A STUDY OF WATERLESS WEB OFFSET PRINT CHARACTERISTICS

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Abstract

Waterless web offset printing is gaining attention among US commercial printers as more printers are experimenting with the technology. One of many advantages attributed to waterless printing is the increase in print quality. However, little quantitative data is available. This study compares the print characteristics of the waterless process with the conventional process in terms of color space, dot gain and print contrast. In addition, this study attempts to quantify the ink consumption difference between the two processes.

Introduction

Today, many commercial printers are testing the waterless process. Print buyers are attracted to the technology because it offers enhanced print quality, higher screen ruling capabilities and a more friendly environment. Printers are attracted to the technology because it offers great potential productivity gain. The productivity gain can be measured in terms of less waste time and materials by eliminating the process of attaining ink-water balance in conventional offset.

Much has been reported on the enhanced print quality of the waterless process over its conventional counterpart in terms of dot gain and print contrast. However, little quantitative data has been available for the comparison. In order to gain a deeper understanding of the waterless process, this study focuses on the print characteristics of the waterless process as compared to the conventional process.

Because of its low dot gain and high print contrast characteristics, the waterless process consumes more ink. In order to achieve the most optimal economic return for investing in this new technology, it is imperative to know exactly how much more waterless ink is being used compared to its conventional counterpart. Again, little quantitative data has been available for the comparison. This study attempts to quantify the extra waterless ink consumption.

The Print Characteristic Study

The experiment was conducted on a Harris M90 press in RR Donnelley's Mendota, Illinois plant. The 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 print characteristic study.

	Waterless	Conventional
Press	Harris M90	(same)
Paper	Norkol CTD Free 60 lbs	(same)
Plates	Toray Negative	Du Pont Howson PN85
Exposure Control	UGRA	(same)
Inks	Flint Aero Dri	Sun Versatuff Process
Fountain Solution	---	Rycoline Ultra/Ph = 4.2
Blankets	Day 9500	(same)
Press Speed	600 fpm	(same)
Inking Sequence	KCMY	(same)
Add'l Temperature Control	Tri Service	(same)

The test form consisted of linearized tone scale wedges, one for each process color. Each set of wedges was screened with rulings of 133 lpi, 150 lpi, 200 lpi and Accutone™ at 1000 dpi. Accutone is RR Donnelley's proprietary stochastic screening algorithm. The forms were RIPed and output on an Optronics CS4000 imagesetter at 4000 dpi plotting resolution. Dot area readings were made on the film to confirm the linearization.

A color control bar was included on the test form to provide a means for press control. The methodology was to match the test form solid density with the normal production density. Densities were measured with an X-rite 418 (with E-response) densitometer. The average solid ink densities over six press samples are listed in Table 2.

Table 2. Average solid ink densities over six print samples.

	Black	Cyan	Magenta	Yellow
Waterless	1.70	1.35	1.45	1.32
Conventional	1.63	1.19	1.35	1.10

The waterless process was run first and then followed by the conventional process. When the test form density matched the normal production density, samples were collected.

Color Space

Six samples were randomly selected from each of the waterless and conventional test runs. The color space of the two processes were measured using the CIELAB system in which a color is described by (L*, a, b) values. The (L*, a, b) values were measured with a Gretag SPM100 Spectrophotometer. The six samples from each process were measured and averaged. The results are plotted in Figure 1.

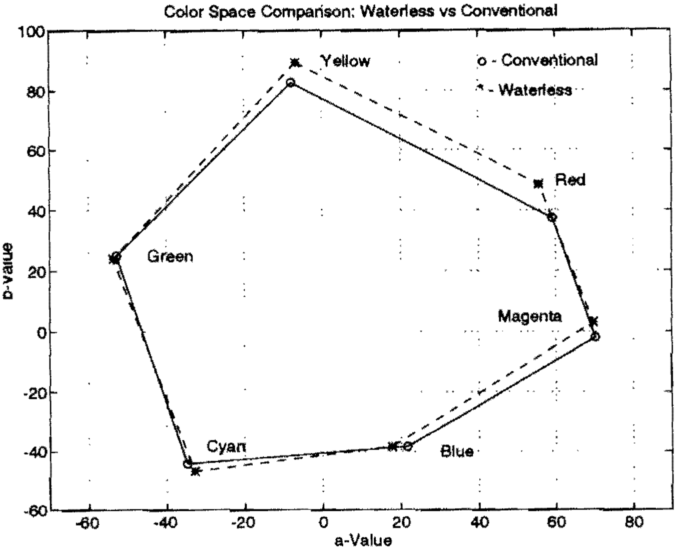


Figure 1. Color space comparison between waterless and conventional process.

In general, the color spaces of the two processes are similar. A slightly larger waterless color space (in yellow, orange and red color region) is mainly due to its higher solid ink densities.

Dot Gain

Much has been discussed about the dot gain behavior of the waterless printing process. The test results showed a large difference in dot gain among the four different screen rulings and between the two offset process. The dot gain values for each color, each screen ruling and each offset process were averaged from six random samples. Then the dot gain values for each screen ruling were averaged from the dot gain values of the four process colors. The dot gain values were plotted against the measured film dot percent in Figure 2 and Figure 3. The photomicrographs of the film, the conventional plate, the waterless plate, the conventional print and the waterless print are shown in Figure 4.

The dot gain curves in Figure 2 and Figure 3 show that the waterless process consistently yields much lower dot gain than its conventional counterpart for all the screen rulings. For regular halftone screening (133, 150, 200 lpi), the waterless dot gain is only about half of that of its conventional counterpart. For stochastic screening, the conventional process yields a maximum of 45% dot gain while the midtone dot gain of the waterless process is about 23%. Also, using the stochastic screening, the dot gain curve of the waterless printing appears to be more symmetric than the conventional process. This confirms the results reported by A. Stanton.

The photomicrographs in Figure 4 show that the conventional and the waterless plate have about the same dot area in the 50% tone value. Much of the dot gain difference between conventional and waterless process is generated by the printing process

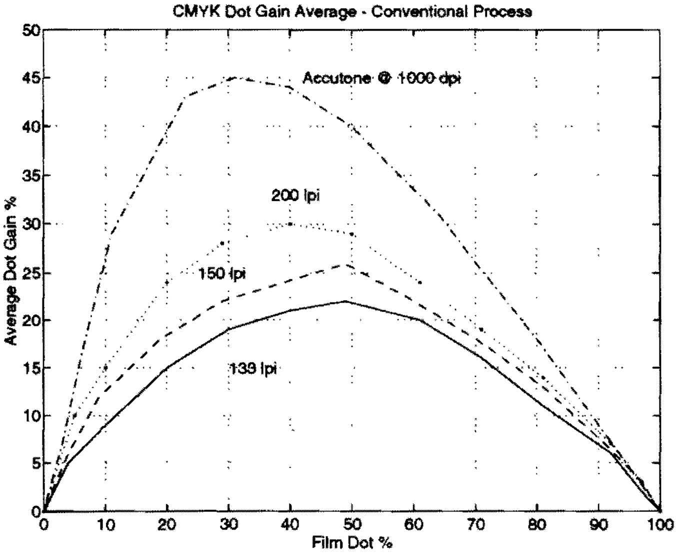


Figure 2. Dot gain behavior of conventional offset.

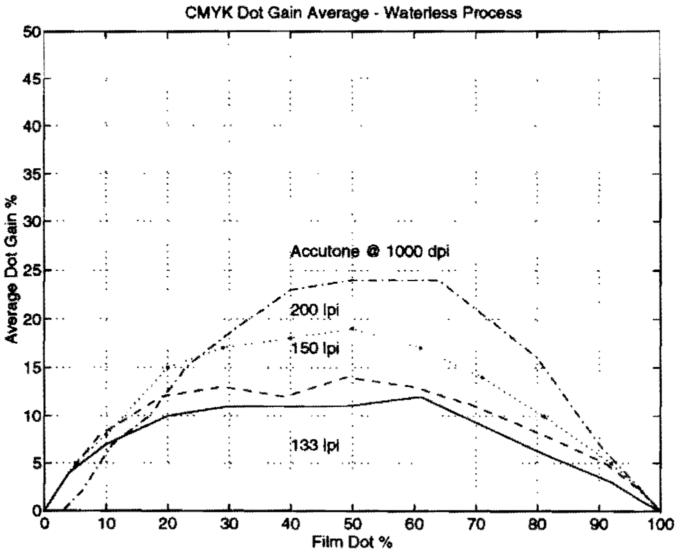


Figure 3. Dot gain behavior of waterless process.

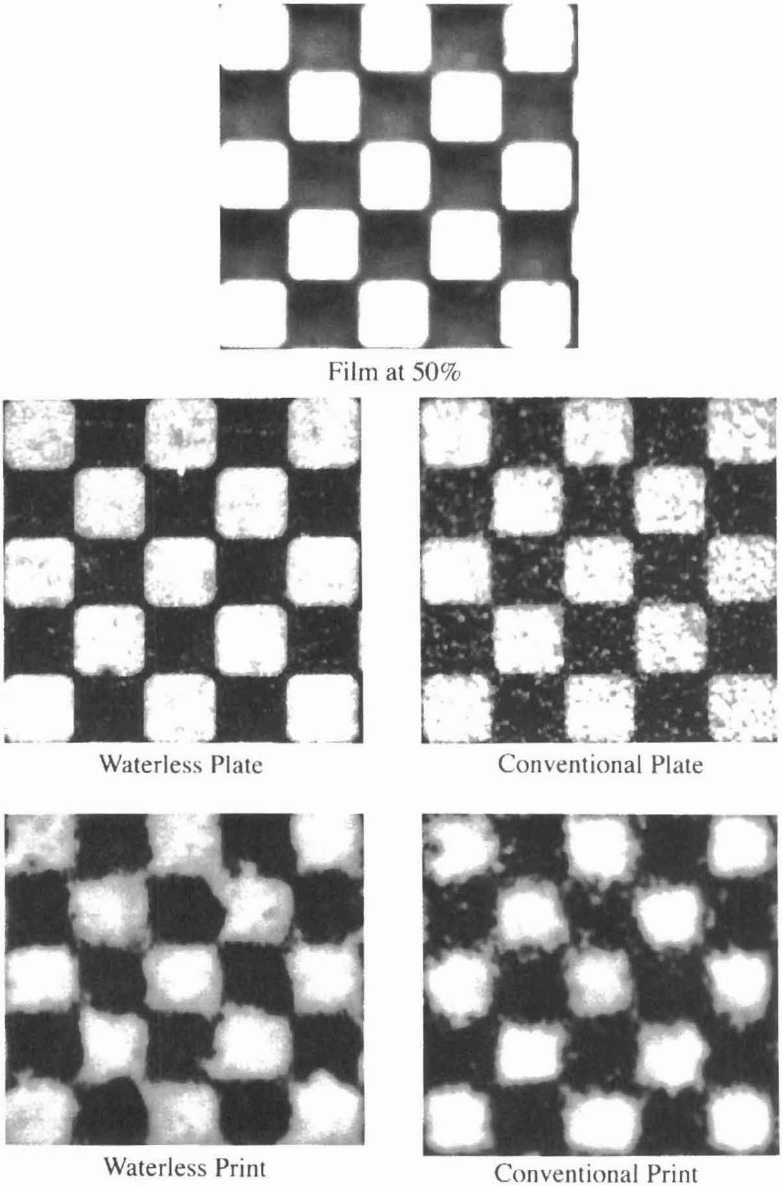


Figure 4. Photomicrograph comparison between conventional and waterless plates and prints.

itself. The size of conventional dot on paper is much bigger than its waterless counterpart. Also, the ink film of the waterless dot on paper appears be to more uniform and thicker.

Print Contrast

The print contrast index is derived from the solid and the 75% tone patch. The print contrast is closely correlated with the dot gain. It quantifies the visual change in contrast between solid and the 3/4 halftone areas. The higher the print contrast index, the sharper the print. The print contrast for each of the 133 lpi, 150 lpi and 200 lpi screening rulings is tabulated below in Table 3 for the waterless and the conventional process.

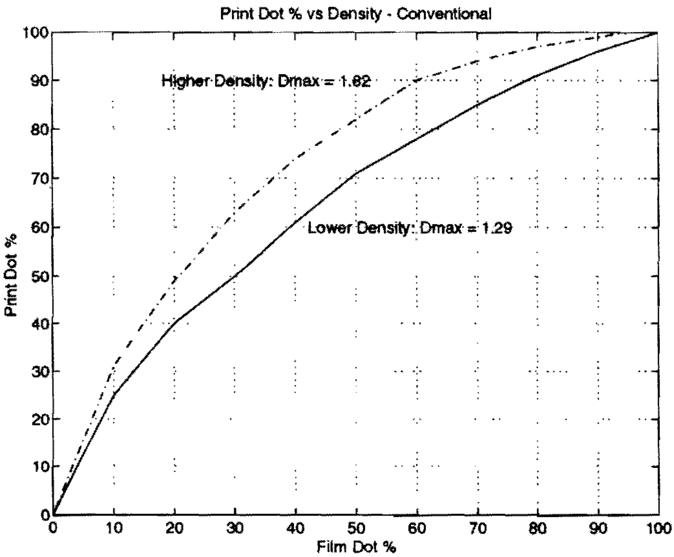
The print contrast for the waterless process is higher than its conventional counterpart by an average of 9.73 for the 133 lpi screen, 9.33 for the 150 lpi screen and 4.72 for the 200 lpi screen. This increase is consistent with the lower dot gain

Table 3. Print Contrast: Conventional vs. Waterless printing

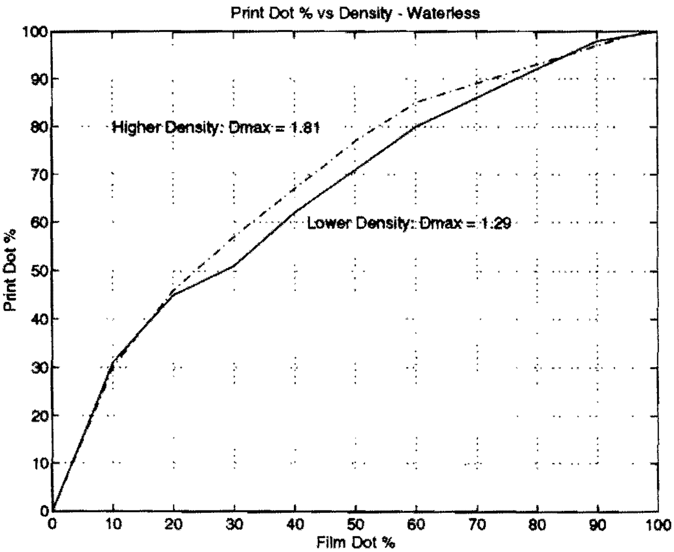
Screen Ruling	Color	Conventional	Waterless	Contrast Difference	Average Contrast Difference
133 lpi	Cyan	29.38	44.13	14.75	
	Magenta	33.58	43.00	9.42	
	Yellow	55.77	60.03	4.27	9.73
	Black	39.98	50.47	10.48	
150 lpi	Cyan	29.78	42.02	12.23	
	Magenta	28.75	42.32	13.57	
	Yellow	58.72	61.75	3.03	9.33
	Black	37.88	46.38	8.50	
200 lpi	Cyan	27.05	33.23	6.18	
	Magenta	25.95	34.90	8.95	
	Yellow	59.53	55.97	-3.57	4.72
	Black	34.47	41.77	7.30	

experienced with the waterless process. The smaller dot gain yields more tone details in the shadow area.

Another way of looking at the print contrast is to examine the printed dot percent change as a function of solid ink density. Figure 5 plots the conventional and waterless input-output dot percent transfer function at two different inking densities. (The dot percent values are computed from density measurements using Yule-Nielson formula.) When the solid density increases from 1.29 to 1.81, the conventional dot percent on paper for a 75% film dot increases from 88% to 96%, while the waterless printed dot increases only from 89% to 91%. It appears that, as the solid ink density increases, the conventional dot grows in size as well as in ink film thickness while the waterless dot grows mainly in ink film thickness. This remarkable difference

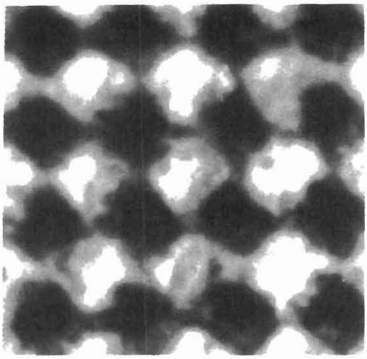


(5.a)

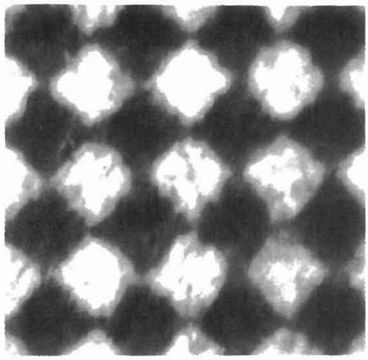


(5.b)

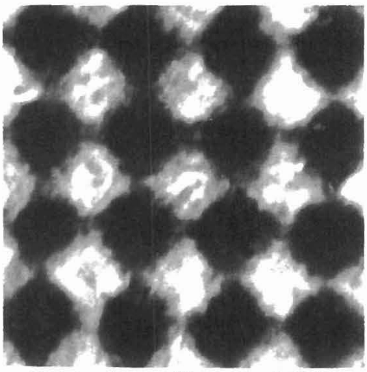
Figure 5(a-b). Conventional and waterless input-output dot percent transfer function at two different solid densities



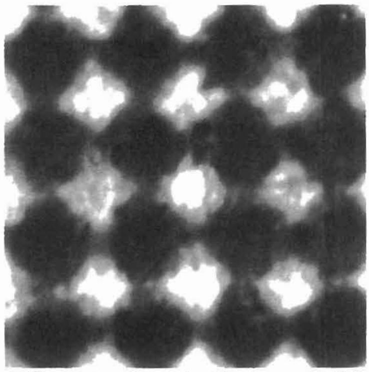
Waterless, Dmax=1.29



Conventional, Dmax=1.29



Waterless, Dmax=1.82



Conventional, Dmax=1.83

Figure 5.c Photomicrograph of 50% conventional and waterless dots at two different print densities.

indicates that the waterless process has the ability to print higher ink densities without losing the shadow details. Figure 5.c shows the photomicrographs of the 50% halftone dots on paper at two different densities for waterless and conventional processes. At Dmax=1.29, the dot size of waterless and conventional are comparable. But at Dmax=1.82, the conventional dots are much bigger than its waterless counterparts.

The Ink Mileage Study

Today, waterless ink commands a higher price than its conventional counterpart. In addition, it has been reported that the waterless process uses more ink ranging from a few percent more to as much as 40%. The extra cost of ink could easily offset any savings achievable from eliminating fountain solution and reducing makeready and run waste. This study attempts to provide a more precise estimation of ink consumption for the waterless process as compared to the conventional offset.

Two print tests were run at the Rochester Institute of Technology. One test was run with the waterless process and the other was run conventionally. The same test form was used for both runs. The methodology for both runs was set up as follows:

The press was makeready to run at 1000 fpm and a "color OK" sheet was determined by matching visually with the Matchprint proof. Solid ink density measurements from the "OK" sheet were used as targets to be matched (+/- 0.07) by the press crew during the test run. Once the targets were determined, the press was stopped. The blankets were washed and all the inks were scooped out of the ink fountains. Inks from unopened kits whose weights had been recorded earlier were used for the test run. About 88,000 impressions were run at the speed of 1000 fpm. Samples were collected at every 2 minute interval to monitor the density fluctuation. At the end of the test run, all inks were scooped out of the fountains back into the kits. The weights of these kits were recorded and the amount of ink consumed was calculated. The waterless test was run first. The conventional run's "color OK" sheet was determined by matching the solid density of the waterless "color OK" sheet. Table 4 summarized the equipment and materials used for this test.

Table 4. Equipment and materials used in the ink mileage study.

	Waterless	Conventional
Press	Harris M1000B	(same)
Paper	Consol Gloss 40 lb	(same)
Plates	Toray Negative	3M GMX
Exposure Control	UGRA	(same)
Inks	Sun Drilith	Sun Heatset Process
Fountain Solution	---	Anchor MXEH Ph=4.0
Blankets	Day 9500	(same)
Press Speed	1000 fpm	(same)
Inking Sequence	KCMY	(same)
Add'l Temperature Control	None	(same)

Ink Consumption Comparison

Figure 6 shows the histogram of four color separations of the test form. The test form is mainly composed of tone scale wedges and typical magazine and catalog images with relatively balanced highlights, midtones and shadows. Three process colors are about evenly distributed. The amount of ink used for two test runs is tabulated in Table 5.

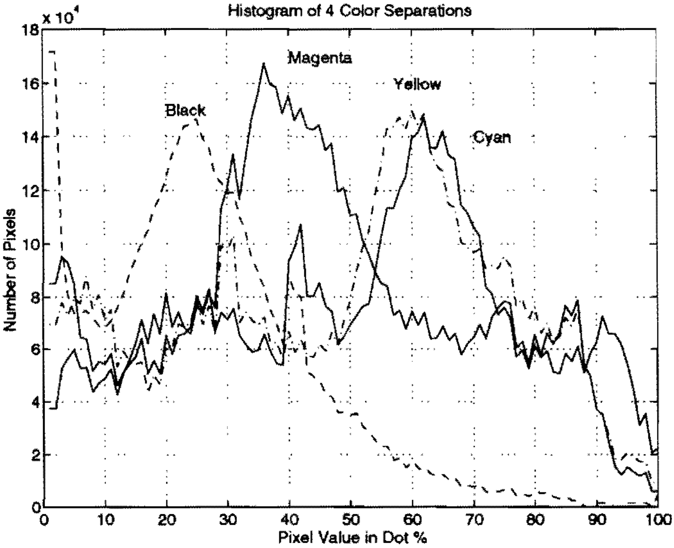


Figure 6. Histogram of 4 color separations in the test form.

Table 5. Density match: Ink consumption by color and process.

	Black	Cyan	Magenta	Yellow	Total
Waterless	45	83	72	84	284
Conventional	45	98	63	70	276
Extra Waterless	0%	-15%	+14%	+20%	+2.9%

The test result shows that more cyan ink was used by the conventional process than by the waterless. Examining the average solid ink density reading throughout the run in Table 6 (X-rite 418 densitometer, T-response) below, reveals that the cyan density for the conventional process is much higher than its counterpart. The continuous process of balancing ink and water in the conventional test has in effect generated more usage of cyan ink. Overall, by matching the solid density between the two processes, the ink consumption of waterless process is about +2.9% more than the conventional process.

Table 6. Average and range of solid densities throughout the run

	Black	**Cyan**	**Magenta**	**Yellow**
Waterless	1.88 (2.00 ~ 1.76)	1.60 (2.03 ~ 1.17)	1.49 (1.67 ~ 1.30)	1.05 (1.29 ~ 0.81)
Conventional	1.95 (2.08 ~ 1.83)	1.70 (1.92 ~ 1.48)	1.42 (1.52 ~ 1.32)	1.10 (1.19 ~ 1.01)

Since the dot gain of the two processes is different, when matching the solid density of the two processes, the conventional press sample looks heavier than the waterless sample. In a previous conventional test run on the same press and the same test form, where the conventional press samples were visually matched by the waterless printed images in the midtone range, the conventional ink consumption was calculated to be 248 pounds total. Compare to the waterless run, the increased of waterless ink consumption is about 14.5%. The ink consumption of the three test runs are summarized in Table 7. The density readings of all these tests are plotted as a function of film dot percent in Figure 7 (X-rite 418, E-response).

Table 7. Ink consumption comparison: waterless vs. conventional.

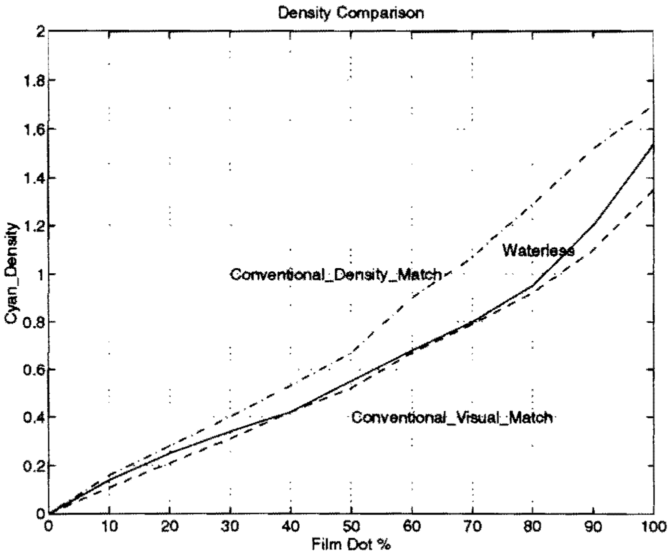
	Ink Used (lbs)	**Extra % of Waterless Ink Used**	**No. of Impressions Printed**
Waterless	284		87,770
Conventional Density Match	276	+2.9%	87,770
Conventional Visual Match	248	+14.5%	Projected from 19,500 impressions with 55 lbs of ink

Note: Conventional density match means attaining comparable or higher density at solid.
Conventional visual match means attaining comparable density at midtone to achieve visual match.

The test results draw the range of extra ink consumption for the waterless printing process. If only the solid density of both processes is required to be matched, the increase is a mere +2.9%. If the output of the two processes is to be matched visually by matching their midtone densities, the increase is going to be +14.5%.

This increase of ink consumption can be attributed to the fact that the midtone dot gain for the waterless process is about 50% less than its conventional counterpart. As a result, in order to obtain the same visual match, more ink is required to punch up the midtone. For this study, no extra effort was expended to compensate for the dot gain on the film.

There are many ways to reduce ink consumption of the waterless process. One logical move is to adjust the film curve to compensate for the smaller dot gain in the waterless process. If both processes achieve comparable densities throughout the tone range, the ink consumption difference should be less than 14.5%. Increasing the screen ruling is one way of bringing the waterless midtone dot gain to a more


Density Comparison
Cyan_Density
Film Dot %
Waterless
Conventional_Density_Match
Conventional_Visual_Match
0
0.2
0.4
0.6
0.8
1
1.2
1.4
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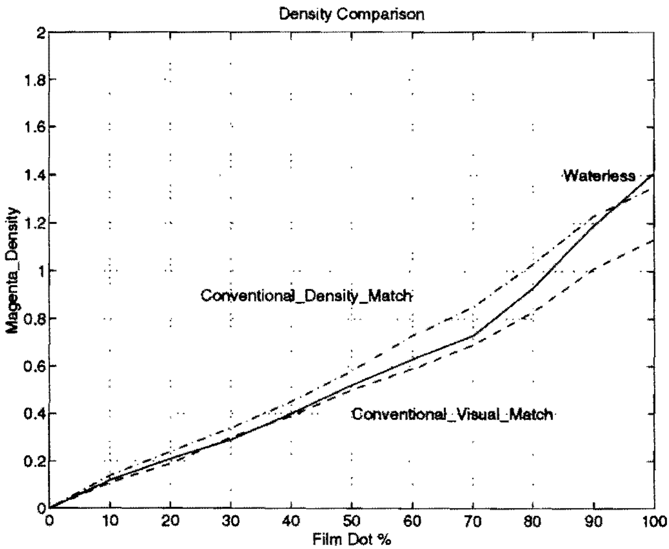
1.8
2
0
10
20
30
40
50
60
70
80
90
100
(7.a)


Density Comparison
Magenta_Density
Film Dot %
Waterless
Conventional_Density_Match
Conventional_Visual_Match
0
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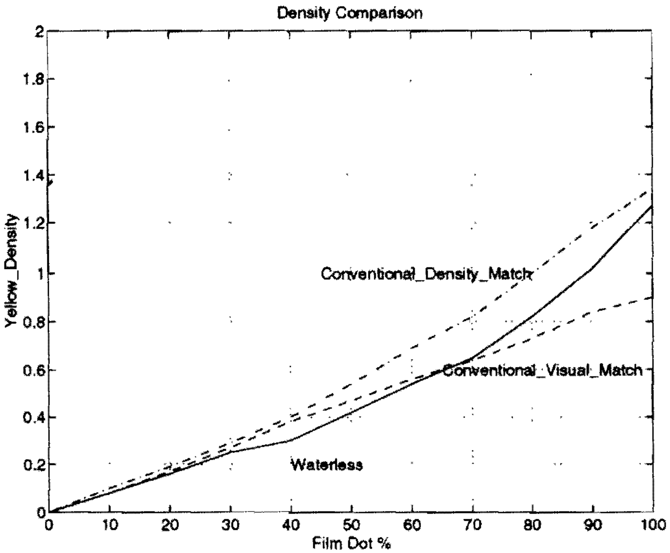
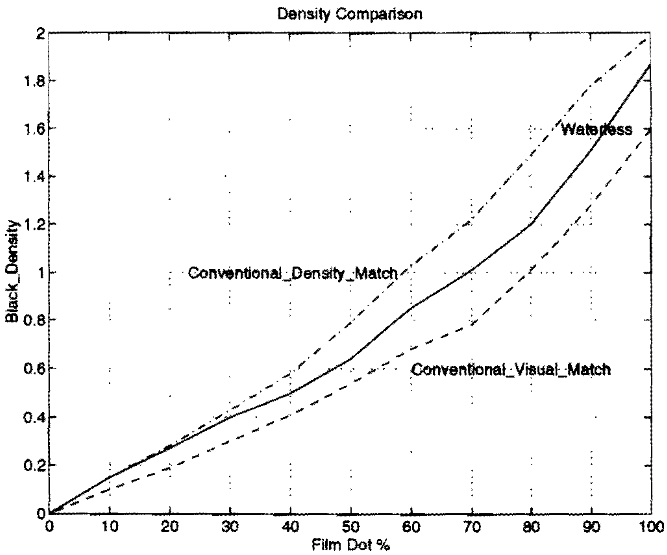


(7.c)



(7.d)

Figure 7 (a - d). Print density comparison between waterless sample and two conventional press run samples as a function of film dot percent.

normal level. A study in Japan showed that the combination of reducing the thickness of the silicone film in a waterless plate from 2 microns to 1.75 microns and increasing the pigment content in the ink can also generate a remarkable decrease in ink consumption.

Conclusion

The results in this study represent a specific set of test conditions. The test form, the materials and the printing presses are all unique. These results cannot be completely generalized to different printing conditions. But it can certainly serve as a guideline for all who are interested in deploying the waterless technology.

The color space is quite similar between the waterless and the conventional process. There should be no need of major color adjustments in switching from conventional to waterless.

Dot gain is less for waterless and the reduction is even greater when using stochastic screening. This observation indicates that the waterless process can be coupled with stochastic screening to produce very high quality printing.

The waterless printing generates better print contrast than its conventional counterpart. Using waterless process, higher print density can be achieved without scarifying the shadow details. Also, more spatial details can be reproduced by waterless process due to its well-defined dot shape.

The extra ink consumption for the waterless process can seriously offset any savings that may be achievable by reducing makeready and run waste. This study established the range of extra ink consumption for the process. If the shadow and solid density of the waterless print is to be matched by its conventional counterpart, the extra ink use is about +2.9%. However, if the waterless image is to be matched visually with the conventional printed image, (i.e., punching up the midtone of the waterless printing to compensate for its lower dot gain), it could use as much as +14.5% more ink.

Several methods have been proposed to reduce waterless ink consumption. Further research should be conducted to confirm these methods.

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Flint Ink.

Day International.

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