# WHY THE OFFSET LITHOGRAPHIC PROCESS MUST BE CHANGED TO MEET PRINT-ON-DEMAND REQUIREMENTS WITH RESPECT TO COLOR CONTROL

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Keywords: Color, Density, Dot, Inking, Oscillating

Abstract

If getting to the correct color on press in the shortest number of meters is the goal then there are fundamental design problems in the process that must be recognized and corrected. This paper will deal with the three basic problems: consistency, predictability, and response time, that are needed to be understood and dealt with. Analysis and experimental results will be presented. This material has been collected over a ten year period and will also include the knowledge learned by Fountech Inc.

Fountech Inc. attempted to develop a better ink fountain and control system that could preset color densities and run with stable color densities that were independent of press speed and water setting. That technology was not commercially viable but the analysis of the performance relative to consistency, predictability and response time brought about new understanding of the problems and will be discussed. The problems their causes and solutions, with ink feed, presetting and roller train design will be discussed in depth. Limitations with using the press as a research tool will also be commented on.

## Introduction

There are problems with offset lithography, which are preventing the process from reaching its potential. These problems are caused by faults that have existed for

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so long that they are assumed to be an integral part of the process. They are mechanical design faults with the equipment and they are conceptual faults with how the process is evaluated. Many assumptions that are quoted universally as truths, can not hold up under closer examination.

Color control of the offset lithographic process looks complicated, because these faults are interrelated and combine to create confusion. Print-on-demand requires getting to the correct color in the shortest number of meters, therefore, the process must have: consistency, predictability and short response time. To achieve those goals we must have an understanding of the physical requirements, that affect those goals, well enough to be able to design them into a system.

This paper will deal directly with problems in the process. The description of these problem areas, it is hoped, will clear up some of the confusion there is with this process in general.

## Color Control The Process

Color control is the process of putting the right amount of ink in the right place.

Water is used in the process to separate the regions of image area from the non image area. For the most part, this is done very well on press. Therefore, this will not be discussed. On the other hand, the color of the image area is neither predictable or consistent. Why should that be the case?

If one looks at a solid patch of ink on paper, one can measure its density with a densitometer. Looking at an ink curve one can say something about the quantity of ink or ink film that produced that density. If one measures the patch, when it has a higher density, one can again look at the ink curve and say that there is a thicker film of ink and that it is a certain percent greater than the original patch. Why can the color be so accurately and specifically described after it is printed but so unpredictable before and inconsistent while it is being printed?

Look at the patch again. We have specific information about how much ink is used. Can you tell how much water was used? No, it has evaporated. Can you tell how fast the press ran? No. Can you tell what the temperature of the press was or what the humidity level in the press room was? No. The reason you can't determine those variables in the final print is because they are not dependent variables of the process. The amount of ink is the dependent variable. Good color control requires good control over the dependent variable.

## Ink Feed

Consistency of the steady state average solid color density of a print is only related to the ink feed rate into the press. Color consistency is a steady state problem. Steady state analysis is independent of the actual process.

Let's do a mental experiment. A one unit printing press has ink being fed into the roller train at the top and is printing a large solid patch on a web. The press has reached steady state conditions and the density of the patch is consistent. Now let's change some settings on the press other than the ink setting. Observing the density of the patch, we see that it is changing as the process goes through a transient. Finally it reaches a steady state at some consistent density other than the one we started out with.

We know from our ink curve that the new density is the result of a change in the amount of ink going out of the system, on the patch. How can we account for the difference in ink? The only explanation that can be possible is that some how the ink feed rate into the roller train has changed even though the ink setting was left constant. That's fine with a mental experiment, but how can that happen on a real press?

## Offset Press Design Fault

Inconsistent average solid color density, ink-water balance, and wash out are all caused by a single mechanical design fault in the offset press. The fault is in the method of transferring ink, at the ink transfer point between the slow moving ink fountain roller and the high speed press rollers. This transfer point is unique. Other transfer points in the press have little choice but to transfer the ink that is supplied to them.

The low to high speed transfer point has an ink transfer equilibrium condition that is sensitive to many variables. As an example, let's increase the water setting on the press. This increase in the water quickly affects the ink in the high speed roller train. The ink transfer equilibrium has been disturbed by this change and less ink is being transferred across to the high speed rollers. The density will start to drop until the ink transfer rate out of the press matches the ink transfer rate into the press. To regain density, the operator can open ink keys or increase the ink fountain roller speed This action affects the ink transfer equilibrium, restoring the ink transfer to the original rate The density now starts to increase to the original value. Steady state conditions then exist when the ink flow rate out of the system equals the ink flow rate into the system. But now the ink setting is higher than it was before.

It is the mechanical design method of transferring ink into the press that is dependent on so many variables, not the process of offset lithographic printing. There is no use studying this press fault. If one wants a solution to the problem, one must reinvent, redesign, and rebuild.

## Testing the Theory

The theory is stating that the steady state change in density of the print is caused by the ink feed rate change into the press. The corollary is that, if the ink feed rate into the press is constant relative to press speed, then the color density of the print will be independent of press speed, water setting, temperature, etc.

A simple test was set up on press to see if the theory could be confirmed. A method was set up to deliver ink into the roller train of the black print unit, proportional to the press speed. The press had a system with on line densitometers and values of density, press speed, water setting could be tracked and plotted. The general results are shown below.

General Test Results

| | |
|---|---|
| Speed Change | The press was run at 75 meters per minute for about 5 minutes to get to steady state conditions.<br>Black color density 1.95 range<br><br>The press speed was increased to 217 meters / min.<br><br>Black density stayed in the 1.95 range. |
| Water Change Up | Water was set at 47%.<br>Press speed 217 meters / min.<br>Black density 1.95 range<br><br>Water setting changed to 71%<br><br>Black density drops to 1.89 in 100 meters.<br>Black density recovers to 1.95 range over the next 300 meters. |
| Water Change Down | Water set at 71%<br>Press speed at 217 meters / min.<br>Black density 1.95 range<br><br>Water changed to 47% |

| | |
|---|---|
| | Black density increases to 2.00 over 100 meters. Black density recovers back down to 1.95 range over next 300 meters. |
| Start After Stop | Press speed 217 meters / min. Black density 1.95 range |
| | Press was stopped for about 20 minutes. |
| | Press was restarted and press speed brought up to 210 meters / min. |
| | Black density immediately returned to the 1.95 range. |

The testing showed strong confirmation of the theory.

## Fountech Inc. Experience

Fountech Inc. was formed to develop technology that was based on knowledge that had been gained on color control.

An experimental system was developed that combined, the area coverage per key zone data from a plate scanner, the ink curve data and the density set point values, that were set by the operator. From these sources of data, calculations were made for the output values of the thirty two independently controlled pumps on each of the new ink fountains. The ink fountains pumped ink onto the ink fountain roller. Ink was taken from the ink fountain roller by the existing continuous ink ductor.

The aim of the system was to achieve two goals.

1. Achieve consistent color density, independent of press speed, water setting, etc.
2. Develop presetting capabilities that could preset density targets and produce very short color make-readies.

Resulting performance. The goal of consistent color control was basically achieved. The color could be set at lower press speeds and when the press was sped up, adjustments were not required. No major swings in density such as washout occurred. When water was increased, dot gain increased slightly with minimal affect on solid densities.

The second goal of presetting density targets, and very short color make-readies was not meeting its projected performance levels. Something was wrong, but what? After months of running the system and analyzing the problem, it turned out that there were two major problem areas.

One was presetting, which will be discussed later in this paper. The second was related to the fact that the ink fountain was pumping ink onto the ink fountain roller. This does not affect the steady state conditions because pumping onto the ink fountain roller is in fact, pumping ink into the system. That ink must come out on the web.

The problem is that response time is much longer when pumping ink onto the fountain roller. There is a base ink film thickness on the fountain roller that is related to the equilibrium transfer conditions of the continuous ink ductor. High coverage areas have a thicker base ink film thickness on the fountain roller than low coverage areas. Also high density print will have a thicker base ink film thickness than lower density print.

What this means is that when you go from one density level to another, there is this extra storage of ink on the fountain roller between those two equilibrium levels that has to be accommodated. Therefore, the result is longer response times which is especially true with low coverage designs. Several other operational problems result with pumping ink onto the fountain roller and it is therefore better to avoid doing it.

Most of the benefits and the expense of the proposed technology were tied to the presetting capabilities. Since the performance was below expectation the technology was not commercially viable.

## Design Specification for Ink Supply System for Consistent Color Control

Analysis and testing experience showed that what was required for consistent color could be described in a few simple conditions. They are:

Ink to be fed directly into high speed section of the press.
Ink feed rate is to be proportional to web speed.
Ink feed to be continuous

The above specifications are for ideal conditions. These conditions will result in consistent steady state average solid color density, that is independent of press speed, temperatures, water setting etc.

The real problem for the design engineers, will be in developing a system that is economical, user friendly, and that does not make too many compromises to the ideal specifications.

## Presetting Ink Delivery System

For accurate presetting of the ink delivery system, the output must have a linear relationship to the input set point, for each ink zone. This means that if the requirement is a 50% output, you get that output when the set point is set to 50% . See fig. 1. This is extremely critical in the low output

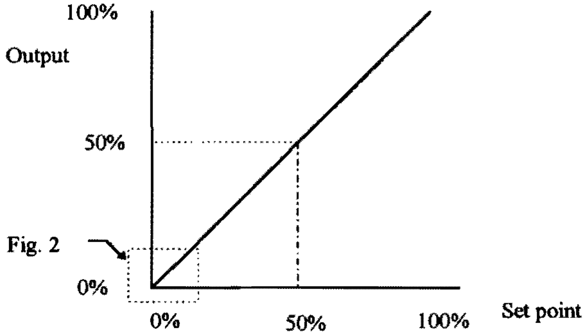



Figure 1. Ink Output vs Set Point

range, used for low area coverage. Seemingly small errors will result in relatively large errors in output and therefore density. Look at fig. 2. We see the bottom end of the output curve. Shown is the ideal curve that starts at zero. Also shown are two curves, one with a +2% error and the other with a -2% error. At a 5% set point we can see what those small errors actually mean to the output.

A +2% error will produce an output of 7%. That is 1.40 times the ink required. That would result in a density error of about +0.28 density points.

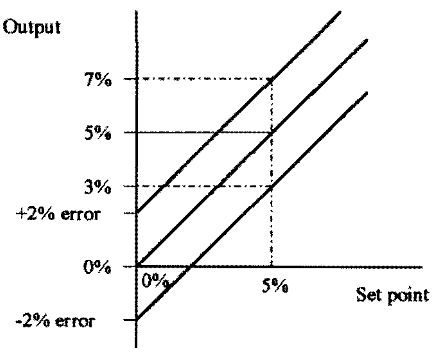



Figure 2. Relative Error at Low Output

The -2% error will produce an output of 3%, that is 0.60 times the ink required. That would result, using the same ink curve, in a density error of -0.43 density points.

Note: In this paper, all references to density, ink curves are related to inks that have a density slope of 0.08 density points per each 10% increase in ink film thickness. Newspaper inks are about 2.5 times weaker than the reference ink and therefore, density changes would be 2.5 times smaller for newspaper inks.

Zero Setting. The above example shows why zero setting is so critical. Zero setting is not just setting a zero output, but that the output in the low range corresponds to its set point. Zero setting should not require calibration, it should be predetermined by the way the ink delivery system is designed. Setting a gap and observing the result is not predetermined by design. A gear pump with speed control is a predetermined design. Running it at 4% speed gives 4% output. No calibration required.

Design Specification For Ink Delivery System For Presetting Capabilities.

The system must have a linear output curve where the output corresponds to the set point.

Zero setting is to be predetermined.

Presetting Information Ink Key Setting, Ink Consumption

Presetting ink keys is a very difficult problem. Setting keys or zones on an ink delivery system is meant to set the relative ink consumption values for those zones. The source of the information for the consumption of ink has traditionally come from the image area of the plate. This is not a good source for this information because, the image area on a plate is not directly related to ink consumption. This can be illustrated with the following examples.

Wet Trap. When printing wet ink on wet ink, the ink film thickness printed, is less than it would be if printed directly on paper. Let's look at the following example. Fig. 3. shows two large solid areas with small measuring patches. The one large solid is printed directly on paper while the other is printed on wet ink of a previous unit.

First, let's assume both measuring patches will have the same solid density measurement. Therefore, their ink film thickness t will be equal. We also assume that the wet trap is 70%.

We can then calculate the volumes of ink for both conditions.

Print on paper .  A1 = 5 x 50 = 250 $mm^2$,
A2 = 200 x 50 = 10,000 $mm^2$

Vpp = t (250 + 10,000) = t 10,250

Wet trap  trap 70%  0.7

Vwt = t 250 + 0.7 t 10,000 = t 7250

where

Vpp ink volume printed on paper
Vwt ink volume printed on wet ink
t ink film thickness

Compare volumes

Vwt / Vpp = t 7250 / t 10,250 = 0.71

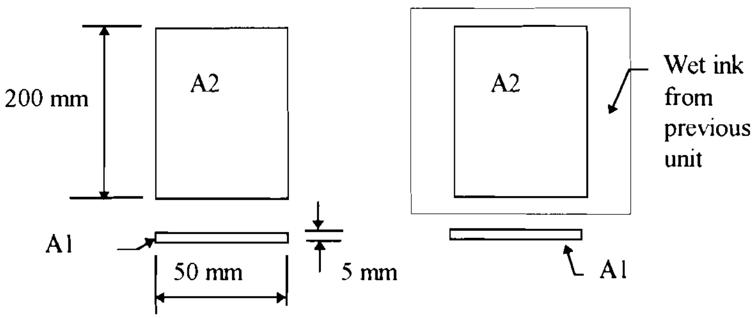



Figure 3  Wet Trap Affects Ink Consumption

Therefore, the condition with wet trap will require only 71% of the ink of the condition for printing on paper. If the press supplied ink based on area, the wet trap condition would get too much ink. 1 / 0.71 = 1.41  41% more ink

The density of the patch for wet trap, would be 0.29 density points higher than the print on paper patch. Wet trap can cause large errors in predicting ink consumption if using area of plate coverage as a model.

Screens.  There is no reason to assume a dot on the plate will hold the same amount of ink per image area as a solid would. The fluid dynamic conditions are quite different when the ink splits in those areas. The dot on the plate may hold less or more ink, or transfer differently to the blanket and only testing ink consumption will tell for sure. A suggested relationship shown in fig. 4., shows the plot of Vd/Vs vs dot diameter, which is based on circumstantial observations.

where Vd volume of ink on a dot per image area
Vs volume of ink on a solid per image area

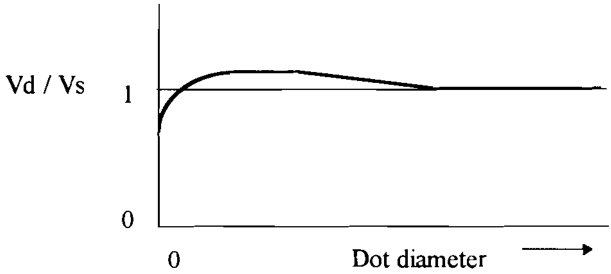



Figure 4. Relative Ink Volume on a Dot (Suggested)

At very small dot diameters, one must expect that the dot can not hold an ink film as thick as the solid. Therefore, Vd / Vs < 1.

Large diameter dots would act like solid areas. Vd/Vs = 1.

The guess about the region in the middle is that the dot holds more than the solid. The reasons for this guess is that, when the plate and form roller separate, the low pressure over the dot may pull in extra ink from around the dot. Another reason is related to Fountech Inc. experience. It seemed that jobs that had a lot of screen work, tended to under shoot density targets. That might imply that more ink went to the screened area and less to the color patch. Finally it is suspected that dot gain is influenced by extra ink on the dot on the plate. The Vd/Vs value is not directly related to dot gain. If Vd/Vs < 1 there will still be mechanical dot gain.

Press Oscillation. Most presses have oscillation that tend to move ink locally from high coverage area to low coverage area. This will affect how the profile for setting the ink zones should be made. Presetting information would have to account for this.

## Presetting Information Solution

As one can see, this is a very complicated problem. Image area, no matter how it is determined, can not solve this problem. The solution is now possible due to the fact that complete plate data is in digital form, used by CTP type systems. The solution will require the algorithms to calculate screen effects and wet trap effects, then finally adjusting for press oscillation effect. This requires a great deal of computer capacity, but this is finally becoming possible.

Presetting Prepress

Correct separations and proofs, speed up the process at the press. All the significant physical phenomena related to the press process performance must be accounted for. One question that is not clear. Is wet trapping being accounted for?

Dot Gain. Mechanical dot gain is one of the physical phenomena of the printing process, but is optical dot gain? There are problems with optical dot gain.

Optical dot gain is a result of the combined use of the Murray-Davies equation and the densitometer, when measuring a fine screen on material that can diffuse light under the dots.

The Murray-Davies equation, shown below, is used to calculate area coverage with a relationship that compares reflectance values that can be measured by a densitometer. This makes it convenient but not necessarily accurate.

Relationship of reflectance to density used by a densitometer.

$$R = ( 1 / 10^{D} ) \tag{1}$$

$$D = \log ( 1 / R ) \tag{2}$$

where R reflectance
D density

Murray-Davies equation in terms of density and in terms of reflectance.

$$A = [( 1 - 10^{-Dr} ) / ( 1 - 10^{-Ds} )] \times 100\% \tag{3}$$

$$A = [( 1 - Rr ) / ( 1 - Rs )] \times 100\% \tag{4}$$

where
A Calculated optical dot area percent of screen
Dr density of screen
Ds density of solid
Rr total reflectance of screen
Rs reflectance of solid

Let's look at fig. 5. Here we see a 50% dot on a substrate that can not diffuse light into it. The arrows coming off the surface and the dot represent the reflected light to be measured. The graph above it shows the reflectance values.

The dot is assumed to have the same ink film thickness and density as the solid patch. The densitometer reads the combined reflectance Rr . Notice that the reflectance from the dot is only 5% of the reflectance from the surface. This means that, when measuring screens, a densitometer is very sensitive to the changes in light coming from the non print surface, but is not sensitive to the changes in the density of the dot due to changes in the ink film thickness.

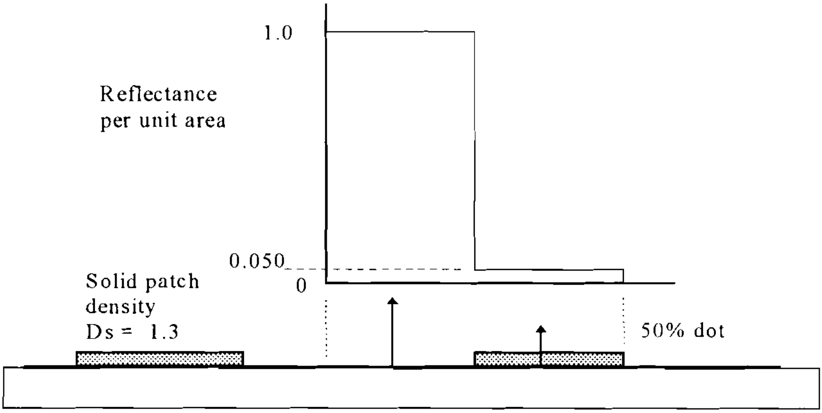



Figure 5. Reflectance From a Screen Simple Model

Calculated total reflectance from printed screen.

$$Rr = 0.5 \times 1.0 + 0.5 \times 0.050 \quad (5)$$

$$Rr = 0.525$$

Calculated reflectance from solid patch. Eq. 1.

$$Rs = ( 1 / 10^{1.3} )$$

$$Rs = 0.050$$

Calculated optical dot area percent of screen. Eq. 4

$$A = [(1 - 0.525) / (1 - 0.050)] \times 100\%$$

A = 50%

Mechanical Dot Size = 50%     also     Calculated Optical Dot Size = 50%

This result looks good but this model does not represent reality. Most substrates that are used in printing, diffuse light to some degree. The light goes into the paper, bounces around, and some of it can come up through the surface in a different location. For a little more realistic model, let's look at fig. 6.

Here we have a 50% dot with a density of 1.3 on a substrate that diffuses light. Arrows show light, that will get to the densitometer, reflecting off the non image surface, the dot covered surface and the light diffused in the substrate that gets under the dot and comes up through it.

The reflectance from the non image area must be less than the model in fig. 5. because some of the light has diffused under the dot. Let's assume the reflectance has dropped 10%, from 1.0 to 0.9. The diffused light under the dot comes up through the dot, increasing the reflectance there. Let's assume a 10% increase, from 0.050 to 0.055. Now we can calculate the optical dot size A .

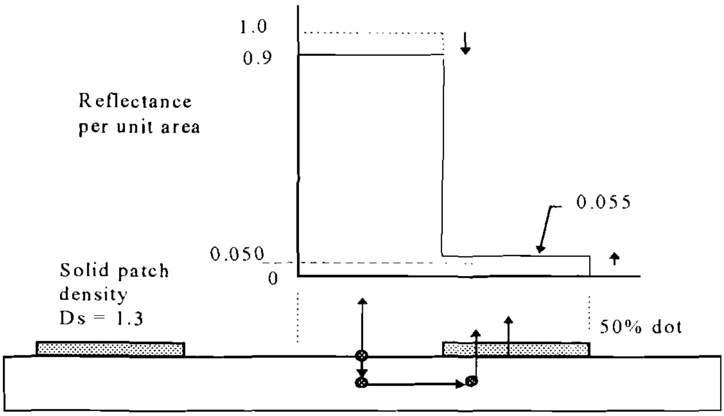



Figure 6.     Reflectance of a Screen   Light Diffusion Model

$$Rr = 0.5 \times 0.9 + 0.5 \times 0.055$$

$$Rr = 0.478$$

$$Rs = 0.050$$

$$A = [(1 - 0.478) / (1 - 0.050)] \times 100\%$$

$A = 55\%$

Mechanical Dot Size = 50%    but    Calculated Optical Dot Size = 55%

This result looks more realistic. Optical dot size is larger than mechanical dot size, but something is wrong. There are two major problems with this result.

First, the difference between optical dot size and mechanical dot size is all related to the loss of light diffused under the dot. Since this happens with all components of white light, it is a loss of brightness and should not affect the color. Therefore, there should not be an adjustment of C, M or Y dot size for loss of white light.

Secondly, the diffused light coming up through the dot will make the dot look lighter or less dense. This is affecting color.

Apparent density of dot    $D = \log( 1 / 0.055 ) = 1.26$

Optical dot calculations imply that the dots have a greater area or density, but this analysis implies the dots visually appear to have a lower density. This means that dot gain correction curves maybe over correcting and it may be worse, the greater the light is diffused. One can not tell for sure whether the correction is too much, because we don't know anything about how much ink film thickness the dot actually has.

What one does know is that optical dot gain is a false concept. The Murray-Davies equation and the densitometer are not the proper tools for analyzing screens. New tools are required.

## Color Gain

To obtain accurate information about how the screens are affecting color, we must deal with real phenomena. The density of the dot and its mechanical dot size are real values. A direct measure of the density of the dots would account for many physical phenomena such as , ink film thickness, dot geometry, light diffusion, etc. Knowing the mechanical dot size will tell us the area that is at that dot density.

The Color Gain function is an attempt to use these physical properties of the dot density and the mechanical dot size and compare them with standard values. The standard values would be the solid patch density  Ds  and the screen patch area percent  Sdot% . The total effect of color change due to the mechanical dot gain and actual dot density could be determined. Color Gain could be used instead of Dot Gain to compensate separations for the way, ink type, screen geometry and paper, perform on press.

$$\text{Color Gain} = (Rs / Rd) \times (Mdot\% / Sdot\%) \qquad (6)$$

$$\text{Color Gain} = (10^{Dd} / 10^{Ds}) \times (Mdot\% / Sdot\%) \qquad (7)$$

| where | | |
|---|---|---|
| | Mdot% | mechanical dot area percent |
| | Sdot% | screen patch area percent |
| | Rs | reflectance of solid patch |
| | Rd | reflectance of dot |
| | Ds | density of solid patch |
| | Dd | density of dot |

Comparing two systems with Color Gain Ratio CGR , may lead to a method to easily transform print from one system to another.

System 1 fine screen 300 lines/in., strong ink
System 2 course screen 150 lines/in., weak ink

$$CGR = (\text{color gain system 1}) / (\text{color gain system 2}) \qquad (8)$$

The densitometers in use now are not able to measure dot density or mechanical dot area. A new densitometer technology is needed.

New Densitometer with CCD Technology

A CCD produced image of a screen could be considered as numerous individual densitometers, each one capable of measuring reflectance of the image it sees. The digital nature of the information obtained from the CCD approach, allows us to keep the information we want and disregard the information that is not useful. This may also be the device needed to measure screens on plates.

Fig. 7. shows a dot on a pixel grid. Each pixel acts like a single densitometer. The plot above the grid shows the reflectance values for the pixel line -aa-. With this method we can obtain the dot density and mechanical dot size directly. The Murray-Davies equation is no longer needed. Using threshold values as filters, we can define what information we want to process. Suggested methods for calculating Mdot% and Rd , Dd are shown below.

The mechanical dot area percent Mdot% is calculated using the upper and lower thresholds .

$$Mdot\% = [\,[\,(Npbu + Npbl)/2]\,/\,Ntp\,] \times 100\% \qquad (9)$$

where

| | |
|---|---|
| Npbu | number of pixels below upper threshold |
| Npbl | number of pixels below lower threshold |
| Ntp | total number of pixels |

The dot reflectance Rd is calculated using the lower threshold.

$$Rd = ( \Sigma Rpbl ) / Npbl \qquad (10)$$

where

| | |
|---|---|
| Rd | average dot reflectance |
| Σ Rpbl | sum of the reflectance values of all the pixels below lower threshold |

The density of the dot from eq. 2.

$$Dd = \log ( 1 / Rd )$$

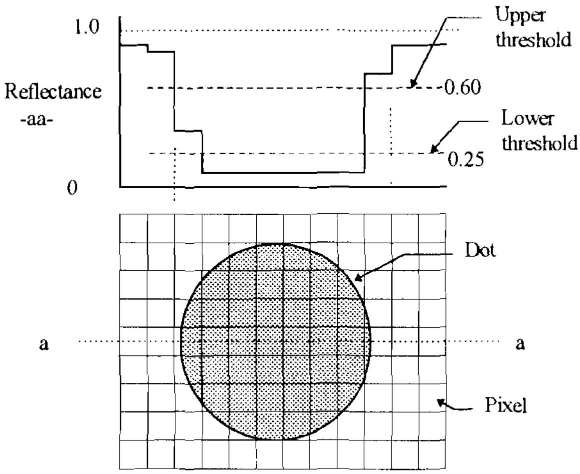



Figure 7. Pixel Grid of CCD Densitometer

## Roller Train

The feature of an ink roller train that has the most affect on getting to the correct color, is the oscillation rollers of the press. Generally, oscillation has a very low capacity to move ink across the press, but it does affect ink in local areas.

Oscillation moves ink from regions of thicker ink films to regions of thinner ink films. At lower capacity rates, oscillation smoothes the ink film and at higher capacity rates it also transports ink. The capacity of oscillation of a vibrator roller increases with, the increase in stroke speed, the increase in roller diameter, the increase in the difference in ink film thickness of adjacent regions, but not necessarily with the increase in stroke length.

Oscillation rollers can be of two types. Surface oscillators have one contact nip and act on a single surface only. Internal oscillators will have more than one contact nip and maybe involved with the transporting of ink down through the roller train.

## Definition of Modes of Oscillation

There are three distinct modes of oscillation and they are defined by their affect on how they distribute ink across the press.

Divergent Oscillation. For a perfectly set ink profile from an ink fountain (ink delivery system), diverging oscillation will move ink from high area coverage regions to low area coverage regions. Most presses have predominantly diverging oscillation, This is the primary cause of the inability to print a layout, such as the "T" shape, with even color density.

Converging Oscillation. For an almost perfectly set ink profile, converging oscillation will tend to correct small positive or negative errors in the ink film, so densities will converge to the same value. This mode of oscillation is only seen on a press with a single form roller.

Resolving Oscillation. For a perfectly set ink profile, resolving oscillation will move ink from the low coverage regions to the high coverage regions. Few presses use this mode of oscillation. This mode of oscillation is needed to overcome the fact that ink fountains have relatively wide ink key spacing. It can overcome some of the problems with diverging oscillation.

## Method to Determine Oscillation Mode

Step 1 Determine the ink distribution of the roller train for 100% coverage, with 50 - 50% splits in all nips, and an ink film thickness of "t" on the web. See fig. 8. and Table 2.

Step 2 Determine the ink film thickness on the roller train, that will print an almost zero coverage patch, an ink film thickness of "t" on the web.

Step 3 For all the surfaces on the roller train, calculate the delta values (Table 2), where,

$\Delta$ = ( 100% coverage value of ink film - 0% coverage value of ink film ) (11)

Modes of oscillation are determined by the delta values.

| | |
|---|---|
| Divergent | $\Delta > 0$ |
| Convergent | $\Delta = 0$ |
| Resolving | $\Delta < 0$ |

Calculation Of Zero Coverage Value. To print a very small patch, we can assume that the ink distribution on press is a constant ink film thickness tzero . This value of tzero must produce a film 3t on the small patch, on the plate, after the splits by the number of form rollers available. The calculation below is for a three form roller press. Table 1. shows values for tzero for presses with 1 to 4 form rollers.

$$\frac{\dfrac{\dfrac{2t + tzero}{2} + tzero}{2} + tzero}{2} = 3t \qquad tzero = 3.143$$

Table 1. Zero Coverage Ink Film Values

| Form Rollers | Ink Film tzero for Zero Coverage |
|---|---|
| 1 | 4.000 |
| 2 | 3.333 |
| 3 | 3.143 |
| 4 | 3.067 |

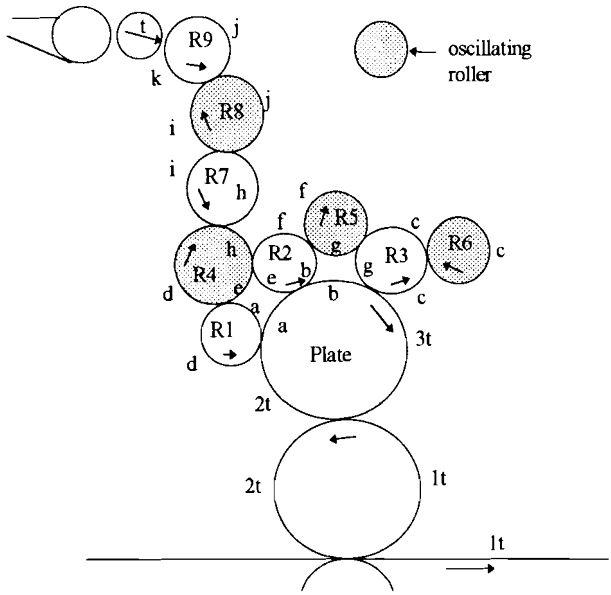


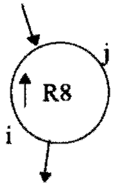

Figure 8. Ink Distribution Sample Press

Myth Of Uniform Ink Film Roller Train. By analyzing roller trains in this way, it will become apparent that the idea of a uniform ink film roller train is a myth. That concept requires a delta value of zero.

Table 2. 100% Ink Distribution Film Thicknesses and Delta values

| Ink film letter | Ink film t | Delta value $\Delta = (t - tzero)$ | tzero = 3.143 |
|---|---|---|---|
| a | 2.5 | -0.64 | |
| b | 3 | -0.14 | |
| c | 3 | -0.14 | |
| d | 3 | -0.14 | |
| e | 3.5 | 0.36 | |
| f | 3 | -0.14 | |
| g | 3 | -0.14 | |
| h | 4 | 0.86 | |
| i | 5 | 1.86 | |
| j | 6 | 2.86 | |
| k | 7 | 3.86 | |

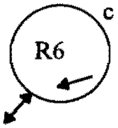
Calculation Of Oscillation Mode For A Roller. A surface oscillation roller or an internal oscillation roller can have their “combined delta value” calculated in a similar way. Four oscillating rollers, of the sample roller train, are analyzed below for their combined delta value.




| film letter | angle | t | delta |
|---|---|---|---|
| i | 140 | 5 | 1.86 |
| j | 220 | 6 | 2.86 |

combined delta value

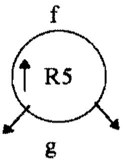
$$\frac{140(1.86) + 220(2.86)}{360} = 2.47$$




| film letter | angle | t | delta |
|---|---|---|---|
| c | 360 | 3 | -0.14 |

combined delta value

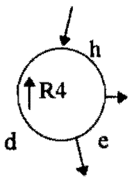
$$\frac{360(-0.14)}{360} = -0.14$$




| film letter | angle | t | delta |
|---|---|---|---|
| f | 240 | 3 | -0.14 |
| g | 120 | 3 | -0.14 |

combined delta value

$$\frac{240(-0.14) + 120(-0.14)}{360} = -0.14$$




| film letter | angle | t | delta |
|---|---|---|---|
| d | 200 | 3 | -0.14 |
| e | 75 | 3.5 | 0.36 |
| h | 85 | 4 | 0.86 |

combined delta value

$$\frac{200(-0.14) + 75(0.36) + 85(0.86)}{360} = 0.20$$

Total Mode Of Oscillation Of The Press. The total mode of oscillation of the press is the sum of the combined delta values of all the individual oscillating rollers.

| | | |
|---|---|---|
| R8 | 2.47 | |
| R6 | -0.14 | |
| R5 | -0.14 | |
| R4 | 0.20 | |
| Total Mode of Oscillation | 2.39 | Rating: High-Divergent |

The total mode of oscillation only shows tendencies. If the oscillation capacity of R8 is reduced and the oscillation capacity of R6 and R5 are increased, then the overall affect will be to reduce the divergent tendencies.

## Researching The Offset Lithographic Process

If you want to find fundamental understanding about the limits of the process, you must do it on equipment that is continuously being modified to design out causes of variation or ambiguity. Doing research on a production press will only give you an idea of how the process works on that piece of equipment. Fundamental understanding will be impossible to obtain working on production presses.

## Conclusion

Much greater control over color can be obtained when the fundamental causes of problems and misconceptions about how the process works are understood and corrected. A fundamental understanding of what is required for color control to be, consistent, predictable, and responsive, will be applicable to all the different types of offset lithographic printing. Change will only come, if there is an expectation that improvements can be made and that there is a demand for it.