EFFECT OF BLANKET PROPERTIES ON PRINT QUALITY

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Abstract

Five blanket types were evaluated against four printing surfaces (two papers and two board samples) with respect to selected printability parameters. Testing was conducted using a Heidelberg 5-color press. During the trials, no piling was noted.

Back-trap mottle was measured instrumentally and visually. Except for one sample that had a coating defect, the instrumental results indicated that there was little difference in mottle between print substrates or blankets. Visually, however, differences were seen and, in general, the non-compressible blanket surface looked the worse. The severity of the mottle seen with this blanket is highly dependent on the impression setting between it and the substrate.

With respect to print gloss, blankets, in general, did not have any major influence. Ink position on the press did, however. The gloss of the 1[st] down cyan (C1) was several points higher than that of the 5[th] (and last) down cyan, C5. This is attributable to ink-paper interactions that are not apparently related to blanket roughness, nor the ink absorptivity of the substrate.

Dot gain was affected by the choice of blanket; a substrate-dependent increase in dot gain, and corresponding decrease in print contrast, being observed with one blanket. This is attributable to the nature of this blanket's surface.

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Background

DePaoli (1981), working primarily with newsprint and uncoated paper, found no correlation of dot gain with the various blanket properties used in his study. Dot gain was, however, substrate dependent.

Iwasaki *et al.* (1988) investigated the ink transfer characteristics of five printing blankets having the same construction but differing in top surface roughness, R_z, from 2-12 micrometers. They found that edge raggedness and solid ink uniformity began to deteriorate at $R_z > 6$ micrometers. R_z is defined as the average maximum peak-to-valley distance.

Pobboravsky *et al.* (1989), studied, using a designed experiment, the effects of solid ink density, paper tension, press speed, the number of printing units "on impression," and blanket packing on web offset fill-in and slur. They found that only solid ink density had a statistically significant <u>and</u> meaningful (observable) impact on dot gain.

MacPhee and Lind (1990) found that blanket type, particularly compressible versus non-compressible, had no effect on dot gain.

Chagas and Baudin (1995) evaluated a series of blankets that were based on different rubber formulations with three different types of treatments to affect surface roughness. Roughness values were not supplied, however. Although primarily interested in transfer properties, they also found that the dot gain (@ 50%) for all blankets averaged between 13-15%. The Contrast Index varied slightly more, but was not meaningfully different (< 3% difference) between blankets.

Experimental

Five different sets of blankets, each set consisting of five blankets, were received Day International, Inc. – see Table 1.

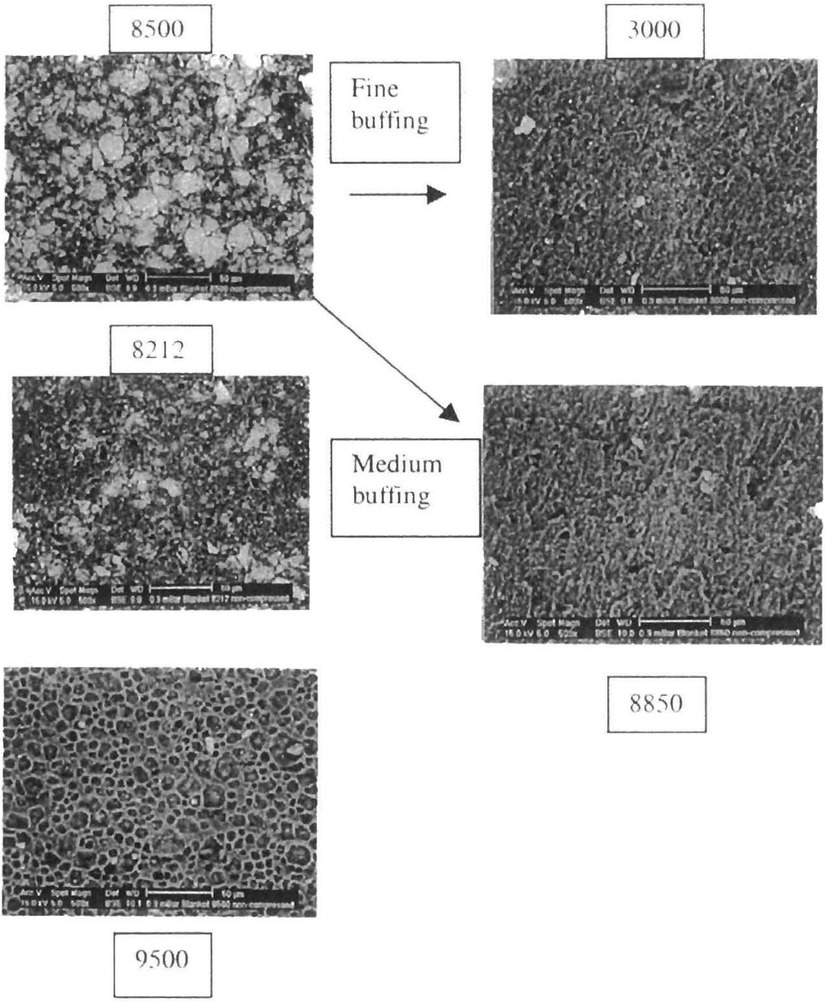
Table 1. Blanket Properties

Name	Surface Type	R_a, µm*	Compressible?	Comment
8500	Cast	0.5 – 1.0	Yes	
3000	Buffed, fine	0.4 – 0.8	Yes	
8850	Buffed, medium	1 – 1.5	Yes	
9500	Cast, texturized	1.3 – 1.8	Yes	
8212	Cast	0.4 – 0.8	No	Non-compressible version of the 8500

- manufacturer's specifications, based on stylus measurements
- Note- all blanket surfaces are similar in chemical/mechanical properties EXCEPT for the 9500, where, according to the manufacturer, the rubber composition is somewhat tougher (as measured by Taber abrasion resistance).
- R_a = average peak or valley height relative to the mean

Figure 1 shows scanning electron micrographs (500X) of the blanket surfaces. As can be seen, the 8850 and the 3000 blankets are derivatives of the 8500 blanket, differing only in surface finish. The 8212 has the same surface finish as the 8500, but is constructed differently (non-compressible). The 9500 series blanket has a unique, open-cell foam construction. The white particles seen in the pictures of the 8500 and 8212 are talc, used as a release agent in the manufacturing process.

Figure 1. Blanket Surfaces (500x) bar = 50 μm



Using conventional sheetfed inks (tack ranges 15-17 @ 1 minute @ 1200 rpm @ 90 °F), an E-Chip based experimental design was run (see Table 2). The experiments were not totally randomized as we did not want to keep changing the blankets for each trial, nor did we want to risk damage to the blankets by mixing paper and board samples. Therefore, the general testing procedure was as follows:

1. Mount new blankets; pack and torque to manufacturer's specification
2. Using an 80# gloss paper to start-up, adjust color and "break-in blanket" for 1,000 impressions.
3. Re-torque blanket, run 5000 sheets for each experimental condition. Collect 20 sheets at 1K, 3K, and 5K (end of run) impressions. Collect tape pulls from blanket for observation of piling. Clean blankets.
4. Repeat #3 until all testing with that blanket set is complete.
5. Repeat #1 until all testing has been completed.

Table 2 . E-Chip Design and Running Sequence

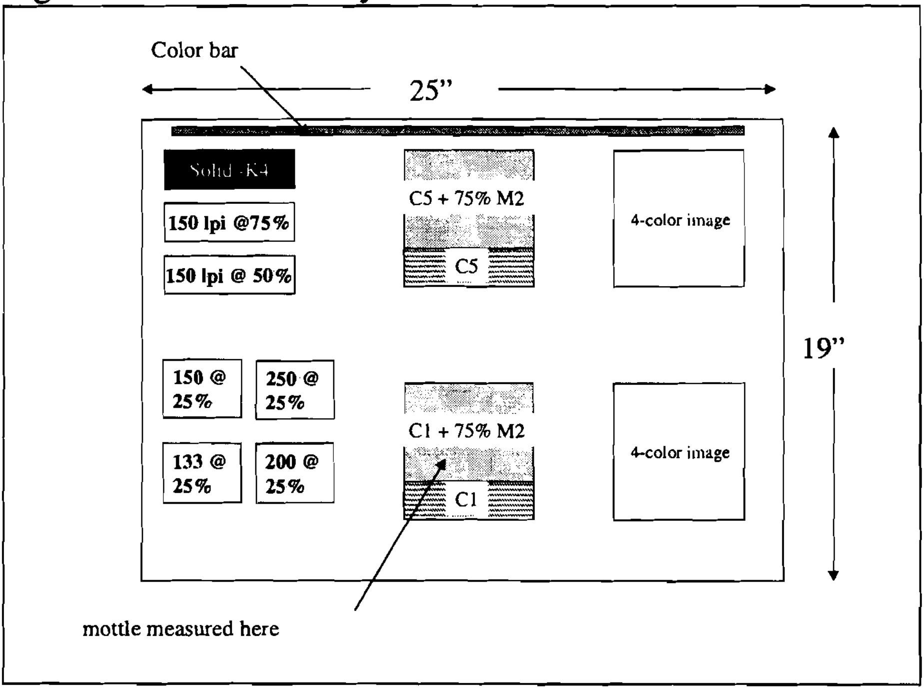
Run #	Blanket	Substrate
1	3000	Paper A
2	3000	Paper B
3	3000	Paper A
4	3000	Paper B
5	3000	Board A
6	3000	Board B
7	8500	Paper B
8	8500	Paper A
9	8500	Paper B
10	8500	Board B
11	8500	Board A
12	8850	Paper A
13	8850	Paper B
14	8850	Board A
15	8850	Board B
16	8850	Board A
17	9500	Paper A
18	9500	Paper B
19	9500	Board A
20	9500	Board B
21	8212	Paper A
22	8212	Paper B
23	8212	Board A
24	8212	Board B
25	8212	Board A

No piling or contamination problems were encountered when running the paper samples. Therefore, all paper samples printed using a specific blanket were printed without cleaning the ink train, but the blanket surface was cleaned between runs with a mild organic cleaner. Although no piling was observed with the board samples, some debris could sometimes be seen in the ink train; therefore, after each run the ink train was completely cleaned before preceding with a subsequent run.

Figure 2 shows the layout of the test form. Analysis of the image consisted of:

1. Analysis of color bars for density, dot gain, percent contrast
2. Paper and print gloss, the latter measured in the solid black region and the C1 and C5 regions.
3. Mottle in the lower, two-color region (M2/C1).

Figure 2. Press sheet layout



Density was measured using a Gretag MacBeth D19C, mottle was measured using a Tobias MTI Mottle Tester (data were collected every 0.15 mm using the high pass digital filter set at 75, 1.5 mm aperture, and green filters), 60° gloss with a Gardco Statistical Novogloss 20°/60°/75° meter.

Paper and board samples were as follows:

1. Paper A - 60# C1s (coated one side) gloss
2. Paper B - 70# C2s gloss
3. Board A - 18 pt. C1s
4. Board B - 18 pt. C1s

Results

Gloss

Table 3 shows the results of the E-Chip data analysis with 60° gloss as the dependent variable. Samples were collected at 1,000 impressions (there was no change in the gloss values at 5000 impressions). The data analyzed are the average of readings taken on 6 samples collected at 1,000 impressions, there being no significant difference between those data and data collected at 5,000 impressions. Rather than compare gloss values, we have chosen to use the ratio of gloss to print density in order to smooth out any minor variations in density. Average densities (± 1 SD) were: C1 = 1.28 ± 0.04; C5 = 1.31 ± 0.03 and K4 = 1.64 ± 0.09.

Table 3. E-Chip Summary Results -Gloss

C1_G/d	C5_G/d	K4 G/d	
*	*	.	4 Blanket
***	***	***	3 Substrate
.	*	.	12 Substrate*Blanket

"significance"
* = 95%
** = 97.5%
*** = 99.9%

Table 3 indicates that substrate effects are appreciable. This is an expected and unimportant result in that print gloss is normally highly correlated with substrate gloss. More interestingly, blanket type has some effect, at least for the cyans (see Figure 3) and there are some significant 2-way interactions, at least for the last down (C5) cyan. Figure 4 shows that the gloss values for the cyans, C1 and C5, are significantly (and noticeably) different in several instances

Figure 3. Gloss (normalized)

+/- 95% CI

60° gloss/density

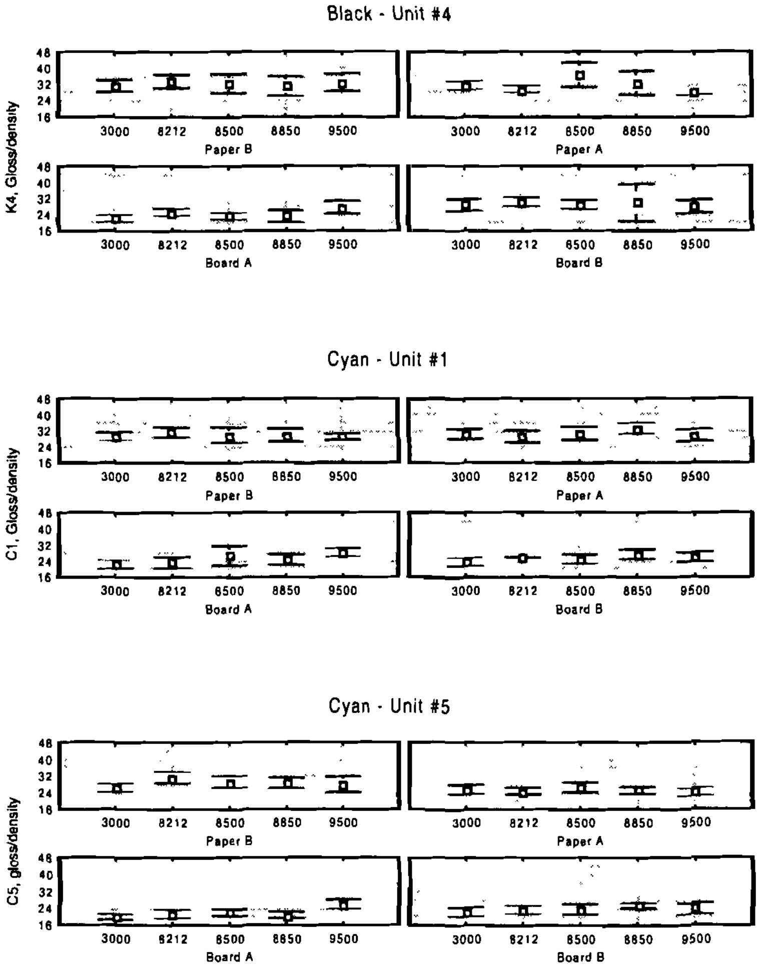
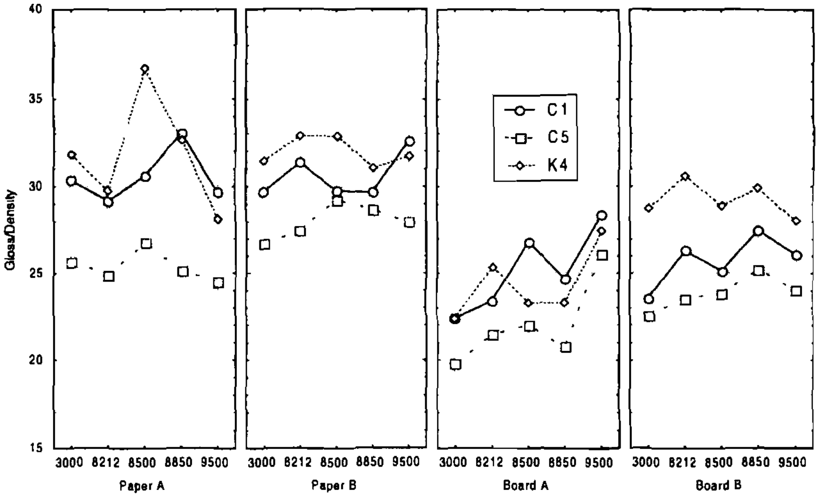


Figure 4. Means of the three significant gloss variations



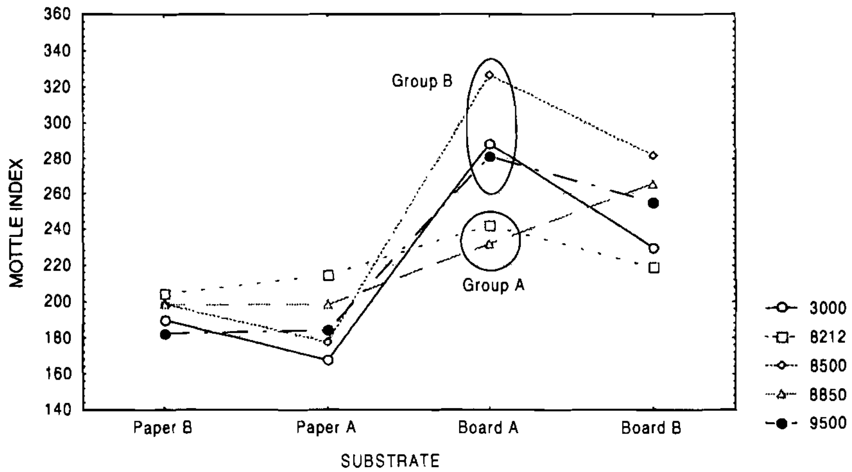
Mottle

Mottle measurements were made in the machine-direction using the Tobias Mottle tester. Six adjacent scans were made on each of two different regions shown in Figure 2. Figure 5 shows the mottle means for all conditions. First, mottle indices for coated boards are, in general, higher than those for the paper samples. For three substrates, Paper B, Paper A and Board B, blanket type had no statistically significant impact on the Tobias mottle indices. For Board A, however, there were two distinct clusters.

Figure 5. Mottle - Plot of Means

2-way interaction

F(12,280)=6 83, p< 0000



Group A, consisting of the 8212 and the 8850 blankets performed the best whereas the other three blankets were measurably and noticeably worse with respect to mottle. A visual inspection of the mottle targets showed that those samples in Group B (Figure 5) contained MD-oriented coating streaks. Similar streaks could be seen in the unprinted region, but no streaks were evident in the 5th down cyan (C5) target. Thus, we can say streaks, representing uneven coat weight distribution, have given rise to back-trap mottle (BTM). In Group A, what mottle is present does not appear to be particularly MD-oriented and any MD-oriented coat streaks in the unprinted areas were also difficult to see.

The visual perception of mottle, shown in Table 4, does not necessarily coincide with the Tobias mottle indices seen in Figure 5. For example, while the two paper samples showed no significant effects of blanket type on measured mottle, visually some difference could be detected.

Table 4. Visual Perceptions of Mottle

Paper	Least Mottle	Intermediate	"Worst"	Comment
Paper A	3000, 8850, 8500	9500	8212	v. small differences
Paper B	3000, 8850, 9500	8500, 8212		v. small differences
Board A	8850	3000, 8500, 9500	8212	Coating streaks and packing influence results
Board B	3000, 8212	8850, 8500, 9500		v. small differences

As noted in Table 4, the differences are often small and some improvements could be made in the performance, particularly of the non-compressible blanket (8212) with a slight increase in blanket to substrate impression. We found that a 0.001" increase in blanket-substrate impression made a significant difference in the appearance (mottle decreased with increasing impression) of the mottle when using the non-compressible blanket. This change in impression could be readily detected in the width of the impression stripe.

Aside from the problems seen with the Board A, a customer examining prints from a single blanket might not find the mottle objectionable. However, if a printer was shown the prints from all the blankets and asked to select which one they would like to try, then the ranking shown in Table 4 becomes important. It is also important to keep in mind that the blankets are "new" and have very few impressions (20K-25K) on them. Whether such differences would be visible after 100,000+ impressions was not determined.

Dot Gain and Print Contrast Characteristics

Effect of Run length on dot gain and print contrast

Table 5 shows the results of significance testing on print samples collected at 1K and 5K impressions. The way the table is read is that, for example, a statistically significant difference (a 2% decrease in this case) in the magenta contrast when going from 1K to 5K impressions was found. Print contrast (PC) is defined as:

$$PC = \frac{D_s - D_t}{D_s} \times 100\%$$

where: D_s = density of printed solid
D_t = density of 75% tint area

Table 5. Comparison of 1K vs. 5K results (significance testing)

	Contrast	Dot Gain		
		25%	50%	75%
Black	-	-	-	-
Cyan (C2)	-	(1)	-	-
Magenta	(-2)	(2)	(1)	-
Yellow	-	-	-	(-1)

( ) = change in going from 1K to 5K. See text for how to read this table

No statistically significant differences in contrast were found for the other colors. With respect to dot gain measurements, it should be noted that the actual dot gain values are not necessarily normally distributed but the differences between values at the two different run lengths appear to be. Thus, t-testing was conducted using pair-wise comparisons. Where there was a statistically significant difference, the absolute differences were small (Table 5). The direction of change, except for the yellow, was as anticipated; the characteristics worsen with time.

Figure 6 compares the results for the Magenta 25% dot gain. The ellipses encompass the repeated trials and form the basis of E-Chip's significance testing. It can be seen in Figure 6 that the majority of the points, representing all blankets and paper combinations, are higher than the line that represents "0" dot gain; hence, the significant two-point difference reported in Table 5. The fact that the magenta was the primary color affected may be a reflection of the oft-noted difficulties in running magenta ink on a litho press.

Figure 6. Effect of Run Length on Dot Gain - 25% Magenta - ellipses encompass repeats

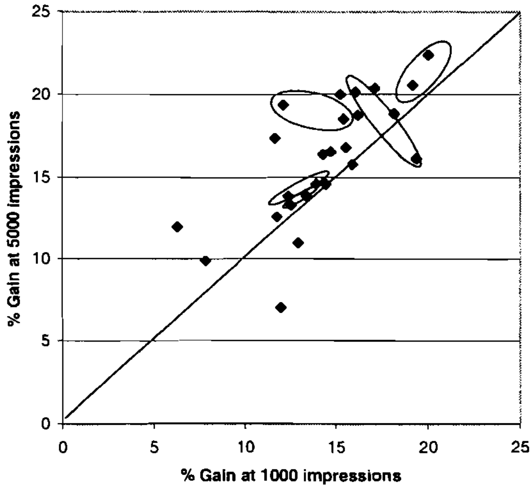


Table 6 shows the results of significance testing for the 1K data. As before, we will ignore obvious substrate-related issues and concentrate on blanket-related issues. It can be seen that there are only three variables affected by the blankets: black contrast, and the dot gains for the 25% black and yellow halftones. The color-specific nature of the results may be indicative of ink-related variations, particularly rheology and/or pigmentation level. Thicker ink films result in more dot gain as reported by Pobboravsky *et al.* (1989). The three variables are plotted in Figure 7.

Table 6. E-Chip Summary Results- Dot Gain and Print Contrast @ 1K imp.

Summary results by sources

```
Contrast-K
. Contrast-C
. . Contrast-M
. . . Contrast-Y
. . . . Dot-50%K
. . . . . Dot-50%C
. . . . . . Dot-50%M
. . . . . . . Dot-50%Y
. . . . . . . . Dot-25%K
. . . . . . . . . Dot-25%C
. . . . . . . . . . Dot-25%M
. . . . . . . . . . . Dot-25%Y
-----------------------------------------------------
* . . . . . . . * . . *      4 Blanket
. . . . ** . * . ** . ** .   3 Substrate
. . . . . . . . . . . .      12 Blanket*Substrate
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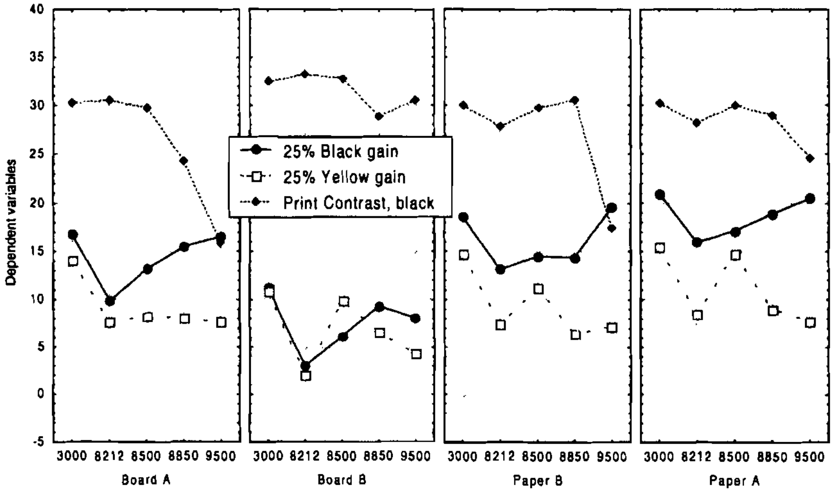
Figure 7. Plot of Significant Dot Gains Means

All at 1000 impressions



Lower dot gains and higher contrast are preferred. Print contrast is based on the 75% dot and, for three of the four substrates, it can be seen that it worsens (decreases) significantly when using the 9500 blanket. One explanation for this is that, under compression in the blanket-paper nip, ink flows from the honeycomb cells in the blanket surface -see Figure 1. This would manifest itself in the prints as fill-in in the shadows.

These gain and print contrast changes are not trivial – variations of only a few points can be considered objectionable by SWOP guidelines. Thus, in preparing halftone separations, it is important to understand the gain characteristics of the press equipped with the intended blankets. Color separations based on the performance of the 9500 blanket, for example, could give slightly, perhaps noticeably, different results if the 3000 blanket is used.

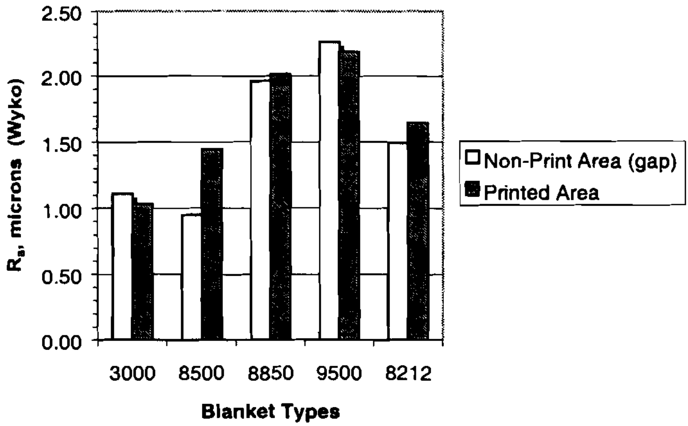
Why pick one blanket over the other? In the case of the 3000 and the 9500 blankets, the 9500 blanket finds its greatest use in web printing, where its rougher surface helps blanket release and results in improved blanket piling characteristics. The 3000 blanket, with its "sharper" dot reproduction, is popular in the commercial sheetfed market. Absolute gain numbers are not always important. What is important for all blankets is that their gain characteristics be consistent.

An issue does arise when the printer is using supplied separations that were prepared with a specific dot gain in mind. If that is not the same gain the printer normally finds, then corrective action may be necessary.

Effect of Printing on Blanket Roughness

Figure 8 compares the roughness attributes of the original blanket surface (using that portion of the blanket that was in the cylinder gap) with that of the mottle region shown in Figure 2. In all cases, the blankets have been cleaned, in the sense of wiping the blanket with press solvent and rags to remove residual ink, prior to measurement on a Wyko profilometer, a non-contact laser interferometric device. Readings are the averages of three different spots, 2-3 centimeters apart, in each region of the blanket surface.

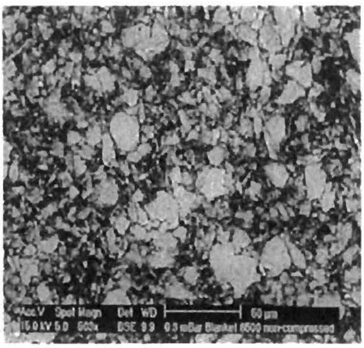
Figure 8. Effect of Printing on Blanket Roughness



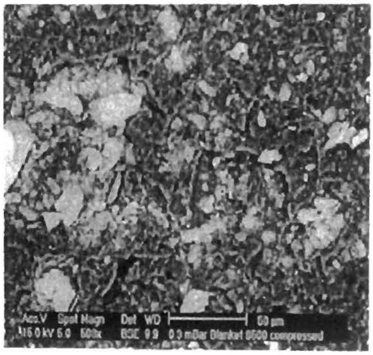
In all cases, except for the 8500 series blankets, there is little to no change in the roughness of the blankets due to printing. The 8500, however, does show a substantial increase in roughness. The surfaces of both the 8500 and 8212 blankets have been treated with talc and it is hypothesized that printing cause the talc particles to be removed from the surface of the blanket leaving a surface with more pits. SEM photographs of the surfaces of the 8500 blankets would appear to support that contention- see Figure 9. The effect on measured roughness was not as noticeable on the 8212 blanket, the non-compressible version of the 8500, although the SEM's showed a similar appearance to that shown in Figure 9.

Figure 9. Effects of printing on the surface of the 8500 blanket

8500 - before



8500 - after



Conclusions

Printing is understood to be a very complicated process, where it is often found that specific results are often dependent on the interactions of material within the total system, and not just on the properties of one particular component. In the present study we have seen that differences between blankets, which given the widely diverse nature of the blankets turn out to be rather small, are often highly dependent on the properties of the other materials (print substrate, ink) involved.

Dot Gain

As noted in the works previously cited, dot gain is primarily affected by changes in printing ink density, insofar as reflection density of the ink film is a measure of its thickness. In this work, we found a small, substrate-dependent and ink-dependent effect of blanket properties on dot gain. The worst case scenario was found only in the gain of the 25% yellow and black screens. There a maximum change in gain values of up to 7% could be seen, strictly attributable to changing the blanket. Over time (1,000 versus 5,000 impressions), only the 25% magenta screen seem to worsen, albeit slightly. Magenta inks have a history of being "difficult to run" and our results may be a reflection of that paradigm.

Mottle

Instrumentally speaking, no meaningful blanket-dependent backtrap mottle could be detected with the Tobias Tester. Visually, there were slight differences in the print appearance, and effect noted by others as well. Whether objectionable or not would be a matter for the user of the blanket to decide.

Gloss

With respect to gloss, or gloss/density as was used here, there were some very slight blanket effects seen, but hardly of a meaningful nature. The most noticeable difference detected was in the gloss of the 5th-down cyan (C5) compared to the first down cyan (C1) – the latter was invariably higher than the former. This is consistent with the notion that the repeated blanket-paper interactions, to which the C5 image area, prior to printing, is subjected, allows for much greater interaction with the dampening solution, effectively reducing the paper gloss as a result of fiber roughening. In the case of Paper A, the effect is more noticeable than for Paper B. Although we did not measure the actual effect of the dampening solution on gloss and smoothness reduction in this study, the phenomenon has been frequently observed and measured in our laboratory.

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