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Transfer of Stickies from a Mat to a Hot Metal Surface

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Abstract

The transfer of stickies (acrylates) and fiber from a mat to a hot metal surface was studied. In the absence of stickies, newsprint fiber transferred more readily than did fiber from bleached kraft, indicating that lignin was responsible for adhesion. The stickie–fiber aggregate was prepared in two ways. First, the homogenized stickie was suspended in the fiber slurry and a sheet was formed. These stickies, termed *free* stickies, represent free-floating material in whitewater that is trapped into the mat during formation. Second, a stickie formulation was applied to a sheet, which was then dried and slurried. These are called *attached* stickies and represent material that enters the system bound to fiber and is carried through without appreciable separation. The transfer of free stickies from the mat to the hot metal surface is independent of temperature. For newsprint, most of the stickies transferred are associated with fiber because of the affinity between lignin and the stickie. Bleached kraft fiber attracts fewer stickies, but it releases them to the hot metal plate more readily. Attached stickies that are transferred to the plate tend to be hairy. More stickie is transferred from wet than from dry sheets.

Stickies deposited on dryer cans cause picking and other product quality problems (1, 2). Variables such as roll temperature, type and moisture content of the fiber, nature of the stickie, and mode of attachment to the mat influence the extent of the transfer. Attempts have been made to alter the surface of the rolls to inhibit deposition. For instance, press rolls have been coated with Teflon (3), but this is an expensive solution since Teflon wears easily. High surface energy coatings have also been applied to increase wettability (4). Hydrophobic chemicals have been sprayed on roll surfaces (5). This study addresses the mechanism of the transfer so that preventive measures can be taken from an understanding of the fundamentals.

Experimental

A cured pressure sensitive adhesive (Carbotac 26171 acrylate latex from B.F. Goodrich) was mixed with fiber, pads were formed, and the transfer of stickies and fiber to a metal plate was measured under various conditions. Stickie-loaded mats were made in two ways. First, cured stickies were homogenized with a Brinkman Polytron homogenizer, added to the fiber slurry, and pads were formed. These represent free-floating stickies trapped into the mat during formation. Second, a stickie emulsion was coated on a sheet, dried, and then slurried. These represent adhesives that enter the system bound to fiber and are carried through without appreciable separation.

Preparation of attached fiber-stickie composites

Stickies were applied to newsprint stock and bleached kraft pulp. For newsprint, the stickie was applied directly onto the surface. A 1% w/w stickie load was targeted. However, because of losses due to adhesion to process surfaces, approximately three times this amount was used. The emulsion was applied as a thin coat, rolled on with a glass rod, and dried. The paper was torn into 1-cm-square pieces, added to a mixture of BRD 2360 (a mixture of fatty acids from Buckman Laboratories) and KOH in hot water, and homogenized.

Pads from kraft pulp were formed under suction on a 7-cm diameter Whatman #4 filter paper in a three-piece filter funnel. For smoothness and even distribution on the filter paper, a 7-cm glass fiber filter and a second 7-cm #4 Whatman filter paper were placed between the forming filter paper and the perforated support plate. After formation, the pads were pressed at 50 psi for 5 minutes, with the filter paper side facing the blotters and the fiber pad side held against a Teflon sheet. They were then dried in a steam drum dryer under weighted felts. The stickie suspension (0.15 mL) was applied as described above, and the pads were peeled off their forming filter paper. In some experiments, talc was added (at 0.3 % of fiber) to the pulp suspension prior to the addition of stickies.

Preparation of unattached fiber-stickie suspensions

The Carbotac emulsion (0.15 mL) was dispensed with an Eppendorf pipet on a piece of plate glass, spread to form a thin film with a glass rod, and dried to a transparent film. The film was removed in tight thin rolls with a razor blade, and placed into a mixture of hot water, BRD 2360, and KOH on the stirrer/hot plate, whereupon the rolls gradually opened into sheets. The stickie was then dispersed with a Polytron homogenizer and added to the fiber slurry.

Transfer of stickies and fiber to metal surfaces

Each filter paper with its formed fiber mat was placed on a stack of three blotter papers, fiber mat side up. A Teflon sheet was then placed on top, the press closed, and 50 psi pressure was applied for 5 minutes. After pressing, each filter paper/fiber pad pair was placed on top of a 7-cm.-diameter glass-fiber filter to which 4 mL of deionized water had been added. This provided a uniform solids content for the filter paper/fiber pad pair of 40±1%. These were placed in Petri dishes overnight for moisture-equilibration. Mild steel shim stock (1.5 mil thick) was cut into 3-inch diameter discs, washed with heptane, rinsed with ethanol, and dried. The discs were placed over the fiber pad, and pressed at 120°C and 35 psi. Initial experiments were carried out at dwell times of 5, 15, 30, and 60 seconds, but the edges partially dried out. When the metal plate was removed from the fiber pad, only stickies in the central wet regions transferred to the metal plate, whereas those in the dry regions were retained in the pad. The problem disappeared when a dwell time of 1-second was used.

Staining and counting

Two stains were considered: Morplas Blue 1003 and Sudan IV. The water in the Sudan IV formulation caused rusting of the metal plate, and this stain could not, therefore, be used. Morplas Blue was prepared at 0.1% w/w in n-heptane. The samples were exposed to the stain overnight, rinsed with solvent, and counted manually under a microscope. Stickie counts on both metal plates and paper were made over a 4 cm^2 area. A 2 x 2 cm square, divided into sixteen 0.5 x 0.5 cm squares, was laser printed onto an overhead transparency sheet to form a counting grid. The transparency was then trimmed to approximately 2 x 3-inches to form an overlay for counting stained stickies adhering to the metal plate or to the fiber pad. The sample to be counted was sandwiched between two 2 x 3-inch microscope slides, and the counting grid was placed either over the top slide, when viewing fiber pads, or between the top slide and the sample, when viewing a metal plate.

Two approaches were used to count stickies in fiber pads after they had been stained and dried. Pads prepared with kraft fiber could be peeled away from the filter paper they were formed on without leaving behind any stickies. It was difficult to detect individual stickies if they were covered by fiber. However, when a mineral oil with a refractive index close to that of cellulose was added to the fiber pad, the fibers became transparent, and all the stickies were clearly visible. The newsprint pads could not be removed from the filter paper without leaving both fiber and stickies behind, and both fiber pad and filter paper were viewed in oil. Counting stickies in newsprint was also more difficult because the newsprint did not wash clean of the stain as did bleached kraft, and it was difficult to differentiate between stickies and fibers that had retained the stain. Similar difficulties with newsprint have been experienced at Beloit (7).

In both cases, the oiled pad was placed between two microscope slides and the counting grid placed on top in a random location. Stickies in each of the 16 grids were counted using a stereoscope with a field of view slightly larger than the 0.5 x 0.5-cm counting square. The counts from the 16 squares were then summed, giving a count for the entire 4 cm^2 area. The grid was relocated to another random location over the sample and the process repeated four times and averaged. For very small stickies, a single 0.25 x 0.25 cm counting square was used. Again, the counting sample area was repeated several times and averaged. All experiments were replicated 5-10 times; the uncertainties reported are standard deviations.

Results and Discussion

Newsprint

The results of stickie transfer from newsprint are listed in Table 1. The "stickie without fiber" designation is semi-quantitative and represents those stickies that are *apparently* unassociated with fiber. The fourth column in Table 1 is an index of the "hairiness" of the stickie; the lower the value, the hairier the stickie. The amount of fiber transfer in control experiments *without any stickies* is illustrated in Figure 1. For newsprint, a strong temperature-dependence is clear. This is in keeping with the results of Meinecke *et al.* 1988 (8), who observed a similar phenomenon. The likely reason is that the lignin becomes tacky at the higher temperature as it approaches its glass transition temperature of about 120°C (9).

The ratio of stickies transferred to the plate to those retained on the fiber mat is illustrated for newsprint in Figure 2 for measurements where free stickie was used. Transfer of these free stickies is relatively temperature-independent, since T_g = -43°C for the acrylate stickie, which is tacky at both 22 and 120°C. Surprisingly, transfer of the fiber is now also temperature-independent (Table 1). It is possible that the stickie coats the fiber and increases its tack well beyond that contributed by the lignin, in which case the glass transition temperature would cease to be a factor. The *apparently* unattached fiber is also transferred, but this is probably because a light coating of adhesive on the fiber would be too small to be visible.

As discussed in the Experimental section, the attached stickies retained on the mat could not be imaged and counted because of interferences. The fiber transferred to the plate shows a

Table 1: Transfer of stickie and fiber (counts) from newsprint				
	transferred to plate			stickie retained in mat
	stickie	fiber	stickie (without fiber)/total stickie	
control at 22°C (no stickie)		25 ± 7		
control at 120°C (no stickie)		300 ± 30		
free stickies at 22°C	50 ± 20	190 ± 60	0.44 ± 0.06	650 ± 30
free stickies at 120°C	60 ± 20	190 ± 60	0.42 ± 0.08	800 ± 80
attached stickies at 22°C	18 ± 5	120 ± 20	0.06 ± 0.06	
attached stickies at 120°C	13 ± 3	340 ± 60	0.08 ± 0.03	

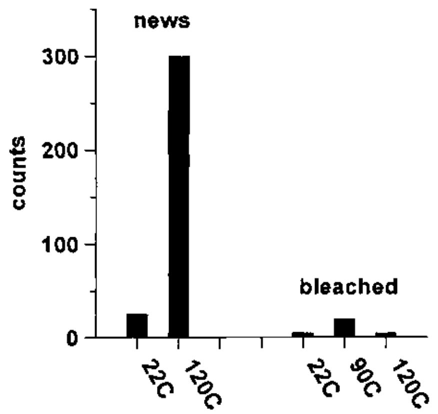

Figure 1: Transfer of fiber from newsprint and bleached kraft.

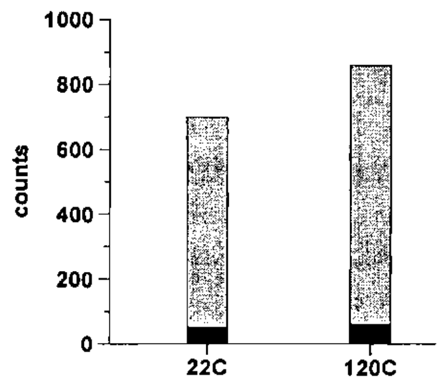

Figure 2: Free stickies retained (hatched) and transferred (solid) from newsprint.

temperature dependence with 120 and 340 counts on the metal plate at 22 and 120°C, respectively (Table 1). Since the viscosity of the stickie decreases with temperature, the attachment of the stickie-coated fiber to the mat will weaken at the higher temperature, which will facilitate its transfer to the plate. As expected, the transferred attached stickies are much hairier than the corresponding free stickies. The question arises as to whether free or attached stickies are more likely to reflect a real mill situation. The former seems more probable, since a stickie strongly attached to fiber will be screened out more easily.

Kraft pulp

Results from control experiments for the transfer of fiber from kraft pulp (without added stickies) are provided in Table 2 and are included in Figure 1. In contrast to newsprint, fiber

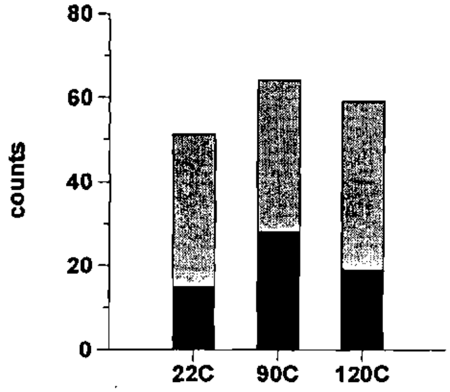

Figure 3: Free stickies retained (hatched) and transferred (solid) from bleached kraft.

Table 2: Fiber transfer (counts) from bleached kraft softwood (control experiments, no stickies)	
	fiber
22°C, no additives	4 ± 2
90°C, no additives	20 ± 10
120°C, no additives	4 ± 2
120°C, talc	1 ± 1

Table 3: Stickie and fiber transfer (counts) from bleached kraft softwood (no additives)				
	transferred to plate			**stickies retained in mat**
	stickie	**fiber**	**stickie (without fiber)/total stickie**	
22°C, free stickies	15 ± 2	30 ± 10	0.62 ± 0.05	36 ± 4
90°C, free stickies	28 ± 7	60 ± 30	0.64 ± 0.04	36 ± 3
120°C, free stickies	19 ± 7	50 ± 20	0.58 ± 0.05	40 ± 10
22°C, attached stickies	220 ± 20	50 ± 10	0.90 ± 0.02	772
90°C, attached stickies	200 ± 20	60 ± 20	0.84 ± 0.03	1000 ± 300
120°C, attached stickies	180 ± 40	80 ± 30	0.85 ± 0.02	900 ± 300

transfer is small from bleached kraft owing to the absence of lignin. Fiber transfer is not affected substantially by the presence of talc. As with newsprint, the transfer of free stickies is largely temperature-independent, as listed in Table 3 and illustrated in Figure 3. However, in contrast to newsprint, a greater proportion of the free stickies is transferred. This is reasonable because we have shown earlier that stickies associate with lignin (10). The stickie-fiber association is weak in the absence of lignin, and the mat more readily gives up the stickie to the plate. As expected, a smaller proportion of attached stickies is transferred as compared to free stickie since the process of attachment binds the stickie more strongly to the mat. As with newsprint, the amount of fiber transferred is much higher than that for the control since the presence of the stickie on the fiber will increase its attraction to the plate.

Differences in behavior between the free and attached stickies are much less pronounced for bleached kraft pulp than for newsprint. The amount of fiber transferred is essentially the same, and the hairiness of the stickies transferred is also essentially unchanged for the two cases. These observations reinforce the fact that the stickie-fiber association is weak and that the attached stickie behaves much the same as the free stickie. A possible outcome is that stickies may be less screenable for bleached kraft fiber than for newsprint since disintegration of the stickie-fiber agglomerate should be easier.

In summary, we have shown that a smaller quantity of stickie material is transferred from dry than from wet sheets. This is consistent with mill experience where stickies are known to deposit on the first few dryer cans. In the absence of stickies, newsprint fiber transfers to a greater extent than does bleached kraft. Transfer of free PSAs from either newsprint or bleached kraft is temperature-independent. Bleached kraft attracts fewer stickies than does newsprint, but gives proportionately more of them up to the plate. Stickies may be less screenable for bleached kraft fiber than for newsprint, since the stickie-fiber agglomerate will disintegrate more easily. Talc promotes stickie retention in the mat, but only by a small amount.

Acknowledgment

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