The Printability of Waterless Web Offset

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Abstract

Waterless web offset has proven to be a viable printing technology with the improvement of plate, ink and temperature control technologies. To advance waterless printing technology, one must understand the printability of the process. The purpose of this study is two-fold:

1. to examine the print characteristics of the waterless web offset process over a wide range of paper substrates
2. to compare these variations between conventional and stochastic screening processes

Introduction

Compared with conventional web offset, waterless web offset has been shown to offer better print quality in terms of lower dot gain and higher print contrast (Wong, Xie, Strong & Stone, TAGA 1995). In production, however, it was apparent that the interactions between paper and ink differed between the waterless and conventional processes. We undertook to conduct an experiment to examine the printability of the waterless process over a wide range of paper substrates. The experiment was first performed on a Harris M1000B press and later on a Harris M3000.

The intent of this experiment was to examine variations in print characteristics over a wide range of publication paper stocks in the waterless process. The print characteristics were measured by the solid ink density, middletone dot gain and print contrast. We also examined the printed samples for piling and solid lay smoothness. Finally, we studied the print characteristics variations among different paper substrates in the cases of both conventional and stochastic screening.

The M1000B Experiment

The experiments were conducted on a Harris M1000B press in Donnelley's Old Saybrook plant. The M1000B press is equipped with Tri Service's temperature control system. Table 1 summarizes the equipment and materials used.

Table 1. Equipment and materials used in the M1000B paper printability study.

	Harris M1000B
Paper	Coated 30 to 100 lb. Basis Wt.
Press Speed	1300 FPM
Plates	Toray Positive
Exposure Control	UGRA
Inks	Flint Aero Dri
Blankets	Day 9500
Inking Sequence	KCMY
Add'l Temperature Control	Tri Service
Production Density Black	1.70 - 2.05
Production Density Cyan	1.35 - 1.65
Production Density Magenta	1.35 - 1.65
Production Density Yellow	0.95 - 1.10

The test form consisted of tone scales and photographic images. For each test page, a conventional 150 lpi halftoned film and a stochastically screened film were generated. The stochastically screened films were produced using Accutone™–R. R. Donnelley's stochastic screening algorithm–at 1000 dots per inch (dpi) resolution. The films were output on an Optronics CS4000 imagesetter at 4000 dpi plotting resolution. Dot area readings were taken on each film using a transmission densitometer. The films were calibrated to linearly reproduce the intended dot percent of the digital value.

Test pages were stripped together to create the test form. Half the test form had stochastically screened films and the other half had conventionally screened films. Since both halves contained the same elements and were in "in-line" position with respect to the ink keys on the press, we were able to compare the two methods directly. The test form was exposed onto a positive waterless printing plate. The UGRA Plate Control Wedge was used to monitor the plate exposure. The same exposures were used for both conventional and stochastic films.

Over ten paper mills participated in this study and donated 27 rolls of paper altogether. Each roll of paper was coded with a number from 1 to 27. The basis weight of the paper varied from 30 to 100 pounds, representing the full spectrum of publication stocks used in the printing industry today. Coatings and absorbing properties may have differed between the paper substrates.

The basis weight, caliper and absorption coefficient of each roll are listed in Table 2. These readings were compiled by the research lab of the Flint Ink Company.

Table 2: Test Paper Characteristics

ROLL #	WEIGHT	CALIPER	ABSORBENCY
1	32	0.002	26
2	50	0.003	23
3	40	0.002	24
4	50	0.0025	30
5	60	0.003	24
6	30	0.0015	20
7	45	0.002	26
8	70	0.0035	33
9	60	0.003	23
10	60	0.003	22
11	38	0.002	20
12	45	0.0026	22
13	30	0.002	21
14	90	0.005	36
15	40	0.002	19
16	100	0.0045	32
17	38	0.002	20
18	70	0.0035	24
19	38	0.002	21
20	38	0.002	24
21	32	0.002	15
22	32	0.002	20
23	45	0.0025	20
24	40	0.002	13
25	34	0.002	17
26	45	0.002	25
27	45	0.002	21

The press was makeready with a butt roll of paper outside the test paper rolls. This makeready roll was used as the control and numbered zero (0). The press was brought to the ink densities with the color of printed samples visually matching the supplied color proof. Once the ink densities stabilized at a press speed of 1300 feet per minute, the ink keys were set and kept constant for the entire press run; the fixed ink key settings kept the ink film thickness constant. The 27 rolls of paper were fed through the press in sequence from high to low basis weight. Each roll ran for 10 to 15 minutes. Blanket washes were performed when piling was visibly noticeable. A set of samples was collected for each paper roll.

Print Characteristics Study

The 27 sets of printed samples were analyzed by measuring the printed density, middletone dot gain and print contrast using an X-Rite 938 Spectrodensitometer with status T filter response.

a) Density

Figure 1 shows the print density measurements over 27 sample sets. The densities among different paper samples changed slightly (within ±0.15 density units) during the press run, confirming the conventional belief that print density varies with paper quality (i.e., the lower the paper quality, the lower the solid ink density value). MacPhee and Lind (TAGA 1992) attribute print density variations to the bi-directional reflectance distribution function of the paper.

b) Dot Gain

We examined the effect of 27 different substrates on dot gain. The dot gain was computed using the Murray-Davis equation by measuring the densities of solid, 50% tone, and paper. Figure 2 shows the dot gain variations among the 27 rolls of paper. The maximum, minimum, average and standard deviation dot gain of the 27 printed samples were 30, 15, 20.3 and 4.5 respectively. The change in dot gain is significant. Correlation analysis indicates there is no meaningful correlation between dot gain and the paper's basis weight, grade and absorption coefficient.

c) Print Contrast

Figure 3 plots the print contrast value. The index of print contrast was derived from solid and 75% patches. The measurement was obtained using a X-Rite 938 Spectrodensitometer with the Yule-Nielsen equation. Print contrast closely reflects the dot gain behavior. The change in print contrast over 27 rolls of paper is significant and again shows no correlation to paper grade, basis weight and absorption coefficient.

d) Piling and Solid Lay Smoothness

The printed samples were checked for piling and solid lay smoothness. In general, the solid lay smoothness was good and did not differ significantly from paper to paper. Edge pilings were detected among the print samples. This phenomenon may be related to the properties of the paper coating used. We did not detect edge piling with the following rolls: 5, 6, 8. 12. 13, 14, 16. 17, 18, 21, 24 and 27.

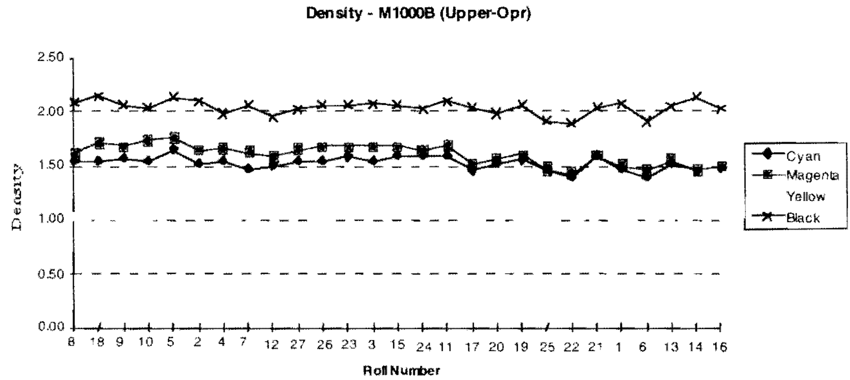

Figure 1: M1000B Density

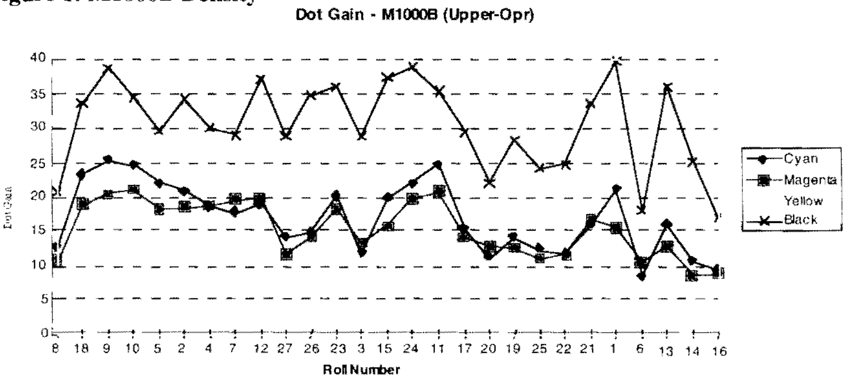

Figure 2: M1000B Dot Gain

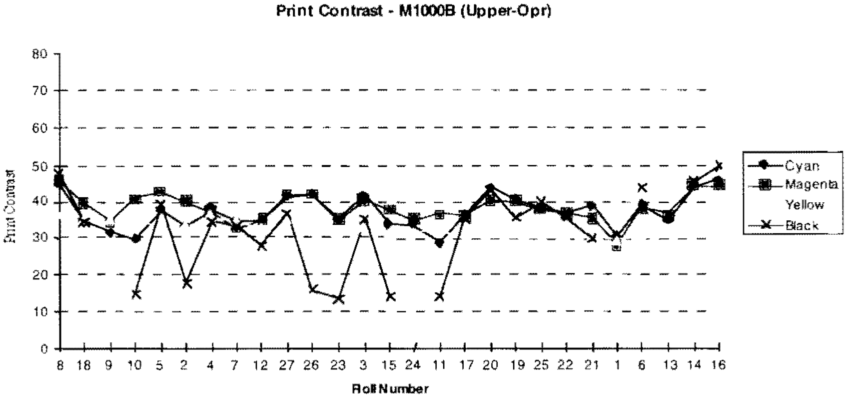

Figure 3 : M1000B Print Contrast

Stochastic Screening Study

To compare the print characteristics difference between conventional and stochastic screens, we measured the print density, dot gain and print contrast variations for each screen over 27 rolls of paper.

Figure 4 shows the ink density measurements over 27 sample sets between the conventionally screened samples and the stochastically screened samples. The densities between conventional and stochastic samples were very close and changed only slightly during the press run.

Figure 5 shows the dot gain comparison between the conventionally and stochastically screened images. Comparing conventionally versus stochastically screened samples, the average dot gain was 20.3 versus 14.7; standard deviation was 4.5 versus 2.1. The standard deviation of the dot gain for conventionally screened samples is much larger than its stochastic counterpart. This indicates that the stochastically screened images appear to be more stable than the conventionally screened images given the different paper substrates, temperature change and normal ink density fluctuations.

Figure 6 plots the print contrast comparison between the conventional and stochastic samples. Once again, the print contrast of stochastically screened images exhibits less change than that of the conventionally screened images.

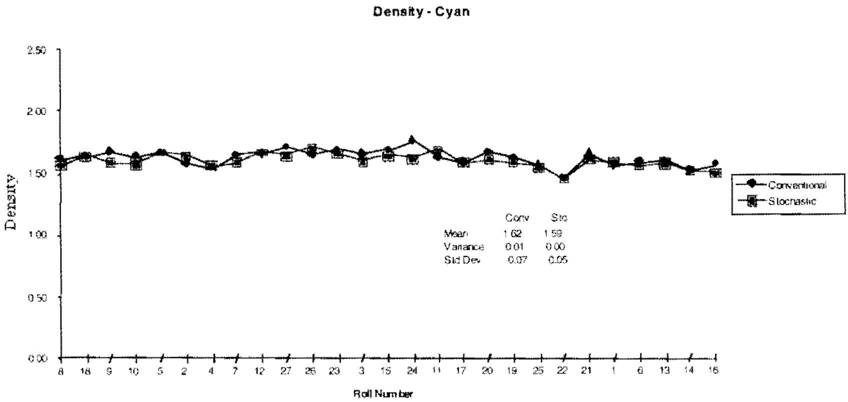

Figure 4: Cyan Density (Conventional Screen vs Stochastic)

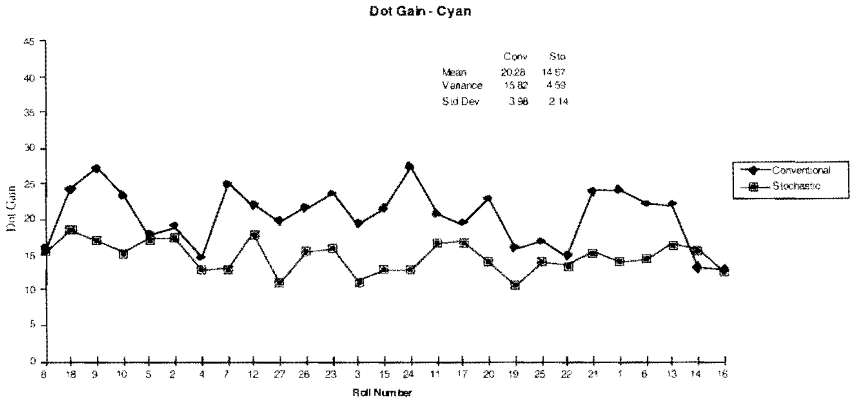

Figure 5: Cyan Dot Gain (Conventional Screen vs Stochastic)

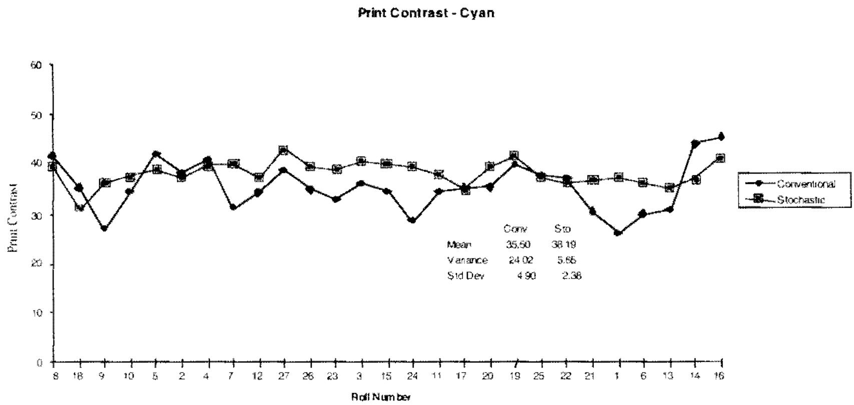

Figure 6: Cyan Print Contrast (Conventional Screen vs Stochastic)

The M3000 Experiment

A similar paper test was also performed on a Harris M3000 in the South Daytona plant. The M3000 does not have any additional temperature control but it is operating in a climate-control press room. The test was run at 2000 feet per minute.

Table 3. Equipment and materials used in the M3000 paper printability study.

	Harris M3000
Paper	Coated 32 to 60 lb. Basis Wt.
Press Speed	2000 FPM
Plates	Toray Positive
Exposure Control	UGRA
Inks	Flint Aero Dri
Blankets	Day 3000
Inking Sequence	KCMY
Add'l Temperature Control	None
Production Density Black	1.50 - 1.90
Production Density Cyan	1.30 - 1.60
Production Density Magenta	1.30 - 1.60
Production Density Yellow	0.95 - 1.05

Comparing the print characteristics between the two press tests (M1000B vs M3000) for the same kind of paper, the M3000 samples measured a slightly higher density and lower dot gain than the M1000B samples. Again, there was no meaningful correlation between dot gain and the paper's basis weight and absorption coefficient. Figures 7, 8 and 9 plot the density, dot gain and print contrast comparison respectively between the two presses for the same paper samples. Measurements were taken with an X-Rite 418 G-35 Status T response.

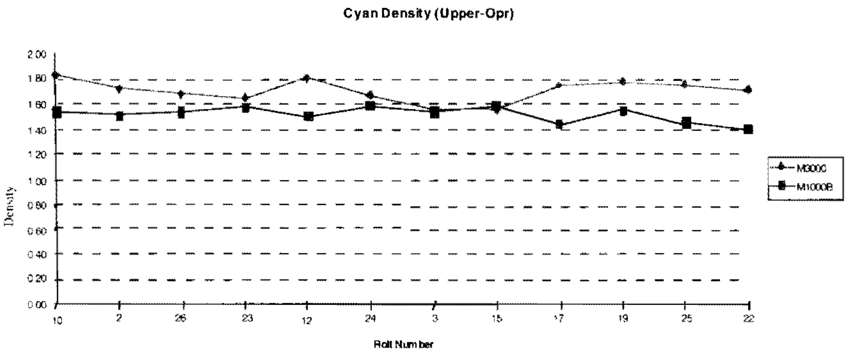

Figure 7: Cyan Density (M1000B vs M3000)

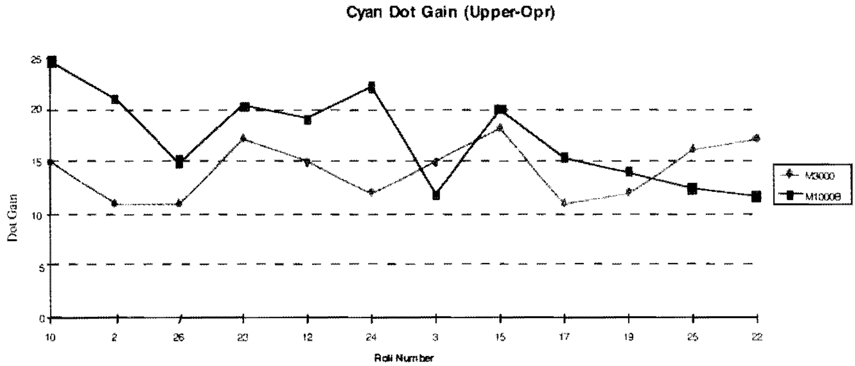

Figure 8: Cyan Dot Gain (M1000B vs M3000)

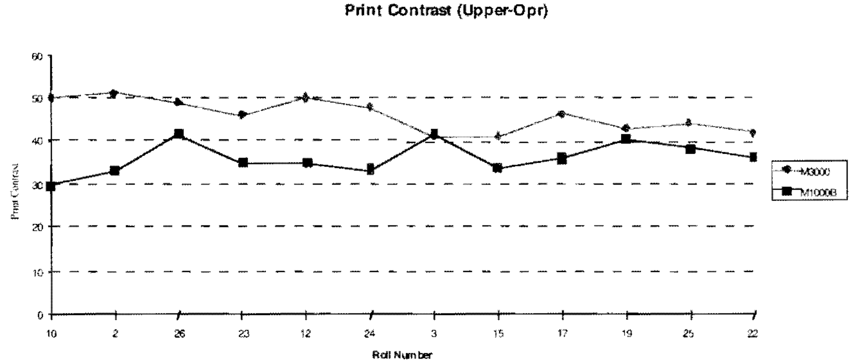

Figure 9: Cyan Print Contrast (M1000B vs M3000)

Conclusion

The print density, dot gain, and print contrast differ among the 27 printed samples. The print density variation relates to the quality of the paper. The dot gain and print contrast variations among 27 rolls of paper are significant and do not correlate meaningfully to the basis weight and absorption coefficient of the paper. The print characteristics behaved similarly under two different press environments (M1000B and M3000) and press speeds (1300 and 2000 feet per minute).

The dot gain and print contrast measurements of stochastic and conventional screened images indicate that the stochastic printing process appears to be more stable than its conventional counterpart. Visual examination of printed samples also confirms this observation. The changes in dot gain among 27 sets of printed samples were mainly induced by three factors: ink density fluctuations, temperature change and different paper surface characteristics. As reported by Schelfant (1993), the dot percent of stochastically screened images is less sensitive to the print density change than the dot percent of conventionally screened images. Our experimental results suggest that the three factors in combination have far less effect on stochastic dot percent reproduction than on conventional dot percent reproduction.

Future research is needed to confirm and explain this phenomenon.

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