



Effect of pulper consistency on stickies size distribution

MAHENDRA DOSHI, SALMAN AZIZ, ROBERT DE JONG, AND CARL HOUTMAN

ABSTRACT: Pulper consistency affects production capacity, defibering efficiency, and particle size distribution of contaminants, and in particular, stickies and inks. The effect of pulper consistency on stickies size distribution, though important, has not been studied in detail.

In this project, pressure-sensitive adhesive (PSA)-containing furnish was pulped in a laboratory at 5%, 10% and 15% consistency. Results show that 15% consistency pulp produced many more small-sized stickies compared to pulps produced at 5% and 10% consistency. This is contrary to the generally accepted hypothesis and needs further investigation.

Calcium carbonate, usually present in varying proportions in many recovered paper grades, is known to have some pacifying effect on stickies. A new pacifying agent prepared from silicone release liner, called desiliconized pulp (DSP), behaves like bleached virgin hardwood kraft pulp. DSP seems to have a pacifying effect similar to that of calcium carbonate. Thus, DSP may potentially replace a small amount of bleached virgin hardwood kraft pulp, with a bonus stickies-pacifying effect.

Application: Stickies size distribution is important for paper recycling mills. The goal is to keep stickies particles large enough for easy removal by screens, cleaners, and flotation. Small-sized stickies or microstickies may be pacified by the new additive—desiliconized pulp (DSP).

Adhesives and glues, called stickies, entering the paper recycling process through recovered papers pose significant problems, as they affect paper machine productivity and/or product quality. Effective removal of stickies is, therefore, of paramount importance to the overall economic health of a recycling mill.

One of the first steps in recycle paper processing is pulping. One of the objectives of pulping is to defiber recovered papers without disintegrating stickies [1]. Stickies removal becomes relatively easy by existing well-developed screens, cleaners, and flotation cells, as long as stickies are kept in a relatively large size and not fragmented into particles smaller than 0.5-mm diameter during pulping [2,3].

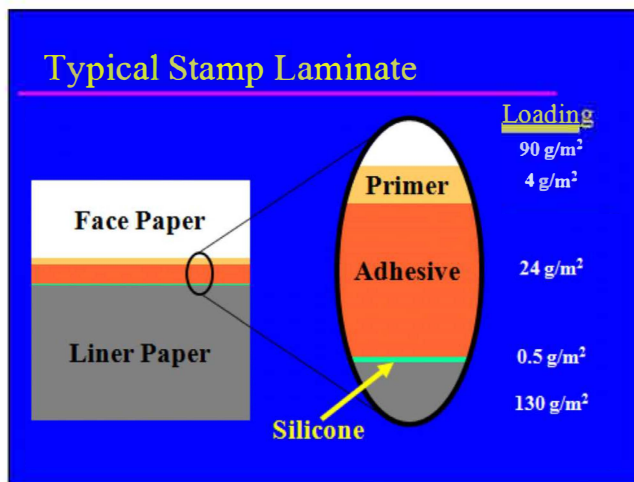
Delagoutte et al. and Fabry et al. [2,3] evaluated stickies size distribution and removal in eleven deinking mills. They concluded that stickies with equivalent diameter greater than 1.52 mm or with area greater than 1.81 mm² are removed with efficiency close to 100%, whereas stickies smaller than equivalent diameter 0.575 mm (0.26 mm² area) are removed with efficiency close to 0%. This is surprising due to the fact that many modern deinking mills use fine screens with slot width 0.10–0.15 mm. One reason for this apparent anomaly is that some of the stickies are not globular but are a flat or fibril shape that may squeeze through the slot opening under the pressure differential across the screen. Another possible explanation is the way stickies size distribution is measured. Delagoutte et al. and Fabry et al. [2,3] point out that during measurement, stickies are “flattened out,” altering the original

3-D structure. Nevertheless, it is clear from this study that the larger the stickies size, the higher the removal efficiency.

The effect of pulping temperature is well summarized in an editorial [4]. In general, there are many examples showing fragmentation of stickies at higher temperature that results in lower screening efficiency [2,3,5,6,7,8,9]. Additionally, stickies become more flexible at higher temperature, allowing somewhat easier passage through the screen opening. Pulping pH also affects stickies size distribution. For example, under alkaline conditions, stickies distribution shifts toward smaller size [3,8,10]. In short, higher temperature, increased pulping time, and alkaline pH each lead to difficult-to-remove, small-sized stickies.

To the best of our knowledge, systematic studies on the effect of pulper consistency on stickies size distribution have not been published. A generally accepted hypothesis is that higher consistency in the range of 12% to 16% will not fragment stickies as much as pulp produced at lower pulping consistency of 5% to 8% [1]. Schabel and Respondek [11] have shown that higher shear forces in medium consistency screening (3% to 6%) may lead to stickies disintegration compared to lower consistency screening (less than 2.5%) where shear forces are generally lower.

After pulping, stickies, inks, and other contaminants are removed by the use of screens, hydrocyclones, flotation, and other operations. However, in most mill operations, relatively small-sized stickies are not effectively removed. These stickies accumulate and agglomerate in the paper machine white



1. General loading of various layers in a postage stamp [14].

water system and eventually deposit on wires, felts, and dryer surfaces. Pacifying additives like talc, enzymes, cationic polymers, or surfactants are used to stabilize or pacify small-sized stickies and reduce their tendency to agglomerate.

Venditti et al. [12] and Hubbe et al. [13] observed that the presence of silicone release liner alters the stickies characteristics and reduces the tendency for stickies to agglomerate. The structure of release liner used in postage stamp laminate is shown in **Fig. 1** [14]. The liner consists of a thin layer of silicone for easy removal of the stamp. A major portion of the liner material consists of well-refined virgin kraft fibers with basis weight of 130 g/m². Currently, most of the liner material with silicone layer is not reused.

Pulp made solely from release liner, called desiliconized pulp (DSP), has a potential as a pacifying agent [15]. DSP has properties very similar to that of bleached virgin hardwood kraft pulp, as shown in **Table I** [15]. Pacifying properties of

DSP and calcium carbonate (CaCO₃) are further explored in this project.

OBJECTIVE

The primary objective of this project is to evaluate the effect of pulper consistency on stickies size distribution. A secondary objective is to compare the efficacy of desiliconized pulp (DSP) to that of CaCO₃ in pacifying stickies.

MATERIALS AND METHODS

Three sets of experiments were planned, as shown in **Fig. 2**. Set I was designed to evaluate the effect of consistency on stickies size distribution. The impact of pacifying agents DSP and CaCO₃ on stickies size distribution during pulping was planned in Set II. The effectiveness of DSP and CaCO₃ to pacify stickies was compared in Set III.

For the purpose of this study, a standard PSA sheet specifically made for U.S. Postal Service (USPS) work from the U.S. Department of Agriculture Forest Products Laboratory (FPL) was used. This sheet contained 10% PSA. The shredded pre-sheets were pulped at high consistency (HC), medium consistency (MC), and low consistency (LC) at 45°C for 8 min in a Formax 450H Laboratory Pulper by Adirondack Machine Corp. (Hudson Fall, NY, USA). The batch pulper and the rotor are shown in **Fig. 3**. After each run, consistency was measured and handsheets were prepared for measuring stickies by blue dye method [16]. Results are shown in **Table II**.

The measured consistencies were: HC 15.6%; MC 11.5%; and LC 6.1% (Set I).

Stickies size distribution and handsheets are shown in **Fig. 4** and **Fig. 5**, respectively.

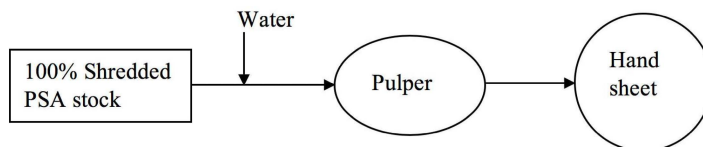
Set II experiments were conducted to evaluate the effect of consistency and the impact of two pacifying agents, DSP

Parameter	DSP	BHKP	BSKP	DIP
CSF, MI	290	500–550	500–550	425
Brightness, %	87	88–90	88–90	85
Ash content, %	0.2	< 0.5	< 0.5	1.0–5.0
Tensile index, Nm/g	42	50	80	45
Tear index, mN m²/g	11.0	7.0	12.0	8.0
Density, kg/m³	667	700	750	750
Dirt count, mm²/kg	< 20	< 20	< 20	< 100
Ink residuals	No	No	No	Yes
Fiber length, mm	1.0	1.1–1.4	1.7–2.0	0.9

DSP and DIP not refined. BHKP and BSKP refined to CSF 500–550 ml.
 DSP = desiliconized pulp; BHKP = bleached hardwood kraft pulp (from birch); BSKP = bleached softwood kraft pulp (from pine/spruce);
 DIP = deinked pulp (from sorted office paper [SOP]).

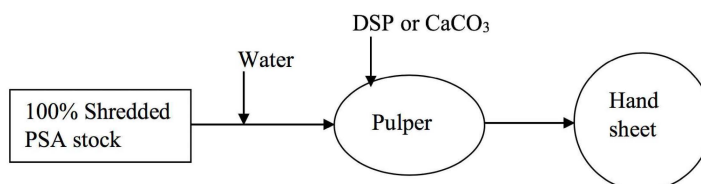
1. Properties of DSP compared to other market pulps [14].

Set I. Effect of pulper consistency on stickies size distribution

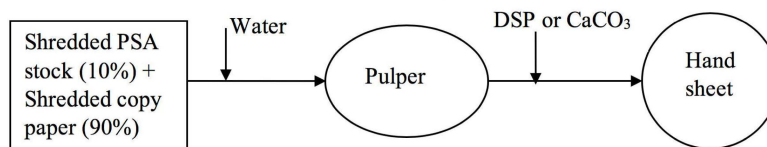


HC 15.6%; MC 11.5%; LC 6.1%.

Set II. Effect of pacifying agents, DSP and CaCO_3 , on stickies size distribution



Set III. Effectiveness of DSP or CaCO_3 in pacifying stickies



2. Experimental plan (PSA = pressure sensitive adhesive; HC = high consistency; MC = medium consistency; LC = low consistency; DSP = desiliconized pulp; CaCO_3 = calcium carbonate).



3. Formax 450H laboratory pulper and rotor.

and CaCO_3 , on stickies size distribution. The following runs were carried out:

- Run P1: 450 g PSA stock + 50 g DSP + 2.7 L water (45°C, pH 7). Pulp for 8 min.
- Run P2: 135 g PSA stock + 15 g DSP + 2.7 L water (45°C, pH 7). Pulp for 8 min.
- Run P3: 450 g PSA stock + 50 g CaCO_3 + 2.7 L water (45°C, pH 7). Pulp for 8 min.

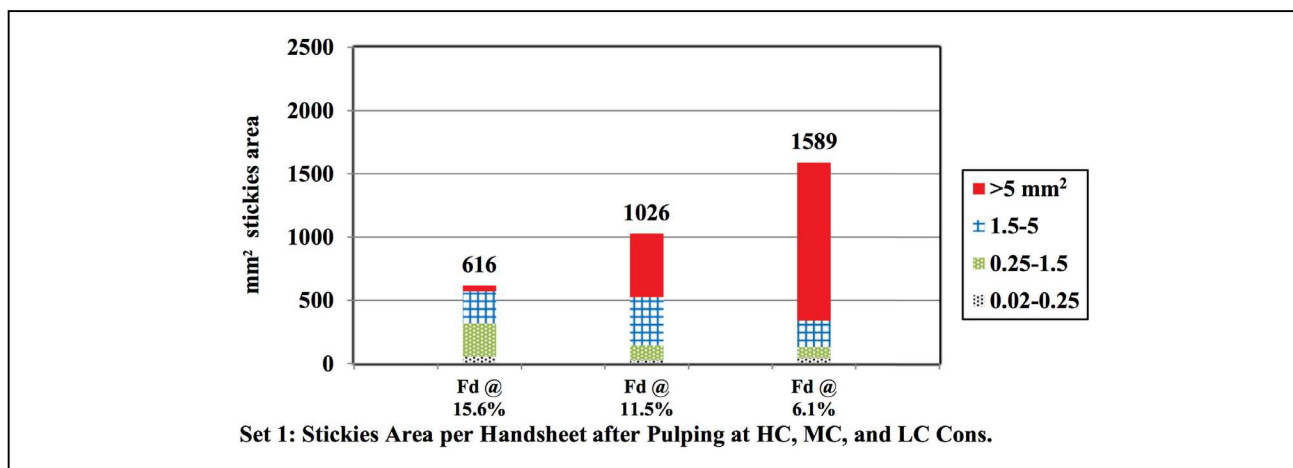
- Run P4: 135 g PSA stock + 15 g CaCO_3 + 2.7 L water (45°C, pH 7). Pulp for 8 min.

Runs P1 and P3 produced pulp with consistency of 12% to 14%, while runs P2 and P4 produced pulp with consistency of about 5%. Two handsheets were made from each pulp sample after mixing in a Waring blender for 30 s on low setting. Results of the blue dye measurement method are reported in **Table III** and **Fig. 6**.

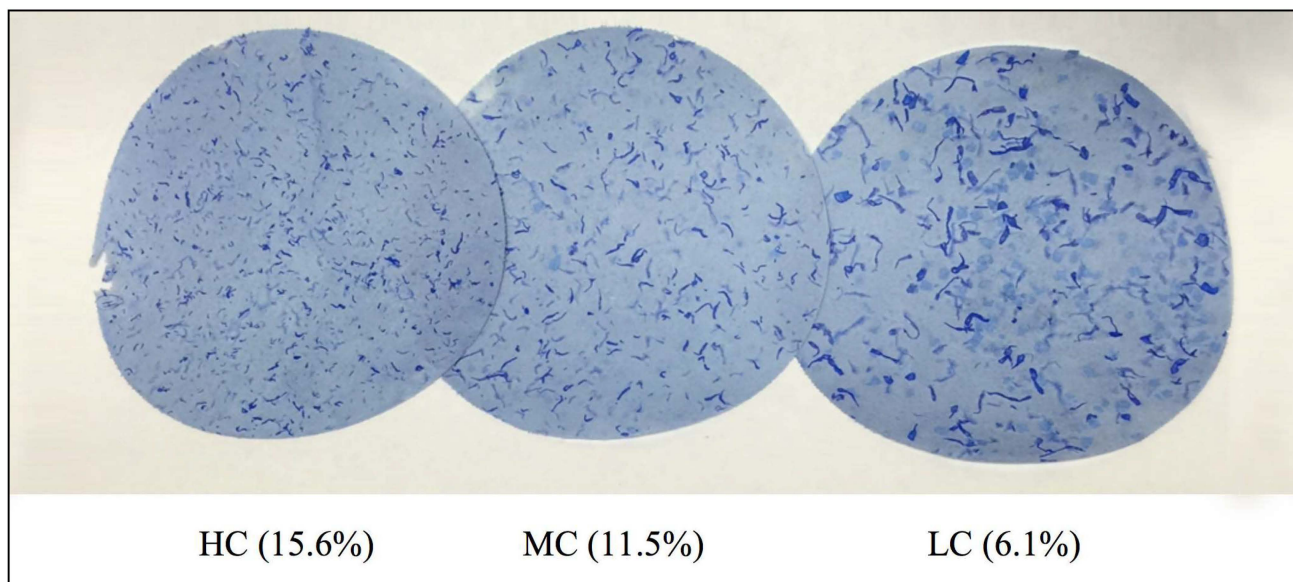


Run	Consistency, %	ppm	Stickies per Handsheet		Mean Area, mm ²
			mm ²	count	
High consistency	15.6	37019	1589	980	0.63
Medium consistency	11.5	61697	1026	664	1.59
Low consistency	6.1	95507	616	772	2.06

II. Effect of pulper consistency on stickies size distribution.



4. Stickies distribution per class size after pulping at (left-to-right) high, medium, and low consistencies.



5. Handsheets after pulping at three consistencies. Left: high consistency, 15.6%; Middle: medium consistency, 11.5%; and Right: low consistency, 6.1%.

So far, all experiments were conducted using 100% PSA stock. A study was carried out by mixing standard 10% PSA sheet with 90% of plain copy paper sheets. The sheets were shredded before pulping. Pulping was conducted as before at high consistency.

Handsheets with no additives, with DSP, and with CaCO₃ were prepared to evaluate the extent of stickies pacification (Set III):

- Pulp P5: Blended 10 g of pulp in a Waring blender for 30 s on low setting.
- Pulp P5 + DSP: Blended 10 g of pulp + 2 g DSP in a Waring blender for 30 s on low setting.
- Pulp P5 + Car: Blended 10 g of pulp + 3 g CaCO₃ in a Waring blender for 30 s on low setting.

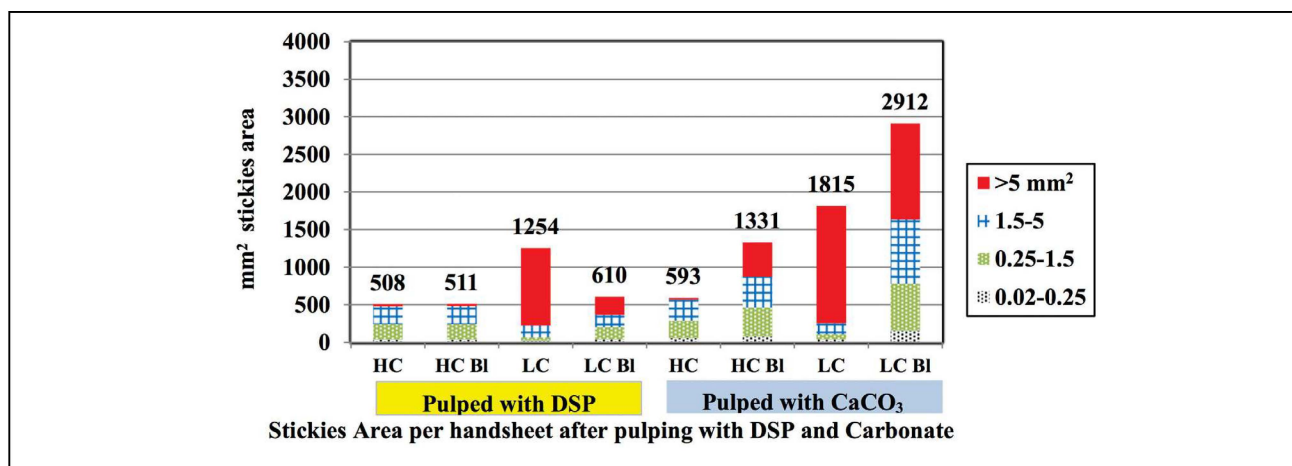
After blending, each pulp was placed in a beaker, diluted



Run No.	Additive	Consistency, %	ppm	Stickies per Handsheet		Mean Area, mm ²
				mm ²	count	
P1.1	DSP	12.1	30558	508	761	0.668
P1.2	DSP	12.1	30709	511	775	0.659
P2.1	DSP	5.2	75383	1254	463	2.71
P2.2	DSP	5.2	36637	610	684	0.891
P3.1	CaCO ₃	14.3	35639	593	1,011	0.586
P3.2	CaCO ₃	14.3	80024	1331	1,550	0.859
P4.1	CaCO ₃	5.1	109118	1815	715	2.54
P4.2	CaCO ₃	5.1	193784	2912	2,899	1.11

DSP = desiliconized pulp; CaCO₃ = calcium carbonate.

III. Effect of pulper consistency and pacifying additives on stickies.



6. Effect of DSP and CaCO₃ addition on stickies size distribution without blending and with blending (BI) in a mixer after pulping at high and low consistencies.

with water, and mixed for 15 min using a magnetic stirrer.

All handsheets (1.2 g each) were made using the TAPPI sheet mold. Handsheets were dried and then dyed with a blue dye (Morplas Blue 1003, Sunbelt; Rock Hill, SC, USA). Dyed handsheets were scanned and analyzed for stickies size distribution using Verity IA software (Verity IA; Brookfield, WI, USA). This protocol was developed for the USPS work by FPL [16].

RESULTS AND DISCUSSION

The effect of consistency on stickies size distribution using 100% PSA stock is reported in Table II and Fig. 4. Blue dyed handsheets are displayed in Fig. 5. Results show that low consistency (6.1 %) pulp has average stickies area of 2.06 mm² (1.62 mm equivalent diameter) compared to stickies area of 0.628 mm² (0.89 mm equivalent diameter) for the high consistency (15.6%) pulp. Thus, based on the study of Delagoutte et al. and Fabry et al. [2,3], stickies from low consistency pulp should have higher screening efficiency (close to 100%) com-

pared to those from high consistency pulp. This is contrary to the generally accepted hypothesis and needs to be further investigated in much detail with different types of adhesives, pulping time, pulper rotors, temperature, etc.

Results from Set II experiments are shown in Table III and Fig. 6. The purpose of these experiments was to study the change in stickies size distribution due to the addition of pacifying agent in the pulper.

Duplicate handsheet measurements, labeled as P1.1, P1.2, etc., are presented in Table III. Most results show significant variation, except for Runs P1.1 and P1.2. The addition of DSP did not have any material effect on stickies area or ppm as can be seen by comparing HC results from Table II and P1.1, P1.2 results from Table III. Other duplicate results in Table III show significant variation, making it difficult to draw any meaningful conclusion.

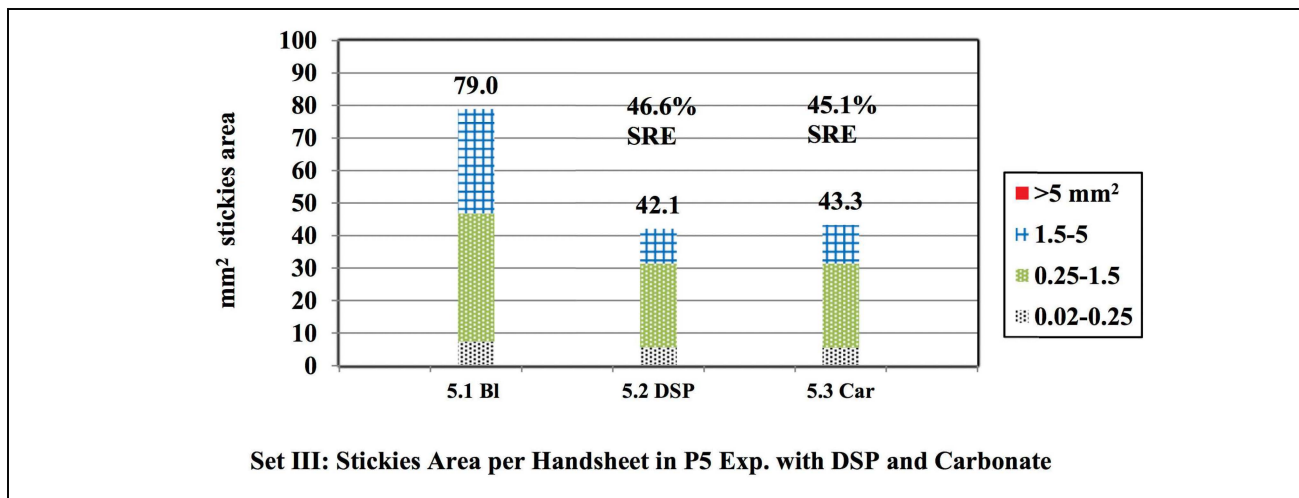
Set III experiments were conducted to evaluate the effectiveness of DSP and CaCO₃ in pacifying stickies. The average results of 3 to 4 handsheets from the blended sample, with or



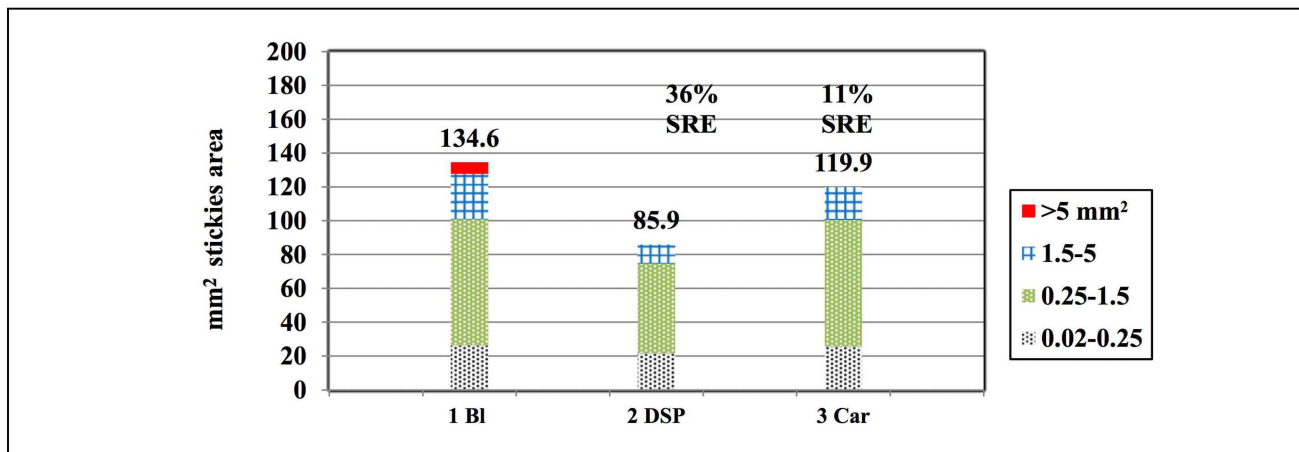
Sample Description	Stickies Area, mm ² per handsheet per class size				Total
	0.02–0.25 mm ²	0.25–1.5 mm ²	1.5–5 mm ²	>5 mm ²	
Blended	7.5	39.3	32.1	0	79.0
With DSP	5.6	25.8	10.7	0	42.1
With CaCO ₃	5.5	26.0	11.9	0	43.3

DSP = desilicized pulp; CaCO₃ = calcium carbonate.

IV. Effect of adding DSP and CaCO₃ on stickies size distribution.



7. Effect of DSP and CaCO₃ on stickies size distribution compared to the blended sample without any additive.



8. Preliminary deinking line experiments adding DSP and CaCO₃.

without pacifying agents, are shown in **Table IV** and **Fig. 7**.

The reduction in stickies area was 46.6% for the DSP sample and 45.1% for the CaCO₃ sample compared to the blended sample without addition of DSP or CaCO₃. Results from Table IV and Fig. 7 indicate that areas of large size stickies (1.5–5 mm²) are much more affected by DSP or CaCO₃ compared to that of small-sized stickies. For example, comparing results with and without DSP in Table IV, pacifying effects of small-,

medium-, and large-sized stickies are 25%, 34%, and 67%, respectively. Pacifying effect of CaCO₃ is quite similar.

The pacifying effect of DSP and CaCO₃ was evaluated on stickies from tertiary fine screen rejects from a deinking mill. Preliminary results displayed in **Fig. 8** show promise with DSP; however, the stock already contained considerable amounts of CaCO₃ so that the effect of additional carbonate was reduced.



CONCLUSION

Experiments were conducted to evaluate the effect of consistency on stickies size distribution. Results from using the same pulper and the same 100% PSA stock reveal that low consistency (6.1%) pulp has average stickies area of 2.06 mm² (1.62 mm equivalent diameter) compared to average stickies area of 0.628 mm² (0.89 mm equivalent diameter) for the high consistency (15.6%) pulp. In other words, the higher the consistency, the greater the stickies fragmentation. This is contrary to the accepted hypothesis that lower pulper consistency leads to more stickies fragmentation. This needs to be investigated further using a variety of stickies and pulper rotors.

The pacifying effect of desiliconized pulp (DSP) and CaCO₃ is about the same—about 45% to 47%. Carbonate is generally present in varying amounts in most recovered paper grades and is known to have a pacifying effect on stickies when present in relatively large amounts. DSP seems to be as effective also. The addition of DSP is like adding bleached hardwood kraft pulp with a bonus stickies-pacifying effect. Therefore, DSP may be worth considering in some special application by replacing a small percentage of bleached virgin hardwood kraft pulp.

INDUSTRIAL APPLICATION

A high consistency pulper could potentially fragment stickies. Therefore, it is very important to control pulping time carefully so as to achieve defibering without significant disintegration of contaminants.

The addition of desiliconized pulp (DSP) that has properties similar to bleached hardwood kraft pulp should be considered for stickies pacification. **TJ**

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ABOUT THE AUTHORS

We needed to produce pulp containing a significant quantity of microstickies. We thought pulping at 5% consistency would accomplish this, but to our surprise, we found more microstickies while pulping at 15% consistency. This was confirmed by one mill representative at the 2016 TAPPI PEERS Conference.

Our next step is to explore the validity of present observations to other types of pulpers or pulping conditions, such as temperature, pH, pulping time, and pulper rotor.

The second part of the project is the extension of our earlier work on the use of desiliconized pulp (DSP) to pacify microstickies [15]. Mills may benefit from the use of DSP as it behaves like hardwood pulp with a microstickies-pacifying effect as a bonus.



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