Characterization of Anilox Rollers

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Abstract: Through this study we will compare the quality of print using four anilox rollers at 400, 700, 900, and 1600 lpi.

A Mark Andy 4150 flexographic printing press will be used for the testing. A test form will be developed to test the print reproduction characteristics of anilox rollers in the following areas:

1. Density of Solids
2. Dot Gain
3. Minimum and Maximum Dot
4. Positive and Negative Type Face Serifs
5. Minimum Reproducible Hairline
6. 150 line Screen Image

Each anilox roller demonstrated its unique characteristics. The amount of ink laid down in the solid area by the 400 lpi anilox roller was dense. The 700 lpi anilox roller performed as a good compromise between the 1600 lpi and the 400 lpi anilox rollers. The smallest positive and negative type printed well with the 900 lpi roller. The 1600 lpi anilox roller printed excellent fine lines and 3 point type.

Results from this project will provide the prepress operator with the necessary data to compensate for anilox roller deficiencies during prepress. It will also serve as a guide when determining what type of anilox roller to use for a particular job.

Hypothesis

This project studies the relationship between anilox rollers, print quality, and attempts to answer the following question. What line screen anilox roller is optimum for reproducing specific image characteristics? Our assumption is that the 400 lpi anilox will print low quality halftones. The 700 lpi anilox will print lower quality halftones than the 900 lpi anilox. The 900 lpi anilox will print denser images, but it will not reproduce fine halftones as well as the 1600 lpi anilox. Lastly, the 1600 line per inch anilox roller should reproduce better fine lines and process halftones than any of the three anilox rollers.

Purpose of Study

The anilox roller is the heart of the flexographic printing process and the focus of this project. The purpose of this study is to compare quality of print using anilox rollers at 400, 700, 900, and 1600 lpi. A Mark Andy 4150 flexographic printing press was used to conduct the testing. A test form was developed to test the print reproduction characteristics of anilox rollers in the following areas:

1. Density of Solids
2. Dot Gain
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5. Minimum Reproducible Hairline
6. 150 line Screen Image

Literature Review

Anilox Roller Evolution: The anilox roller was developed in 1939 by Doug Tuttle, a marketing director of Pamarco Corporation. When Doug first saw a gravure coating cylinder, he realized its application for flexography. The industry quickly embraced this technology and soon it became the focus for increasing print quality in flexography. The anilox roller was originally chrome coated, however, since this coating quickly wore down, in the 1970's a ceramic coating was introduced as a more durable alternative.

Anilox rollers are available in a wide variety of types and engravings, they are: chrome, ceramic, engraved ceramic, and laser ceramic. Chrome rollers are mechanically engraved usually in copper because it is a soft metal that can be electroplated with a thin chromium layer for durability. Ceramic rollers are made from a ceramic coating that is as-sprayed onto the roller surface. Engraved ceramic rollers are mechanically or electromechanically engraved and then sprayed with a thin ceramic chromium oxide layer. Laser ceramic rollers are the standard for flexographic printers. Laser ceramic rollers are preferred for their durability and ability to be laser engraved at 2000 lines per inch (Heckman, 41).

The cell shape has always been determined by the engraving process. Inverted pyramids were initially common, then the quadrangular shape was used because of its steeper walls and flat bottom for increased roller life and more efficient release characteristics. Today, anilox rollers are engraved as fine as 2000 lines per inch using the latest laser technology. Laser engraving provides a cupped shape cell for maximum ink release and ease of cleaning (Trungale, 58).

Characteristics of Anilox Rollers: The anilox roller is considered the heart of the flexo printing process for its ability to lay down thin ink films and offer control in the reproduction process. Control of the reproduction process gives a greater control over dot gain and printing highlight areas (Carrillo, 58). The two main variables that affect anilox roller performance include cell volume measured by the amount of ink delivered per unit area and lines per inch (lpi).

Cell Volume: Cell opening and cell depth make up the cell volume, the units for cell volume are referred to as Billion Cubic Microns (BCM). The higher the BCM value the higher the volume of ink deposited (Carrillo, 58).

Lines Per Inch: The amount of ink deposited by a high line per inch (lpi) roller is small and closely spaced. This provides a more uniform ink film thickness and faster drying. High lpi rollers are used for fine line images and process color work. Low lpi rollers are used where a high ink deposit is needed such as solid line art images.

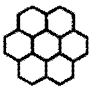
The following table shows the typical uses for various line screens

85 – 250 lpi	High Coverage Coatings	Volumes of 21-45+ BCM/in2
250 - 350 lpi	General Purpose Line & Solid	Volumes of 10-20 BCM/in2
300 - 440 lpi	General Purpose Line & Tone	Volumes of 6-15 BCM/in2
550 - 800 lpi	Fine Line, Tone & Process	Volumes of 1-8 BCM/in2

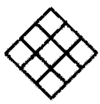
Cell Geometry: Anilox rollers are available in the following cell shapes; pyramid, quadrangle, special channel, and laser engraved. Pyramid cells, which look like an inverted pyramid is one of the earliest shapes available for anilox rollers. It is recommended to be used with two roll metering systems or where accurate ink metering is not required. Quadrangle cells are used to deliver higher amounts of ink than an inverted pyramid, and are typically used with blade metering systems and on images containing dense solids. Special channel cells, typically hexagonal shaped can be used to deliver specific ink volumes for particular printing applications. Laser engraved cells have nearly vertical sidewalls and rounded bottoms (Heckman, 41).

Engraving Angles: The 3 types cell angles available are:

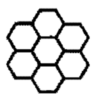
30 Degree Hexagon



45 Degree Diamond



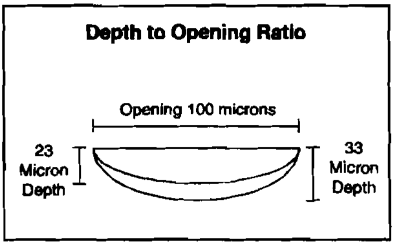
60 Degree Hexagon.



Diamond Cells: The diamond shaped cell is considered inferior to the hexagon shaped cell, because it has a higher land area, and a less uniform ink film. To compensate for a less uniform ink film, the anilox roller must have deeper cells to give the same volume.

Hexagon Cells: The hexagon cell shape is the most efficient geometrical shape since it maximizes space, thereby containing 15% more hexagons than diamonds in a given area. With more cells per square inch, the hexagon pattern delivers shallower cell depths, resulting in more uniform coating films. Shallow cells minimize volume loss and clean up during the run.

Cell Ratio: Equally as important as cell shape is cell depth. An optimum cell has a depth-to-opening ratio between 23 to 33 percent. For example for a 100 micron opening, the cell depth should be within a 23 to 33 micron range. If the cell is too deep, the ink will build up and dry on the bottom of the cell. If the cell is not deep enough an insufficient amount of ink will transfer to the substrate (Carrillo, 58).



Research Methods

Anilox Rollers: This chapter explains how the experiment was conducted, and explains the quantitative methods used to collect the data. The samples were printed on a Mark Andy 4150 at Blake Printery in San Luis Obispo, California. The goal during the printing part of this project was to achieve consistent and repeatable results.

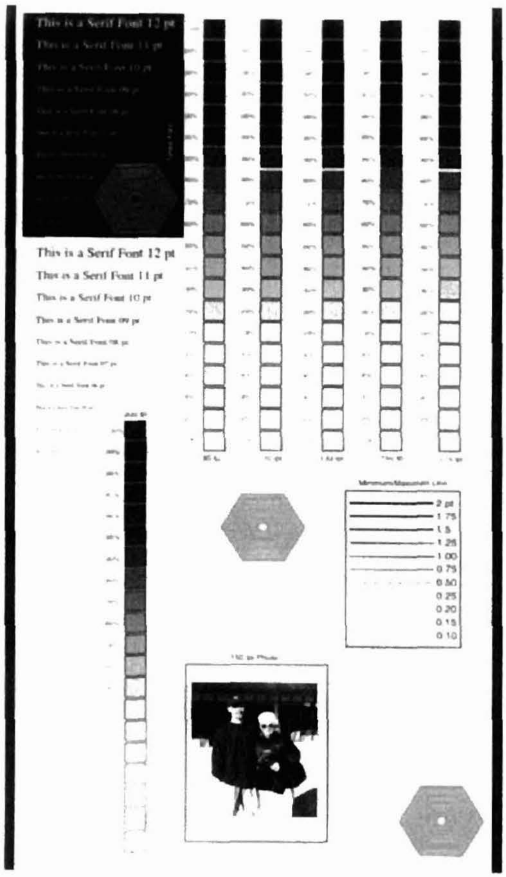
This research project uses the scientific method. The scientific method is a process for gathering information. It consists of five steps:

1. Identify and Define the Problem
2. State the Hypothesis
3. Collect and Analyze Data
4. Formulate Conclusions
5. Modify and Repeat the Experiment

The purpose of this project is to determine the printing characteristics of various anilox rollers. The anilox rollers used for this experiment are from Harper Corporation.

Test Form: The test form was used to measure and record the print characteristics for a particular anilox roller. The following are the elements included on the test form:

1. Solid Ink Density
2. Dot Gain
3. Minimum and Maximum Dots
4. Printable Hairlines
5. Reverses
6. Serifs
7. Slur
8. Line Screen Images
9. Bearer Bars



Applications

Adobe Illustrator 8.0
PhotoShop 5.0
QuarkXPress 4.0

Materials

Film: Output by David Hoydal at Blake Printery
Doctor Blade: Stept Deatwyler stainless steel, 6 mill
Ink: Akzo Nobel UF UFR UV Dense Process Black, and 7135 High Rub UV coating
Paper: Technikote Technigloss AT333 44#PK
Mounter: Mark Andy
Stickyback: 1115 3M Green Harley

Press Specifications

Dupont photopolymer plate donated by David Hoydal at Blake Printery
Repeat length: for Mark Andy 4150 is 11
Percent distortion: 96.46%, 6 x 10.6106 inches (Curtis, 3)
Cylinder: 112 Tooth

Testing: For this project, we used a 9 color Mark Andy 4150 with in-line die cutting and driers. The press operator during the testing was Gil du Long, a flexography printing consultant with over 20 years of printing experience. For the test 50 samples were collected to provide us with an accurate prediction of anilox roller consistency and repeatability.

Measurements: Solid ink density was measured by printing a solid patch on the test form. Solid ink density was measured with a Greytag densitometer and plotted on a histogram. The histogram provided an accurate representation of print variability throughout the run.

To measure minimum and maximum dots, a vignette was created on the test image, with values ranging from 1 percent to 100 percent black. Minimum and maximum dots were measured with the densitometer to calculate dot gain, and the results were graphed on a histogram.

Hairlines helped evaluate the smallest reproducible line for a particular anilox roller. Hairlines were measured by evaluating the samples using a 50 power loop.

Test printing reverses helped determine how well they print with a particular anilox roller. A Times type face was included on the test form, and the type face size ranged from 3 to 12 points on a solid black background.

A positive Times type face was used on the test form in decreasing order from 3 to 12 point type. Serifs helped determine the smallest possible printable serif for a particular anilox roller.

A critical element that was used on the test form are gray bars. The gray bars were modified to print at different line screens: 65, 110, 133, 150, 175, and 200 lpi. These line screens helped determine how well they print with a particular anilox roller. The standard line screen to anilox ratio used was 6 to 1.

Slur targets were included on the test form to set an even impression between the anilox roller and the plate cylinder. Paralleling of these settings is accomplished by comparing the targets on the left hand and right hand side of the web.

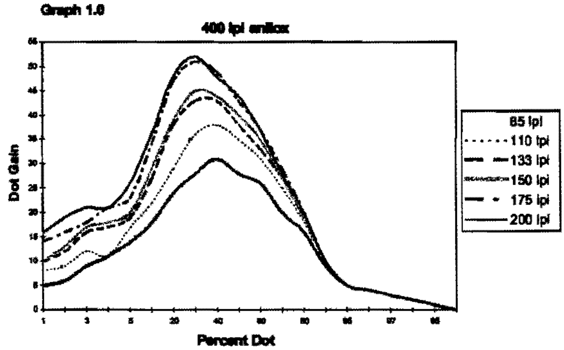
Bearer bars were used on each side of the test image to provide a common height in relation to the other images on the plate. Bearer bars are used to prevent the plate cylinder from bouncing.

These are the elements that were used on the test form. The information obtained from these elements provided specific characteristics for each anilox roller.

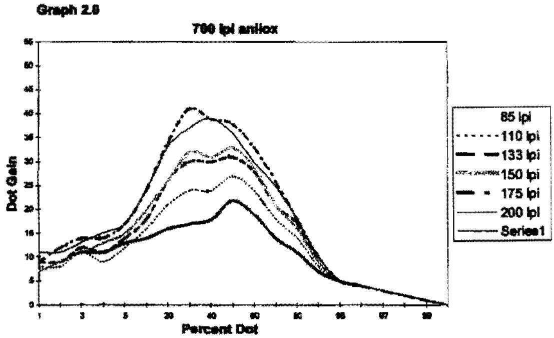
Results

According to our Dot Gain/Percent Dot charts, the reproduction curves for the anilox rollers show that the rollers with a high line screen and low BCM produced a lower dot gain than the lower line screen rollers. This occurred because the low line screen roller has a high BCM or larger cell depth-to-opening ratio, where as the high line screen roller, has a low BCM or lower cell depth-opening ratio. The results can be seen on the next four figures.

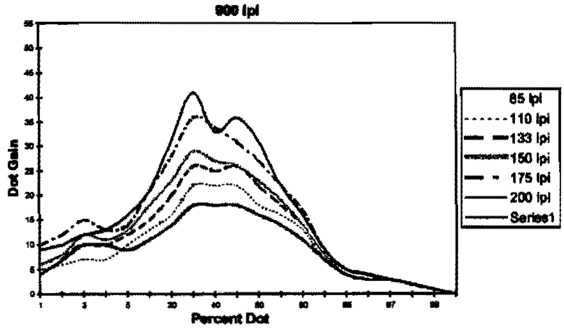
Graph 1.0



Graph 2.0



Graph 3.0



Graph 4 .0

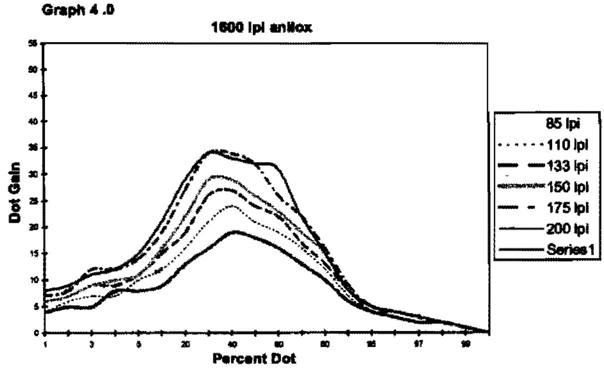
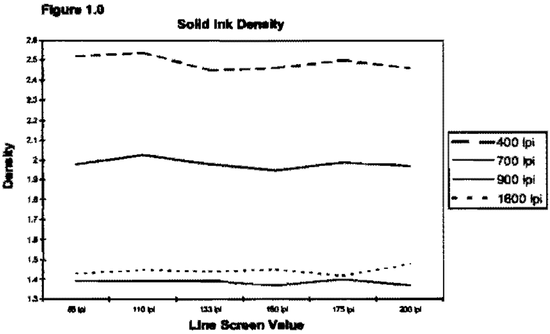


Figure 1.0 shows the solid ink density value of the anilox rollers for different line screens. The 400 line screen anilox roller with a BCM of 4.76 printed denser solids. The 400 lpi roller, had an average density of 2.48. The 700 lpi anilox with a BCM of 2.50, had an average density of 1.98. The 900 lpi anilox with a BCM of 1.48, had the lowest density reading and an average density of 1.39. The 1600 lpi anilox with a BCM of 1.84, had an average density of 1.45. From these observations, we concluded that there is a direct relationship between solid ink density and BCM volume. As the BCM went up so did the density of the ink in the solids.

Figure 1.0



The print reproduction characteristics of hairlines were examined visually. The 400 lpi roller printed thicker hairlines than the 700 lpi roller. The 900 lpi roller printed hairlines of similar width to the 1600 lpi roller. From these observations we noticed that the 900 lpi roller, and the 1600 lpi roller work exceptionally well when printing fine hairlines.

The serifs and reverses printed better than expected with the higher lpi anilox rollers. For this experiment we decided to conduct a printability study of 3 to 12 point type. The press sheets of the 400 lpi anilox plugged from 3 to 6 point type, however 7 point type produced acceptable results. The press sheets of the 700 lpi anilox plugged from 3 to 4 point type, however 5 point type produced acceptable results. The press sheets of the 900 lpi and 1600 lpi anilox produced exceptional results with 3 point type and higher. The serifs looked complete and the bowls were not plugged.

A 150 lpi image was analyzed in a 5000 Kelvin light booth, to determine highlight, midtone, and shadow quality reproduction. The image printed with the 400 lpi roller had poor definition in the highlights, plugging in the midtones, and plugged dense black shadows. The image printed with the 700 lpi anilox had good reproduction in the highlights, plugged midtones, slightly plugged shadows, and as a result the image quality was acceptable. The 150 lpi image printed with the 900 lpi anilox had crisp and sharp highlights, acceptable midtones, and acceptable shadows. The image quality looked much better than the one printed with the 700 lpi anilox. The image printed with the 1600 lpi roller had excellent highlight definition, crisp and sharp midtones, and dense black shadows. Overall, the quality of reproduction for this image was excellent.

Conclusion

Anilox Roller Strengths and Weaknesses: The amount of ink laid down in the solids by the 400 lpi anilox roller was moderate since it produced a dense black image. The dense black color is a result of a large cell volume. The 400 lpi roller performed poorly in the reproduction of halftones and type smaller than 6 pts. The midtones of the image plugged, the bowls of the small positive type plugged and the negative small point type filled in.

The 700 lpi anilox roller performed as a good compromise between the 1600 lpi and the 400 lpi anilox rollers. The density was considerably higher because it has half the volume of the 400 lpi anilox roller, hence, the density is lower. The image was murky and the fine type was not well defined.

There was considerable difference in halftone reproduction between the 900 and 700 lpi anilox rollers. The image printed better with the 900 lpi roller, since it had less volume than the 700 lpi anilox roller. Small positive and negative type printed well. The serifs were noticeable and bowls were well defined.

The 1600 lpi anilox roller performed excellent in all areas except when printing solid dense black. Fine type and hairlines printed sharp and were well defined. Excellent results were obtained when printing halftone images. Besides having sharper highlight dots, dense shadows and crisp detail in the midtones, the image printed very well.

Applications: Results from this project will provide the prepress operator with the necessary data to compensate for anilox roller deficiencies during prepress. It will also serve as a guide when determining what type of anilox roller to use for a particular job.

Project Improvements: The following are some areas of this project that could be used for further research:

1. A printing press with quantifiable plate and impression cylinder pressure. This would eliminate any variance in manual operation of the press, which could alter results in dot gain and density when changing anilox rollers.

2. We recommend a test run of over 500 samples to choose from and measure. This sample size should provide enough repeatability and consistency throughout the run.

Additional Research: Since the use of flexography is growing rapidly, flexographic materials should be the focus of future research. These are several ideas for future research:

1. Which anilox roller prints best with each process color?
2. How anilox rollers affect process trap?
3. Compare anilox rollers based on performance with UV and Waterless ink.
4. How printing plate dot shape affects anilox roller performance?
5. How does the angle of the doctor blade affect the performance of the anilox roller?

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