USING DENSITOMETRY TO CONTROL PROCESS COLOR ON TEXTILES

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Four-color process reproduction on textiles has always been difficult. Besides variability of the substrate, there hasn't been an easy way to measure color or dot gain. As a result, consistency in the product has been difficult to maintain, and image variation was quite common. In the beginning, this was not all that much of a problem as the number of printers using four-color process was relatively small.

The average consumer lacked color awareness. Process color was considered a special effect. Since there was nothing to compare it with, only the most adverse of images were rejected. Artwork with "memory colors" were rarely printed. If it was, the results were usually marginal. Early process color was compared to litho transfers. Acceptance was slow as the market built experience and knowledge.

Today the situation has changed. Process color is becoming a dominant method of color reproduction. Even small shops are practicing as the cost of separations comes down, and the technology lends itself to successful printing. As process color proliferates, the consumer is becoming much more aware of the qualities of consistent color. The range of acceptable variation is narrowing.

Printers using process color for their preprint lines face another issue. As inventory is sold at the retail level, they must replace sold-out sizes with new garments. These shirts must match the remaining inventory from prior runs. Color variation on the rack or display is not acceptable. Large retail buyers like Wal Mart and JC Penney are becoming extremely quality conscious.

The recent explosion in licensed apparel lends another reason for color measurement and control. National recording artists and sports personalities are the subject of licensed reproduction. Licensing groups have an important interest in maintaining accurate and controlled reproduction of their properties. With large corporate acquisitions of licenses, brand and identity management will play a much bigger role in the future. Printers hoping to compete in this marketplace will be faced with new control challenges that have not been a factor to date.

Where does this lead us? Is it possible to control process color reproduction on textiles? The answer is a qualified yes. Like all technologically sophisticated processes, there are many variables. It is possible to measure color and density on a textile medium. That will be the focus of this article. Knowing what to measure, why, and how to do it will help to control consistency of the final images.

There are two methods which can be used to measure color on textile surfaces. The first is colorimetry and the second is densitometry. Colorimetry is commonly used to measure fabric dye, color, and appearance. Most colorimeters use the CIE L*a*b*, X,y,Y, or X,Y,Z approach to measure and describe color. There are more sophisticated measurements available, but they are less commonly used outside the laboratory environment.

While these methods can be used to measure process color, it is much less common. We can, however, borrow some of the measurement methods that have been developed for the textile industry and apply them to using the densitometer for process color.

The traditional approach to four-color process color measurement has been the reflection densitometer. The graphic arts industry has used them for many years. Color reflection densitometers are readily available and do a very good job. The cost is moderate, but something that the serious process color printer should possess.

Why should we take the time and effort to take all of these readings? This is a very good question, especially for our industry that has had a traditional aversion to any kind of measurement or process control. The first logical reason would be to evaluate the quality of your inbound materials. Are they consistent? I often hear printers lament the inconsistency of ink and garments. Remember that the suppliers in our industry are market driven. This simply means that they will not change until we demand it. The more ammunition we have, the easier it is to get improvement.

Besides measuring ink, the densitometer can play an important role in evaluating garment surfaces for process color reproduction. There are two key issues here. One is relative openness of the knit, or how much surface area we can print. The other is the relative opacity of the garment. Thin shirts tend to “show-through.” The resulting image that is printed on this type of garment will tend to look washed out and very light. I often tell customers that “we can’t print on air.” If the ink sticks only to the available thread, the image will almost always look light. In addition, tonal values and print contrast will be poor because of the dot gain that results from unprinted ink that gets left behind on the screen. On the next print these areas provide a double hit, thereby contributing to tone compression and dot gain.

The more opaque the knit, the less influence the underlying surface color will play when the design is printed. Different thread gauges result in differing amounts of fabric bulk or mass. Size of the thread and number of stitches per inch are the two main factors here. The finer the thread (i.e., 24 or 26 singles) and the fewer stitches per inch, the thinner the fabric surface is. This reduces opacity of the garment and the ability to mask or cover the underlying surface color. As a result, a white garment on a dark fleshtone will result in diminished print contrast in the image. Likewise, open end yarn will have a lower opacity than yarn which is ring spun. These are some of the reasons why heavyweight cotton is such a good surface on which to print.

The second reason to measure is to compare consistency in your own operation. The same concentration of ink printed through two different meshes will give two different colors. The same ink printed through the same mesh at different tensions will give different results. Knowing the window of performance will help you to produce a consistent product. Measuring ink deposit is one of the single easiest ways to identify production problems or process inconsistency. Measuring color areas during different parts of the run will help to understand the stability of your printing. If color values are drifting around, there are opportunities to tighten the process control.

Third, and perhaps most important, is that consistent recording of information greatly speeds the learning curve of the printers. When you can see the variation and measure it, it becomes much easier to draw correlations to the printing set-up, press, screens, tension, and ink. This helps to develop a true experience level. There are printers that have done many process jobs, but still do not understand what is happening.

Densitometer functions

There are many useful functions on a modern reflection densitometer. When selecting a model, make sure that it is Status T capable. This is the international standard for wide band color measurement. This refers to the method that most closely matches the response of the human eye to tristimulus color (the way we see color).

Color strength is measured with the density function. The number that is displayed tells us how much light is being absorbed by the printed ink film. It is logarithmic. A value of 1.0 means that 90% of the light is absorbed. A value of 2.0 means that 99% of the light is absorbed. Measuring ink density is important because it controls how strong the color appears. Inconsistencies in color strength mean inconsistencies in overall color. Density also has an effect on how secondary colors are rendered and how neutral the "grey balance" is. Measuring density allows for an easy check of the color strength of any given process color right out of the can and of the consistency of any process color concentration.

Hue error and greyness are the next functions. Since there are no accepted color standards for process color in our industry, these functions are particularly important. Hue error refers to the amount of color variation from the "ideal" primary position. The primary positions are yellow, magenta, and cyan. Yellow is relatively pure and has the best location in relation to the ideal position. A color like magenta can be contaminated with up to 70% yellow. This would lead to a hue error reading of 70. This reading is very important because there are so many different types of inks available to the textile screen printer. By measuring hue error of the ink and comparing it to hue error of the proofing material, you can easily tell if you will be able to match the proof. More often than not, you will not be able to match the proof. Changing inks will give you a completely different look from the same set of film. Every ink that you use should be measured for hue error.

Greyness value of the ink refers to the amount of the complementary color (resulting in grey) in any given color. This means that yellow will have a certain amount of blue (magenta + cyan), magenta will have green (yellow + cyan), and cyan will have red (yellow + magenta). The net effect of adding a complementary color is to "grey" or "muddy" the color. The higher the grey reading, the muddier the colors will be.

Magenta is usually the worst. The two main pigments used in process magenta are rhodamine red and rubine red. The rhodamine is cast to the yellow side, and the rubine is cast to the blue side. Neither is acceptable by itself, and when mixed they result in a muddy magenta.

Cyan has the next largest grey value, and yellow is the purest. If you would like to know more about this, please read:

"Hue Error and Greyness in Process Color Inks As a Predictor of Color Reproduction" (see Tech Library directory).

The Hue Error and Greyness values are very useful in comparing different brands of ink. It is also very interesting to note that as the density of an ink changes, hue error and greyness change as well. A high density magenta will tend to be on the blue side, while a lower density of the same color will be cast more toward the yellow.

While we are on the subject of hue error and greyness, the importance of the garment color must be stressed. The whiteness level of the fabric acts as a platform onto which the image is built. The more color cast there is in the fabric, the more color shift you will see in the final image when compared to the color proof. Whenever possible, the whiteness of backing on the proofing material (Color Key®, etc.) should correspond to the whiteness of the garment.

This value is determined when the densitometer is "zeroed" at the beginning of the measurement cycle. The instrument will ask for a "paper value." This essentially is the white reference point. When this value is taken, the densitometer will display the amounts of the Yellow, Magenta, Cyan, and blacK in the surface you are measuring. These values are added to values in the process colors to arrive at the final color density or color strength. For instance, if the surface you are printing on has a Yellow value of .05, the amount will be added to the value of the yellow ink. The result would be a color shift in the image to the yellow side in the amount of .05.

A third key measurement is dot area or dot gain. This is calculated by measuring the garment, the solid density of any given process color, and then a tint of that color. If we know the value of the dots on the film, we can compare it to the printed area. The difference is the dot gain. It is usually measured in the midtone area (around 50%) and in an absolute percentage. A reading of 20% dot gain means that the 50% dot is growing to 70%. Typical values for textile printers range from 25% to 40%+. The dot gain reading can also be very useful in determining if the platens are level and parallel to each other. If the sample area is measured on each platen, the value should be the same, within ±1%-2%. If it is not, you need to adjust the machine.

Dot gain can vary with color of ink, the amount of ink you print, and the order that ink goes down on the textile. Being able to measure the type of gain you experience will help you to recognize different printing configurations and the stability of each of those.

There are several formulas that can be used to measure dot gain. One is based on physical growth of the dot. Another takes into consideration the "optical gain" as well as the physical gain. This is very important to us because of the porous nature of the fabric that we are printing on. Optical dot gain accounts for internal reflections of the printed image on the substrate. It uses the "Murray-Davies" equation. This is the method that we have had the best success with on fabric and is the most commonly used density calculation.

There is another type of density measurement method known as the absolute density. This is used to calculate physical dot growth. It is less commonly used because the influence of optical gain measured with Murray-Davies is so great.

A less commonly used measurement is Print Contrast (PC). Even though it is not that common, it is one of the most useful measurements. It compares density of the solid color with density of the 75% tint block. The relationship describes the contrast of the 3/4 tone to solid. While this is quite technical, it gives you an immediate indication of how well you can maintain your shadow detail.

This is one of the most common problem areas with textile printers. The usual situation starts with the printer noticing that he has too much dot gain in the shadows, and the image is dark and muddy (this often happens when litho seps are used). If we were to measure the relation of the 75% to solid, the ratio would be low. Now pull the ink out of the screen, and add base to the solid color, hoping to lighten the design. While it accomplishes this, it does nothing to reduce the 75% dot gain, and the PC ratio still remains low. The new result is a lighter, flat, muddy print. Maximizing the PC ratio means that you have good contrast in your image, and the detail is clear and discernable from adjacent tones.

The last area of measurement is called trap. This measurement displays a value of 0% - 100% and represents the efficiency of the secondary colors (red, green, and blue) that result from overprinting the primary colors (yellow, magenta, and cyan). This measurement will change with the order in which you print inks. For textile printers this has again been a problem. Since we print wet-on-wet, there is always a certain amount of set-off on the back side of subsequent screens. By experimenting with different inks and color orders, the printer can produce different secondary colors.

Trapping value varies greatly between different brands of inks. To some degree it is a measure of transparency of the color as well as the tendency of ink to build up or transfer. This is particularly noticeable with yellow as many of the common yellow pigments are translucent, not transparent. Resulting overprints of green and red will have a low level of efficiency, and there will be a dominant cast to the yellow side. Bright reds are reproduced as oranges. Almost all textile plastisols suffer from this, and designs with bright reds almost always require a spot red printer.

Taking measurements

Taking densitometry measurements on fabric is not that much different from taking them on paper. It is important to keep some basic concepts in mind when taking your measurements. Remember that fabric is porous. This will have an effect on your readings, but not as much as you might think. As long as your readings are taken using a specific method, they will be valid. The color that we are measuring is a relative issue. Our main concern is that we maintain consistency. As you sample over a large number of garments, you will begin to recognize patterns and trends. These are what we are trying to identify and correct.

All densitometers come with a ceramic tile that is used in the initial calibration of the device. This provides a known value for standardization. We need to take this one step further for our purposes. Once the densitometer is calibrated, we need to make a trip to the local home improvement center. Take the densitometer with you. In the ceramic tile section, sample the white tiles until you find one with a very low reading. The density should be less than .05 if possible. If you can find several with the same low value, get them all. This will become part of your standard reference method.

Back at the shop we will take the garment that we intend to measure and insert the tile under the fabric. We then take a substrate measurement through the fabric with the tile backer in place. Make sure the tile is clean when you take your measurement. The resulting value will be our starting value. It will usually be something like .10-.15. We enter this value as the paper or substrate value.

The tile backer provides a reflection point. Ink readings that are returned take into consideration the printed ink and the reflected background color. The tile surface acts to smooth or average the open space so that we will have some consistency to the readings.

Try sampling different types of garments, 50/50 medium weight, 100% heavyweight cotton, as well as different types of fleece. Different readings will give you an idea of how the substate will add to the color of the separation.

Ask your separator to provide some type of color control bar to your film. This will be the starting point to gather information about your print. The control strip should have a highlight, midtone, 3/4 tone, and solid color patch. From this you can adjust your color and print until you like the way it looks.

Unlike lithographic or flat stock, you cannot print the color bars during the run. To overcome this minor inconvenience, look for three target areas in the image. These would be highlight, midtone, and shadow. Depending on the type of densitometer you have, it may be possible to automatically filter between each process color. In other words, the instrument will give you a reading for yellow, magenta, and cyan, even if all three colors are printed in the same area.

The values that you obtain will be remarkably close to traditional lithographic values. Typical values are: Yellow .85, Magenta 1.10, cyan 1.20, black 1.40. This set of densities will give good grey balance. If you have an image that is primarily skintones and warm browns, switch the magenta and cyan values. Running a cyan slightly higher than magenta will cast the image toward a cool grey. During the production run, the density should be kept within ±.07. You can check this by running an occasional scrap garment through and printing only single colors on it. Use this piece to check consistency of the ink deposit.

Plastisol changes with time and heat. If the run is long, you will need to check the consistency on a regular basis–and certainly after each addition of fresh ink in the screens. Be extra careful to check when new ink is mixed. Make sure that it is of the same strength as what you had been using.

Many printers do not like to use the densitometer to measure color during the run. This is understandable in that the instrument is somewhat expensive and can be damaged if dropped. In this case, the image should be balanced on the press and the values noted.

After the color bars are taped off, four samples are pulled. Each one is signed and dated by management and the customer (if they are present). One is for the customer, one for the job ticket, one for the press unload position, and one for the end of the dryer. This way each piece is inspected twice, and all parties have samples to compare against when the run is delivered. This avoids unpleasant exchanges if there is a color variation. While not a perfect solution, it does help in getting everyone off to a good start.

While not a common practice at this time, measuring textile process color with a densitometer offers many advantages. The chief reasons are to control inbound ink color consistency, compare different

brands of garments, compare different brands of inks, adjust color on press, and provide a point of return with dealing when repeat process color jobs. With the proliferation of color printing, the increased quality standards of licensed and retail printing, and the low cost of microelectronics, the use of densitometry is likely to spread.