Flexo Quality Consortium
Research Committee of the Foundation of FTA

Taming the Flexo Process Volume III

Doctor Blade Project

Phase I Experiment and Phase II Verification

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Table of Contents

Chapter 1
Introduction

The flexographic industry has, over the past few decades, enjoyed a period of rapid growth. This growth has been accompanied by profound changes in printing technology, both in flexo and other segments of the printing industry. In order to help the industry cope with these technological changes, the Flexo Quality Consortium (FQC) was formed in 1990 to investigate the flexo printing process and gain a better understanding of the factors controlling the quality of the printed image. The FQC's mission statement:

The Flexo Quality Consortium (FQC), acting as a select standing committee of the Foundation of Flexographic Technical Association, Inc. (FFTA), will provide the industry with a better understanding of the factors controlling the quality of the flexographic image. FQC projects investigate selected printing variables in flexographic printing technology.

The Consortium is directed by a steering committee that develops and evaluates proposed research projects. Open participation is encouraged by qualified technical representatives from companies in the printing industry on a non-discriminatory basis. A simple philosophy guides all FQC projects in the experimental design and execution:

- The Consortium will use only commercially available materials - no proprietary products or products under development. The goal of the Consortium is to provide process research for the members of the flexographic community, not to do R&D work for the members of the Consortium.
- The Consortium will use industry standard practices throughout - no special procedures to make any component (plate, anilox, ink, etc.) perform better. This avoids biasing the results and further ensures that each company will be able to duplicate and / or apply the results of the experiment to its own equipment.
- The Consortium will use a statistically designed experiment to assure a total systems approach. This type of experimentation yields the highest quality data with the smallest outlay of time and materials.

Projects follow a well-defined sequence of steps; they are *designed experiments.* Broadly speaking, the experiments are performed under controlled conditions, holding all input variables constant and changing selected input variables according to a statistically designed plan. Specified output parameters are measured and analyzed, again using statistical techniques. This part is Phase I of the experiment. Phase II consists of a validation run to verify the results. In both phases, trials are conducted and the experiment involves using a well-defined target. (The process model used is illustrated in Figure 1-1.)

In recent years, another type of experiment has been carried out called a process capability study. These studies still adhere to the philosophy outlined but don't necessarily adhere to the process model shown in Figure 1-1. These types of projects represent an expansion of the original concept of the types of projects undertaken by the FQC and seek to answer specific questions regarding some aspect of flexo printing. A good example is the project undertaken to determine the ability of the flexo industry to use the Pantone Color Formula Guide as a color standard.

The purpose of this document is to present the findings of the Doctor Blade Project. As such, there will be no detailed exposition on how to design a statistical experiment, nor of all the project steps the team went through in order to successfully carry out this project. These topics have been ably covered in the first ***Taming the Flexo Process "A Beginning"*** and the ***Operating Guide for FQC Team Members.***

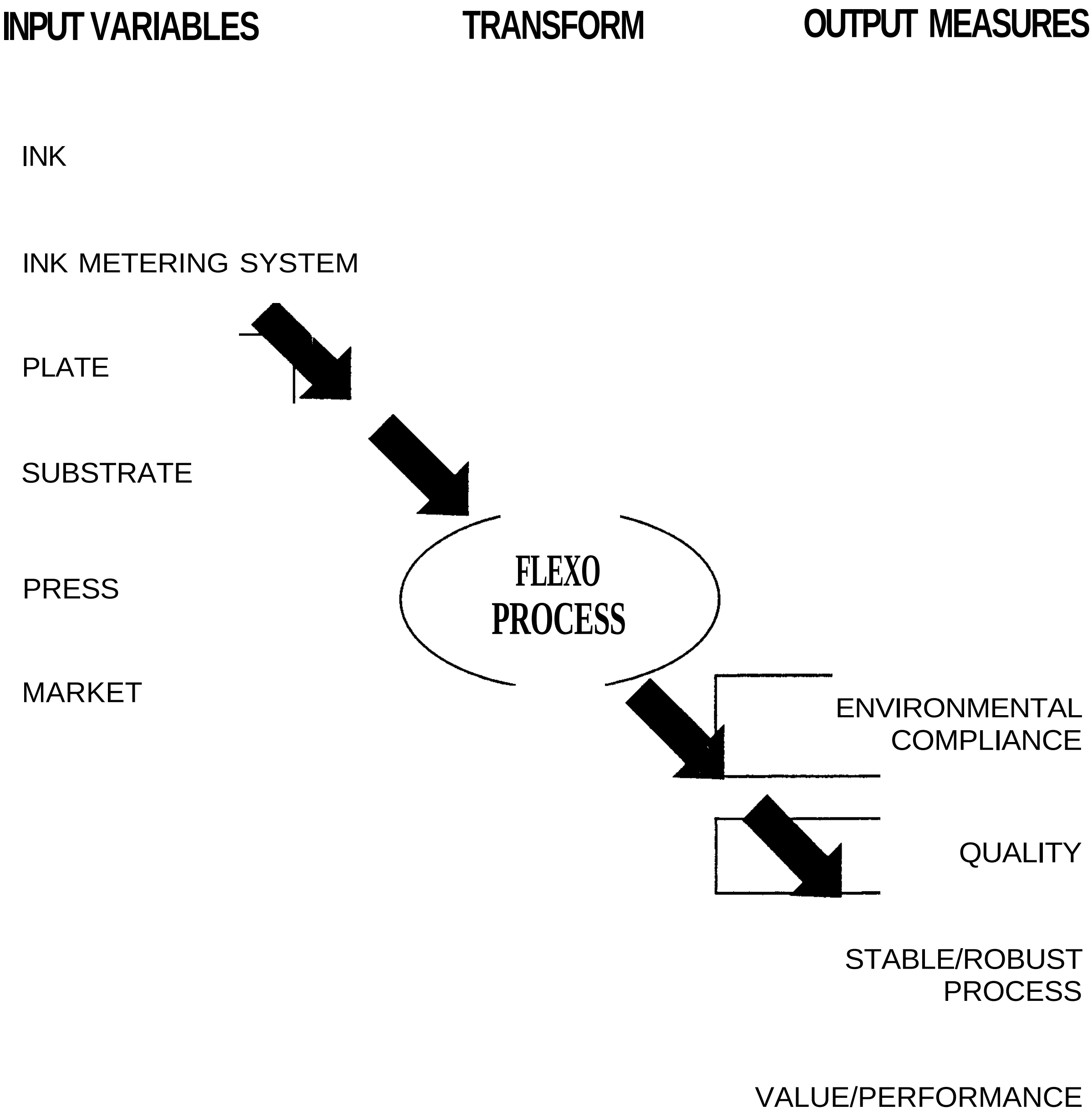


Figure 1-1: Process Model

Chapter 2
The Experiment

Background

Today's flexo printer has come to embrace chambered doctor blade systems as the preferred method of metering ink from the anilox roll. While these systems may seem relatively new, doctor blade systems have patents dating back to the early 1930s. A number of systems entered the flexo or aniline market numerous times throughout the last few decades only to be tossed aside due to their unreliability. Chambered doctor blade systems really became popular about 10 to 12 years ago. Their early popularity was spurred by the need to control the VOCs in solvent-based inks, a need that coincided with the development and acceptance of laser eng[illegible] ceramic anilox r[illegible]

doctor blade systems could team up with the long lasting wear characteristics of laser engraved anilox rolls that they became a viable alternative to ink metering. This combination of chambered doctor blades and ceramic anilox rolls enabled the flexo printer to deliver a consistent and repeatable film of ink to the printing plates.

As chambered doctor blades have become the ultimate method of delivering and metering ink to the anilox rolls, many variables have been taken for granted. This FQC project was formed to analyze several factors and old paradigms with respect to chambered doctor blade systems.

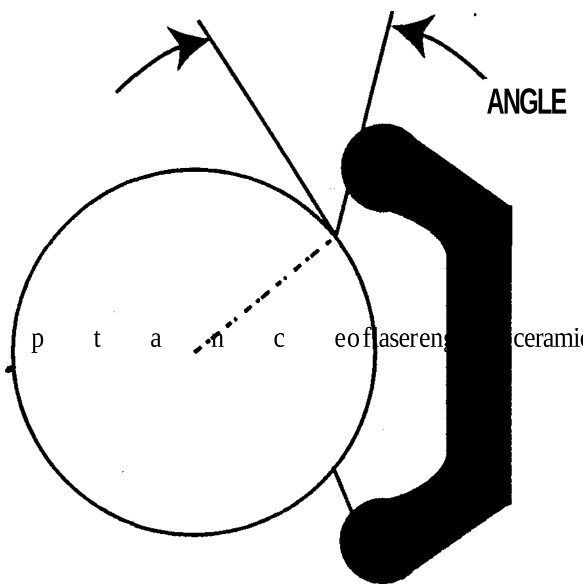


Figure 2-1: Schematic of the doctor blade chamber. Blade metering angles were 26, 32 and 38 degrees.

Project Focus

The team was formed at the Forum in New Orleans in May of 1997. The team's mission statement:

"To determine how doctor blade variables affect printing characteristics in the flexographic printing process."

While doctor blade systems have become an accepted method of metering ink, there has been much discussion of the variables that can be changed on these systems. There is a large number of blade materials that can be used for various printing conditions. Other variables, such as blade angles, dwell times, cell packers and self-cleaning systems, are all pan of the variables that today's printer has to son through. While there arc many variables that can be analyzed and measured, the Doctor Blade team limited the scope of the project to stay within the FQC guidelines of completing the project within one year.

The press trial was run at Fox Valley Technical College, Appleton, WI, October 9 and 10, 1997, on their 16" narrow web press. Following are the constants, variables and conditions used for the press trial.

Materials, 5 inputs:

- Stainless steel, honed, .006"
- Blue Steel, honed, .006"
- Blue Steel, unhoned, .006"
- Blue Steel, honed, .008"
- Plastic (Esterlam)

Traditionally, it has been thought that the thinner, honed materials do a belter job of metering the ink from the surface area of the anilox roll. The honed materials also do not require a dwell period to develop an angle.

Blade Metering Angles:

- 26 degrees
- 32 degrees
- 38 degrees

Blade angles were run as shown in Figure 2-1. Blade angle is paramount to longevity of the blade. This factor was not measurable due to the time constraints of the trial. Blade angle also should affect the metering effectiveness, due to the change in the shear angle.

Trial Constants:

- Chambered doctor blade systems, air loaded, constant blade pressure
- Kiss Impression
- Cyan water based ink (Wernekesystem SX-II)
- Ceramic, anilox roll, 60 degree laser engraved, with 600 lpi and 2.5 (Interferometric measurement) bcm
- Constant press speed for all trials at 300 fpm.
- Fasson high gloss 40 lb liner stock
- .067 photopolymer plate
- Soft cushion stickyback

Test Image (see Figure 2-2):

- Gray scales 2% -100% in 120, 133, and 150 screen rulings
- Output with no cutback; film dot percent shown in Table 2-1.
- 1O%-30%-70% tint blocks

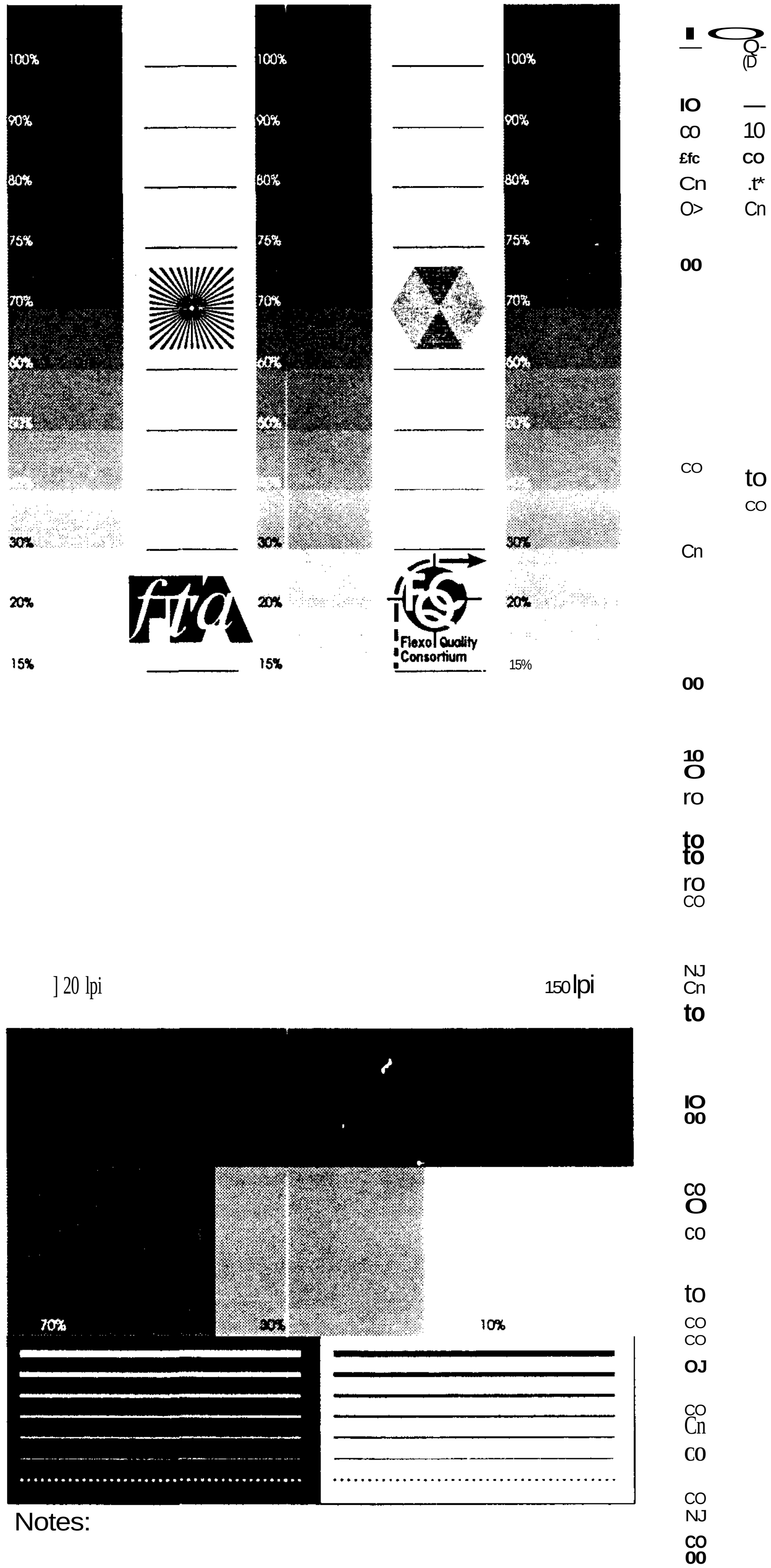
Output Measurements:

- Dot Gain
- Solid Ink Density

Film Dot Percent

Target Value	120 lpi	133 lpi	150 lpi
2	2.4	2.3	1.8
3	3.6	3.6	2.9
4	4.7	4.6	4.1
5	5.8	5.7	5.1
10	11.0	10.9	10.2
15	16.2	16.0	15.4
20	21.2	21.2	20.3
30	31.3	31.1	30.0
40	40.9	40.8	39.8
50	50.9	50.9	49.6
60	61.0	60.9	59.9
70	70.8	70.9	70.0
75	75.5	75.6	75.0
80	80.4	80.4	80.1
90	90.2	90.2	89.9
100	100.0	100.0	100.0

Table 2-1



Notes:

Figure 2-2: Test Image

Chapter 3
Press Trial 1

All runs for press trial 1 were on the Mark Andy 4150 narrow web press. Each blade angle and material combination was run four times. In order to satisfy the randomness requirement of a controlled experiment, the run sequence was randomized as shown in Table 3-1. In the table, the ID number refers to a particular doctor blade angle/material combination.

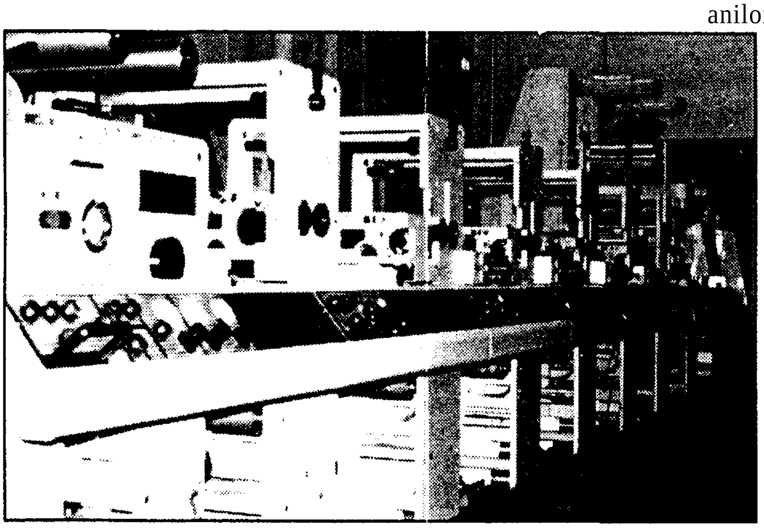


Figure 3-1: View of Mark Andy Narrow Web Press at Fox Valley Technical College.

All other input variables were held constant and monitored to assure that nothing had changed outside acceptable limits. Table 3-2 shows the results of the volume measurements of the anilox roll. In this table, the run number is simply the sequential number of all the runs. During the beginning of the trial, measurements were taken more frequently. Toward the end, we were comfortable that the anilox roll was not plugging and we were also under some time pressure to complete the trial by the end of the second day, a Friday.

The ink used was a waterbased cyan ink. It was monitored throughout the run by measuring pH and viscosity. Viscosity was measured with a #4 shell cup and ranged between 37 and 41 seconds. The pH values ranged from 9.5 to 9.7.

The plan was to run on a plastic coated substrate: Flexcon pressure sensitive stock. Unfortunately, the ink we had was not compatible with this stock. When we tried to run the combination, we had a great deal of trouble printing solids. Rather than abandon the trial, we switched to a stock that was available, Fasson high gloss 40 lb liner stock. The members of the team felt comfortable with this decision since no requirement had been placed on the stock/ink combination in the experimental design, other than the fact that they should be a compatible combination and the stock should be coated.

Press Run Sequence - Press Trial 1

Angle	Blade Material	ID No.	Run #1	Run #2	Run #3	Run #4
26	SS, honed, .006"	1	6	14	3	9
26	Blue Steel, honed, .006"	2	14	8	13	15
26	Blue Steel, unhoned, .006"	3	2	11	2	3
26	Blue Steel, honed, .006"	4	11	5	15	11
26	Plastic (Esterlam)	5	7	7	14	6
32	SS, honed, .006"	6	5	13	6	4
32	Blue Steel, honed, .006"	7	3	2	11	8
32	Blue Steel, unhoned, .006"	8	12	3	4	5
32	Blue Steel, honed, .006"	9	8	6	8	14
32	Plastic (Esterlam)	10	15	10	10	10
36	SS, honed, .006"	11	13	1	7	2
36	Blue Steel, honed, .006"	12		12	1	12
36	Blue Steel, unhoned, .006"	13	10	15	9	13
36	Blue Steel, honed, .006"	14	4	4	12	7
36	Plastic (Esterlam)	15	1	9	5	1

Table 3-1

Volume Measurements - Press Trial 1

Run	BCM	LPI	No. of Cells Measured	Cell Depth (um)
Start	2.45	608	160	8.11
6	2.46	607	168	8.12
9	2.50	607	163	8.26
12	2.46	611	163	8.24
16	2.50	610	160	8.17
23	2.47	601	167	8.27
31	2.50	606	163	8.36
End	2.39	603	167	8.26

Table 3-2

Chapter 4
Press Trial 1 - Results

Summary

The results of press trial 1 can be summarized quite simply: There was no statistically significant difference in solid ink density nor dot gain with either of the input variables of doctor blade angle or material.

Measurements

All measurements were carried out using a scanning spectrophotometer to measure densities of the 2%-100% step scales for each of the three screen values of 120, 133 and 150 lpi. The sample was put on the platen of the spectrophotometer, which is a matte black. Relative densities were measured (i.e., zero out the substrate). From these densities, the dot gains were calculated using the Murray-Davies equation.

Density

Figure 4-1 shows a plot of the solid ink densities of all 15 blade angle/material combinations. The numbers on the "Sample" axis refer to the ID numbers as shown in Table 3-1. For each sample, the center point is the average value and the line is the statistically determined 95% confidence limit (T test). This means that two numbers are statistically different to a confidence of 95% if the bars do *not* overlap. As is evident from the graph, all bars overlap, which means that there was no change in density between the 15 runs.

The statistics were derived from the four repeat runs for each ID number. The densities in Figure 4-1 were taken in the center of the sample, in particular the 133 lpi 100% patch. Taking densities at different locations, such as the 120 lpi or 150 lpi 100% patches or the solid patch across the width of the target, all yielded similar results as is shown in Figure 4-1: that is, no dependence of solid ink density on doctor blade angle or material.

Dot Gain

Figures 4-2, 4-3 and 4-4 show the dot gain curves for 150 lpi, 133 lpi and 120 lpi respectively. Each figure has 15 curves, one for each of the doctor blade angle/material combinations. Each of the 15 curves is the average curve calculated from the four repeat runs for a single combination. Just looking at the curves, it is apparent that they are similar. The question that must be answered is if the variation between the 15 curves is more than the variation within the four curves for a single combination. Figure 4-5 shows the four

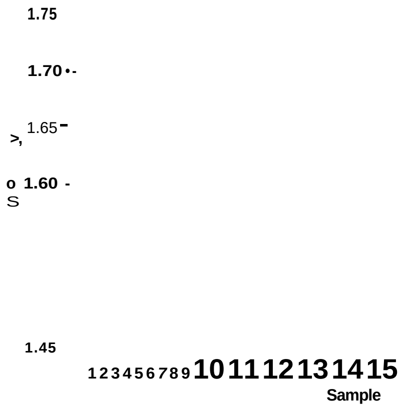


Figure 4-1: Solid Ink Density of 15 different doctor blade configurations.

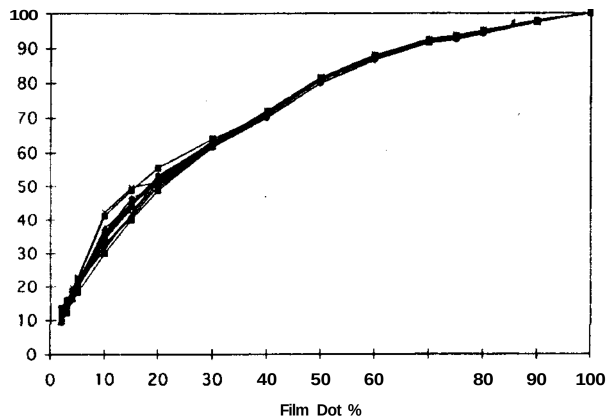


Figure 4-2: Dot Gain Curves of 15 different doctor blade configurations at 150 lpi.

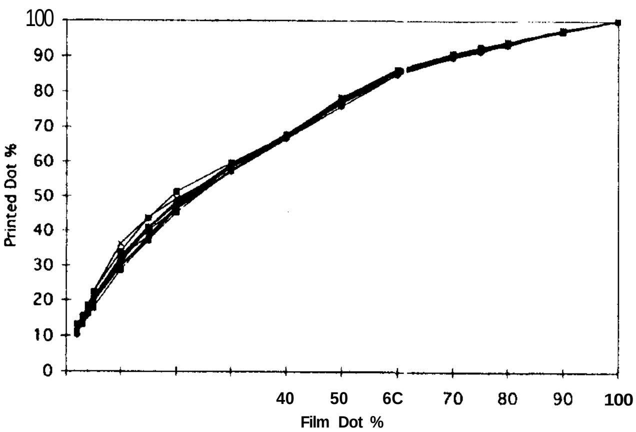


Figure 4-3: Dot Gain Curves of 15 different doctor blade configurations at 133 lpi.

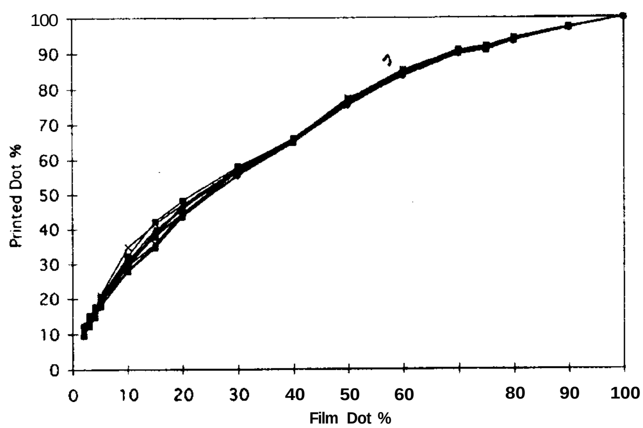


Figure 4-4: Dot Gain Curves of 15 different doctor blade configurations at 120 lpi.

curves for one particular configuration, ID No. 12 of Table 3-1 (honed steel, .006", 36 degrees.) It dramatically shows that the variability within one configuration is comparable to the variability between configurations. That is, there is no correlation with blade angle or material.

Dot Gain Statistics

The last section shows the dot gain result graphically. More detailed statistical analysis bears out the conclusion. At each dot value and screen ruling, the same statistical procedure can be carried out as was done for the density. Two representative plots are shown in Figures 4-6 and 4-7; both are for 120 lpi. Figure 4-6 shows the dot percentage variation for each of the 15 samples at 20% dot and Figure 4-7 at 40% dot. As in the case of density, all bars overlap, which indicates no statistical difference in printed dot percent to a 95% confidence level.

These plots can be generated for all dot values of each of the three screen rulings. Another way to look at the statistics is to run an ANOVA analysis and calculate P values. ANOVA is a statistical program and the P value is a measure to test if a value is statistically different from the rest. For a confidence level of 95%, P must be less than .05 in order to be statistically different. Table 4-1 shows the P values for all dot percentages for the three screen rulings. Note that the overwhelming majority of values are greater than .05, indicating that there is no correlation of dot gain to blade material or angle. The values at 100% confirm no difference in solid density.

Another frequently used output measure is print contrast. Table 4-1 also shows the P values for print contrast. Since there is no difference in dot gain or density, no difference in print contrast would be expected. This is indeed the case: The three P values are greater than .05, indicating no difference. The print contrast was calculated using the solid density and the density at 70% dot.

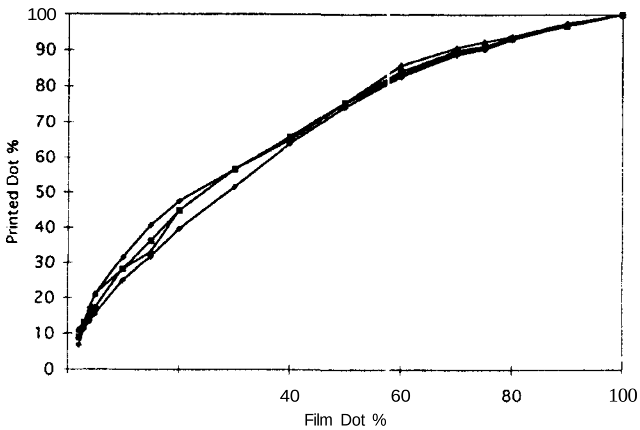


Figure 4-5: Dot Gain Curves of 4 runs for honed steel, .006", 36 degree doctor blade (ID#12.)

51
49 •-
▮ 47
43
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Sample

Figure 4-6: Printed Dot Values of 15 different doctor blade configurations at 20% dot and 120 lpi.

69 f
63
2 3 4 5 6 7 a 9 10 11 12 13 14 1
Sample

Figure 4-7: Printed Dot Values of 15 afferent doctor blade configurations at 40% dot and 120 lpi

ANOVA P values

DOT%	120 lpi	133 lpi	150 lpi
2	0.635	0.874	0.840
3	0.826	0.881	0.650
4	0.817	0.934	0.922
5	0.902	0.569	0.721
10	0.246	0.176	0.150
15	0.494	0.472	0.352
20	0.826	0.675	0.542
30	0.752	0.679	0.695
40	0.434	0.257	0.090
50	0.089	0.001	0.142
60	0.039	0.011	0.096
70	0.150	0.186	0.314
75	0.023	0.025	0.133
80	0.012	0.091	0.221
90	0.864	0.671	0.808
100	0.683	0.855	0.826
Print Contrast	120 lpi	133 lpi	150 lpi
100/70	0.293	0.704	0.518

Table 4-1

Chapters
Press Trial 2 - Validation

What is Validation?

Validation checks the mathematical link between input and output variables. Validation data either supports or refutes the conjecture or the mathematical model developed during the initial or phase I trial. Validation can also imply the repeatability of the first experiment in terms of model verification. On the other hand, repeatability refers to how well one can reproduce a set of print results for a given set of conditions, but repeatability does not imply validation. Parameters have been developed for validation of FQC projects:

- All the validation print trial conditions should fall within the same experimental space as in the original trial.
- Original material and equipment specifications should be maintained.
- Each output value attained by the validation should be within the experimental error of the original model.
- Validation requires development of a model from the results of the original experiment.

Doctor Blade Verification Test

The results of the first press trial showed no effect due to doctor blade material or angle. This was indeed a surprising result and as such, the team decided to deviate somewhat

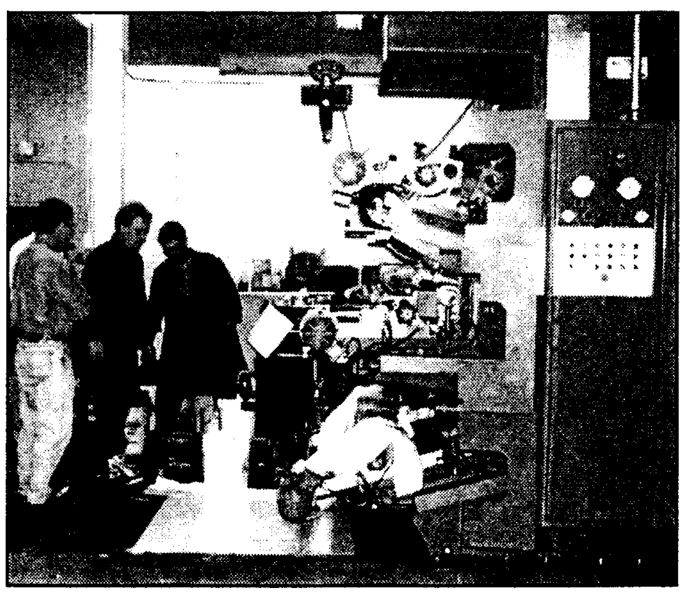


Figure 5-1: View of Carint Wide Web Press at Fox Valley Technical College.

from the strict parameters for a validation experiment. We decided to re-run on the Mark Andy at Fox Valley Technical College (FVTC) using the original substrate with a compatible ink (Werneke 4000-II, cyan), but at a lower density. We also decided to run the same substrate; and ink on the wide web press at FVTC, a Carint 47" wide six-color central impression press.

The goal was not necessarily to repeat the original trial but to verify if the "null" result would hold under somewhat different conditions and on a different press. The test was conducted only with two blade materials, expected to be different, at one angle. Another modification in the trial was to seat the blades by running at speed for five minutes before printing. The verification trials were run on February 26, 1998.

Conditions for Trial 2

The conditions and run sequence for Trial 2 are shown in Table 5-1. For the narrow web part of the trial, the doctor blade angle/material combinations matched those of ID No. 7 (honed steel, .006", 32 degrees) and No. 10 (plastic) of Table 3-1. The substrate was different: Flexcon pressure sensitive stock instead of Fasson high gloss 40 lb liner *stock.* As we learned in the first trial, we needed a different ink to run with this stock. We used a water-based cyan ink (Werneke 4000-11 Series), printing at a lower solid density. All other conditions were repeated as closely to the first trial as possible.

On the wide web press, we ran the same ink and substrate as on the narrow web press. The substrate was physically the same, seven inches wide. We were fully aware that we were probably not optimized for the press but we wanted to run a "sanity check" to see if we still achieved a null result on the wide web press.

As in the first trial, the ink was monitored for pH and viscosity. On the narrow web press, viscosity was measured with a #4 shell cup and stayed constant at 60 seconds. The pH values ranged from 9.0 to 9.4. On the wide web press, viscosity was also measured with a #4 shell cup and ranged from 42 to 52 seconds. The pH held constant at 9.0.

The anilox for both presses was measured before and after each blade material type. Results are shown in Table 5-2.

Press Run Sequence - Press Trial 2

Angle	Blade Material	Press	Press Speed (fpm)
32	Blue Steel, honed, .006'	Narrow Web	300
32	Plastic (Esterlam)	Narrow Web	300
32	Blue Steel, honed, .006'	Wide Web	300
32	Plastic (Esterlam)	Wide Web	300
32	Blue Steel, honed, .006'	Wide Web	600
32	Plastic (Esterlam)	Wide Web	600

Table 5-1

Volume Measurements - Press Trial 2

Narrow Web	BCM	LPI	No. of Cells Measured	Cell Depth (um)
Start Plastic	2.40	574	154	8.33
End Plastic	2.34	594	162	8.09
Start Steel	2.34	594	162	8.09
End Steel	2.42	592	151	8.10
Wide Web	**BCM**		**No. of Cells Measured**	**Cell Depth (um)**
Start Plastic	2.85	584	152	11.59
End Plastic	2.81	583	150	11.75
Start Steel	2.81	583	150	11.75
End Steel	2.84	581	152	11.78

Table 5-2

Chapter 6
Press Trial 2 - Results

Summary

The results of press trial 2 were even more surprising than those of the first trial. On a given press at a given speed, there was no solid density difference between the two doctor blade materials. The surprising result was that the dot gain was slightly less with the plastic blade on the narrow web press at two screen rulings (120 lpi, 133 lpi). On the wide web press, the dot gain was significantly less with the plastic blade at both press speeds.

Measurements

All measurements were carried ou in exactly the same manner as for the first press trial. Again, densities were measured on a matte black surface and the dot gains calculated using the Murray-Davies formula. Since there were no repeat runs, four samples were randomly chosen from each run and measured.

Density

The Narrow Web density result is shown in Figure 6-1. The graph is the same data that was presented in the press trial 1 section, where the bar indicates the 95% confidence limit for the average density value. The bars overlap, which indicates no difference in density.

The Wide Web density result is shown in Figure 6-2. There was clearly a statistically significant difference in the density for the two press speeds, but at each speed there was no difference between the densities using the steel doctor blade vs. the plastic doctor blade.

Dot Gain

For the narrow web press, the same graphs are shown as in the section on press trial 1 results. In this case, there are only two curves for each screen ruling, as shown in Figures 6-3, 6-4 and 6-5. The dashed curve in each figure is the dot gain curve for the plastic doctor blade. The solid curve is the dot gain curve for the steel doctor blade. From looking at the curves, it appears that the plastic blade has less dot gain at 120 and 133 lpi, and the same at 150 lpi. Figures 6-6, 6-7 and 6-8 show the confirming statistics. The dot gains at 40% are shown with the statistical 95% confidence limits. Clearly, for 120 lpi and 133 lpi the bars do not overlap, confirming that the dot gains are indeed different. In both cases, the difference at 40% is about 3%.

For the wide web press, the dot gain curves for the three screen rulings are shown on one graph. Figure 6-9 shows the curves at a press speed of 300 feet per minute, Figure 6-10 at 600 feet per minute. Again, the dashed curves are for the plastic doctor blade. It is clear, without resorting to further statistical analysis, that the dot gain for the plastic blades was significantly less. It is interesting to note that the change with screen ruling closely followed the result on the narrow web press.

Dot Gain Statistics

An important difference in the way the first and second press trials were run was that each configuration was run four times in the first trial. In the second, each configuration was run only once. The statistics for press trial 1 were done using the four repeat runs. The statistics for the second trial were done using four samples within each run. The question that can be raised is whether the variability or statistics in the second press trial were comparable to that in the first. Clearly, this question is only applicable to the narrow web results.

One approach is to assume comparable variability for the narrow web press trials 1 and 2. Many of the conditions were the same and the press was run by the same person in the same way. There is, however, data that supports this conjec-

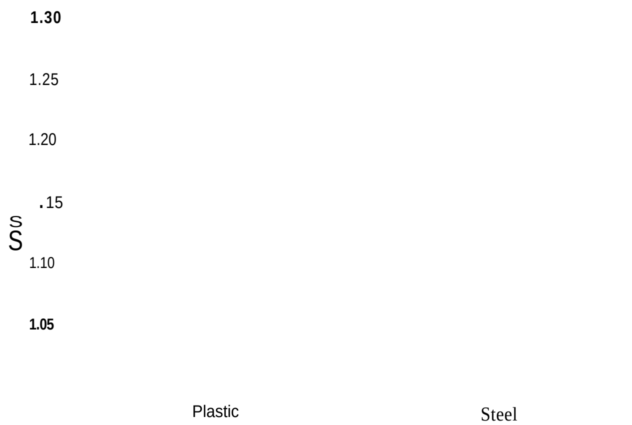


Figure 6-1: Solid Ink Density of two types of doctor blades on Narrow Web Press.

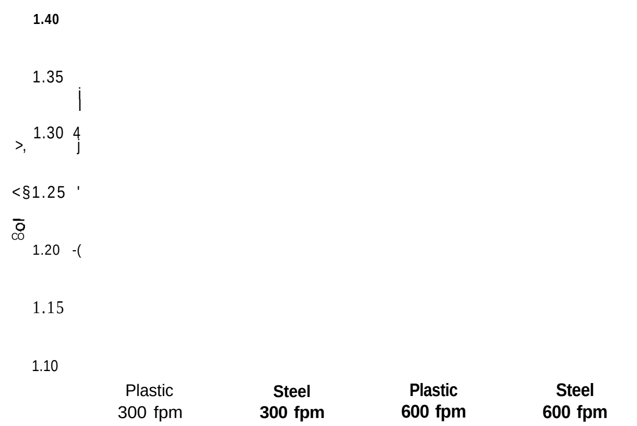


Figure 6-2: Solid Ink Density of two types of doctor blades on Wide Web Press at press speeds of 300fpm and 600fpm.

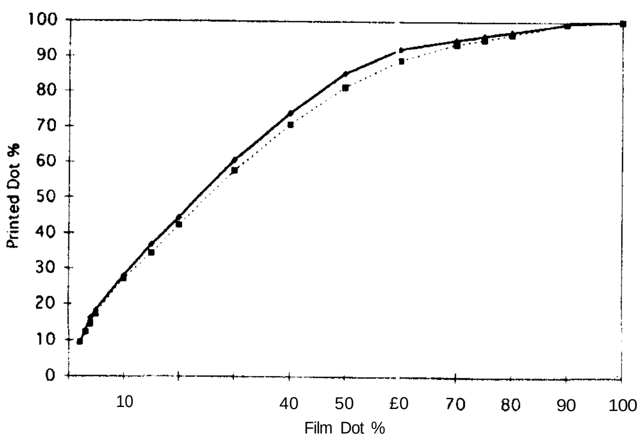


Figure 6-3: Dot Gain Curves of plastic (dash) and steel (solid) doctor blades on Narrow Web Press at 120 lpi.

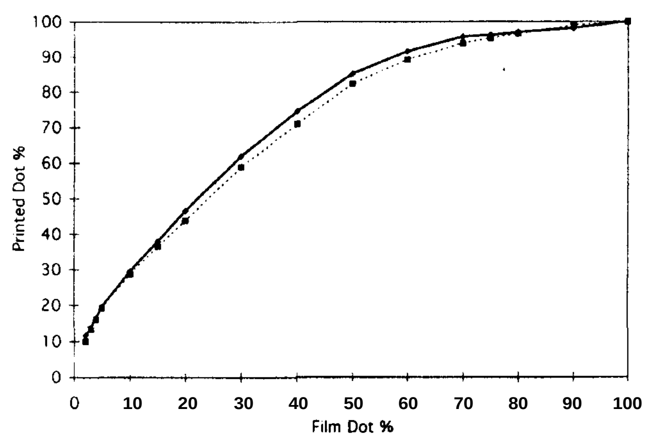


Figure 6-4: Dot Gain Curves of plastic (dash) and steel (solid) doctor blades on Narrow Web Press at 133 lpi.

ture. One piece of evidence can be seen by examining Figure 4-7 on page 11 and Figure 6-6 below. Both show the confidence bars or, equivalently the variability, for the dot gain at 120 lpi at 40%. Note, all error bars are about 2% in range. That is, the variability is about the same.

Another piece of evidence is the change in dot gain as a function of screen ruling. Figure 6-11 shows two screen ruling dot gain curves for the steel doctor blade, 120 lpi and 150 lpi. Figure 6-12 shows the average curves of the two screen rulings for press trial 1. It is to be expected that the curves will not be the same since different substrate and inks were used. However, the difference between the screen rulings is similar. Taking the differences at every dot percentage and comparing them, yields an average difference of less than one dot percent. This supports the conjecture that the behavior and repeatability of the narrow web press, and hence the statistics, were comparable between press trial 1 and 2.

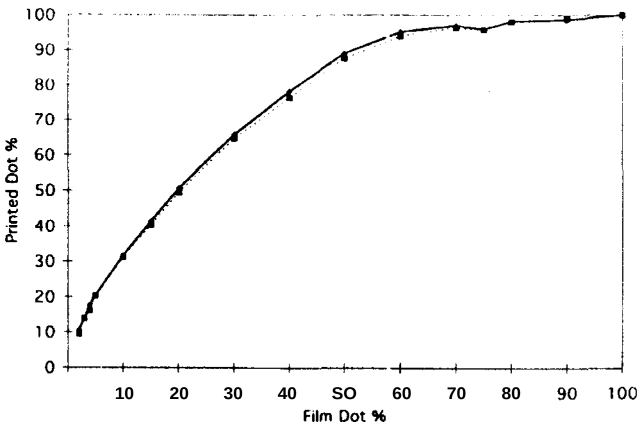


Figure 6-5: Dot Gain Curves of plastic (dash) and steel (solid) doctor blades on Narrow Web Press at 150 lpi.

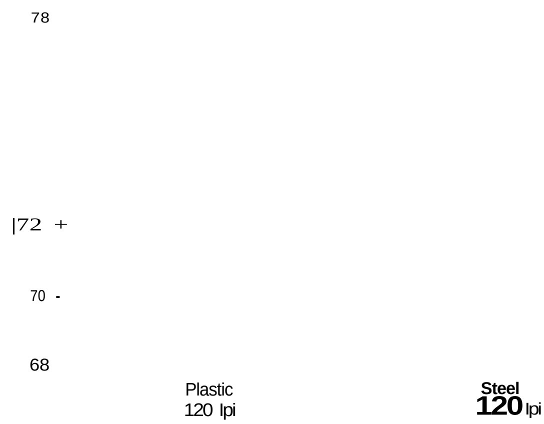


Figure 6-6: Printed Dot Values of two types of doctor blades on Narrrow Web Press at 40% dot and 120 lpi.

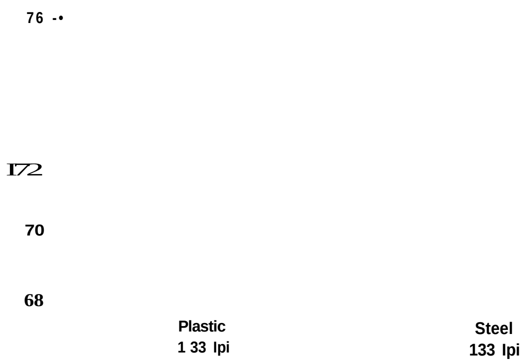


Figure 6-7: Printed Dot Values of two types of doctor blades on Narrrow Web Press at 40% dot and 133 lpi.

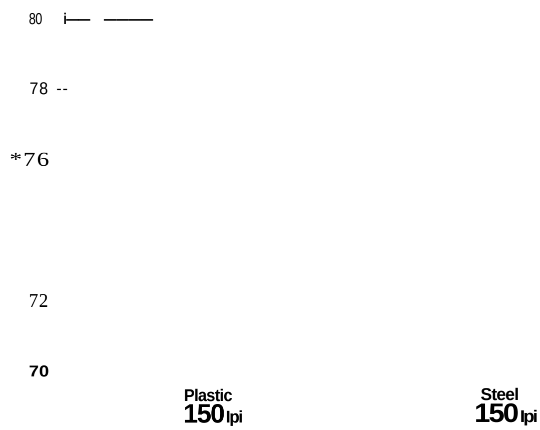


Figure 6-8: Printed Dot Values of two types of doctor blades on Narrrow Web Press at 40% dot and 150 lpi.

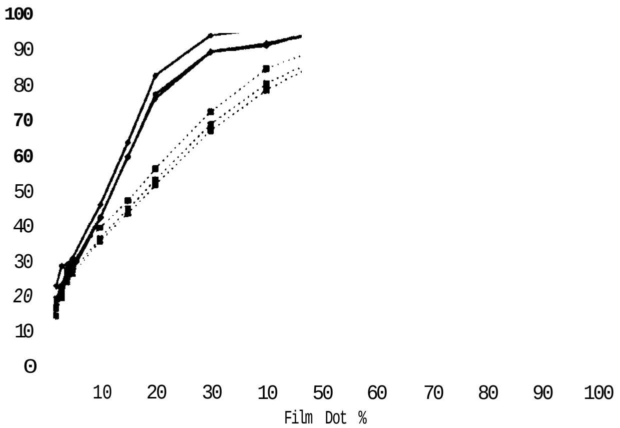


Figure 6-9: Dot Gain Curves of plastic (dash) and steel (solid) doctor blades on Wide Web Press at 300 fpm.

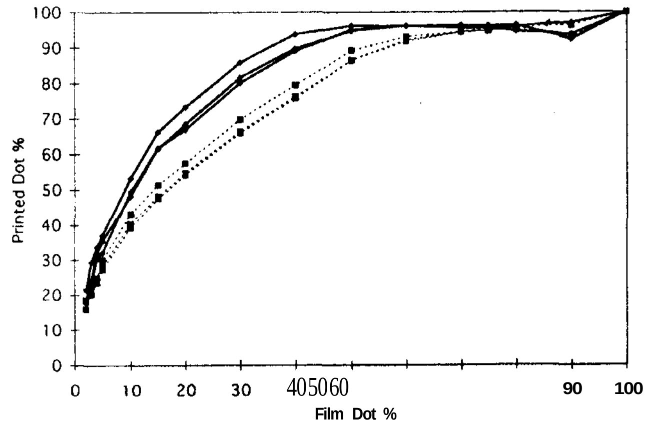


Figure 6-10: Dot Gain Curves of plastic (dash) and steel (solid) doctor blades on Wide Web Press at 600 fpm.

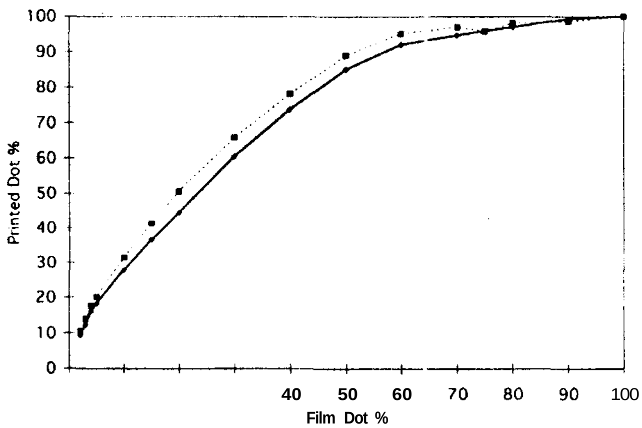


Figure 6-11: Dot Gain Curves of steel doctor blade on narrow web press, press trial two at 150 lpi (dash) and 120 lpi (solid).

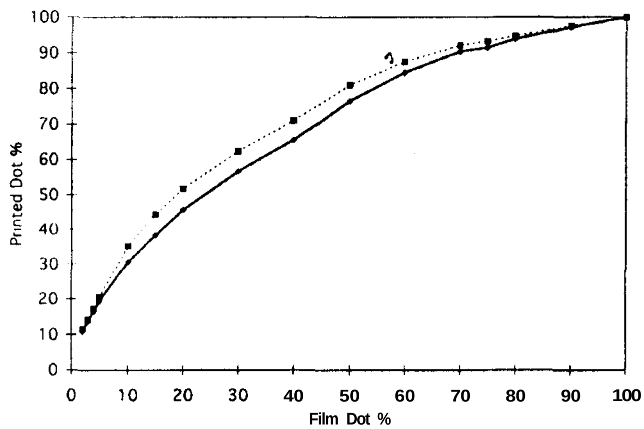


Figure 6-12: Average Dot Gain Curves on narrow web press, press trial one at 150 lpi (dash) and 120 lpi (solid).

Chapter 1
Summary and Recommendations

Summary

The first press trial showed that there was no correlation between solid ink density or dot gain and doctor blade material or angle. Another commonly used metric - print contrast - also showed no correlation. This result was surprising. It was expected that the plastic doctor blade would show more dot gain. Because of this unexpected result, it was decided that the second trial would explore only steel vs. plastic blade, not necessarily at the same conditions of the first trial. The team decided to expand the "experimental space" in order to see if this null result would continue to hold. We did recognize that the solid ink density of the first trial was high, and that was one thing we wanted to rectify. Also, during the first press trial, because of the logistics involved, once the blades were changed and installed, the samples were run immediately. In the second trial, we "seated" the blades by running at speed for five minutes.

The second press trial was run on both a narrow web press and a wide web press. The response and conditions on the narrow web press were similar to the first press run, as shown by some of the results. The ink and substrates were different and the density was nearer to target for the plastic coated paper. Nevertheless, the result again was contrary to expectations in that it showed either little or no effect of doctor blade material - but in the opposite direction as expected. That is, the plastic blade showed slightly less dot gain than the steel blade.

Results on the wide web press were intended only as a sanity check and showed a similar but larger trend: The plastic blade again had less dot gain. Interestingly, some of the other responses were similar to the narrow web result, in particular the dot gain change with screen ruling. Nevertheless, quantitative results developed from narrow web data cannot be used for a wide web press without verification.

Recommendations

The results of this project serve as a new data point in the understanding of doctor blades in enclosed doctor blade systems. We certainly don't consider this the definitive work, and would encourage further testing to verify the findings. Clearly, the project did not show the result of wear, but only the response shortly after startup. Additional FQC projects might be formed using this project as guidance in designing future experiments. Perhaps a different variation of input variables, such as density, substrate and press speed, might be in order. Certainly the wide web result is intriguing and would be an interesting area for further work. The first change for wide web should be to run a wide stock with ink optimized for the wide web press.