficient unit is the fine slot screen, while for dichloromethane-extractives content it is the pre-flotation. The importance of flotation to remove dichloromethane-extractives has already been considered by Delagoutte et al. [15]. Finally, the fine slot screens do not reduce the dichloromethane extractives content.

If we compare the efficiency of the different stages in reducing extractives content and micro-stickies, although there is not a good correlation between them, the same major tendencies are achieved. The pre-flotation is the most efficient



5. Monitoring micro-stickies to monitor the carry over of soap.



6. Comparison of different methods to quantify the different types of stickies.

unit in the reduction of both small micro-stickies and extractives. Also, the fine slot screens are not effective for removing micro-stickies or extractives. According to Delagoutte et al., micro-stickies constitute the principal stickies species involved in the drying section deposit phenomenon, and the separation techniques, screening and cleaning are not able to remove micro-stickies. The only solution is to turn to physical or chemical treatments, such as flotation or dissolved air flotation used as water clarification systems [15].

Comparing the efficiency of the different stages in reducing secondary stickies and solvent extractions, the trend is very similar with only a difference in the disk filter 2. This may be due to the type of contaminants coming from the paper machine. According to Johansson et al. and Delagoutte et al. the contribution of dissolved and colloidal fractions to the extractives content is relatively low. Approximately 10% of the whole deposit potential comes from the colloidal stickies, but in Delagoutte's work the size limit is 1 µm [4, 15]. In the experiments we have conducted, extractives were carried out from the full pulp. Secondary stickies were meas-

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ured as micro-stickies and potential stickies after filtration of the pulp through a 150 µm slot screen.

Finally, the cationic demand of the supernatant of the pulp samples was also measured as a reference. It is observed that cationic demand is not enough to predict stickies deposits in the process except when at the end of loop 2 where it follows the same trend as secondary stickies.

CONCLUSIONS

An integrated approach for full stickies characterization is needed to carry out a sticky audit in a mill. Traditional measurements like macro-stickies and cationic demands do not assess the po-

tential problem of stickies along the process. Macro-stickies measurements are necessary to monitor the stickies removal efficiency at the different stages; however they do not predict deposit problems. Cationic demand only predicts a certain type of potential stickies.

The proposed integrated approach consists of measuring macro-stickies, micro-stickies, and secondary stickies. Secondary stickies could be, in principle, predicted by deposition studies after destabilizing the dissolved and colloidal material or by extraction measurements and cationic demand data.

Micro-stickies cannot be predicted by extraction measurements in this case. Micro-stickies deposition poten-

tial, measured with the UCM deposition rotor, is important to study the carry over of soap along the process.

PRECAUTIONARY SAFETY STATEMENT

Dichloromethane used in solvent extractions is harmful if swallowed or inhaled and also by skin contact. It is a possible carcinogen and mutagen in humans. Safety gloves and glasses in combination with mechanical ventilation are required.

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INSIGHTS FROM THE AUTHORS

Stickies are still one of the remaining issues in the use of recovered paper for paper manufacturing and have an important effect on mill competitiveness. Our study demonstrates the need of a complementary approach for solving problems associated to stickies in papermaking. Every research institute and some mills have developed stickies test methods but each method, considered separately, cannot predict all the complex phenomenology associated to stickies.

The most difficult task was coordinating the work of all people involved in the research. Working together with a mill implies also a high degree of coordination and cooperation. The main discovery of this research was the need of a complementary approach for a complete characterization and understanding of the evolution of stickies along a deinking line. The use of only one test method, separately, does not cover the whole problematic of stickies.

The full characterization of stickies along the process allows mills to identify contaminants and to

improve the stickies control in the mills by use of a complementary approach in stickies analysis methods. Influence of each process step on stickies content can help to increase the knowledge of how the systems run and average values of stickies can be helpful as benchmarking data to compare efficiency of the process steps in different mills. Furthermore, mills may learn good practices to minimize formation of micro-stickies and secondary stickies.

The next step is to complete other surveys in which conditions in the paper mill are different, e.g. different final product. Also, a detailed study of some process stages can be of great interest for studying process conditions affecting stickies and their optimization for a better stickies removal.

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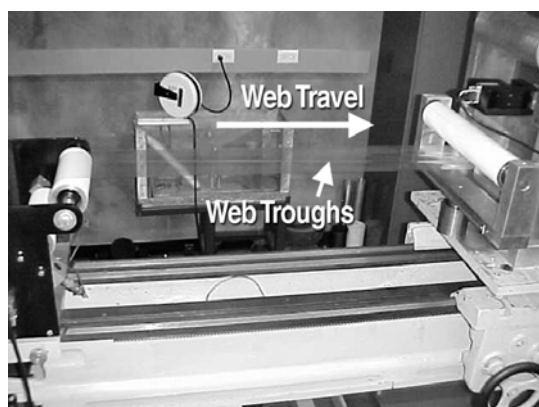


CORRECTION

An error appeared in the paper "Calculations relating to web buckling resulting from roller misalignment," by James K. Good and Joseph A. Beisel, which ran in the December 2006 *TAPPI JOURNAL* (Vol. 5, No. 11). Figure 5 was missing from the published paper and not referenced in the relevant paragraph on p. 12. The figure and corrected paragraph are as follows:

VERIFICATION OF TROUGH MODEL

Expression (14) provides a model for predicting the occurrence of troughs. A set of experiments were conducted to test the validity of the displacement form (1), the shear and tension stiffening assumptions, and to verify that the web orthotropy was included satisfactorily. In these experiments a downstream roller was misaligned until a trough was produced. **Figure 5** shows the experimental setup. The web is traveling from left to right in this picture and the horizontal span is the test span. Note the troughs in the web. Also, note the absence of troughs at the web edges ($y = 0, b$). Before entering the test span, a web guide maintains



5. Experimental setup.

constant web edge position and web tension is measured. The downstream roller is mounted upon a yoke, as shown. The rotation (θ) of the yoke is precisely adjusted using an end mi-

crometer. The downstream rollers sit upon an adjustable table of a former lathe bed so that the web span length (a) is easily manipulated. Tests were run for polyester, newsprint, and spunbond polypropylene nonwoven webs. Table I shows the properties of these webs. In these tests web tension and span length were set.

The misalignment (θ) was slowly increased until troughs were produced. The span length would then be set to a new value and the experiment was repeated.