Bolt-to-Bolt Mesh Variation

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In cooperation with a screen printing company, the Screen Printing Technical Foundation ran a short study involving three different bolts of fabric of the same mesh count and manufacturer (each from different lots). These meshes were tested for the ink deposit they produced, and for the color difference resulting from any deposit changes.

OBJECTIVES

The objectives of the investigation were to:

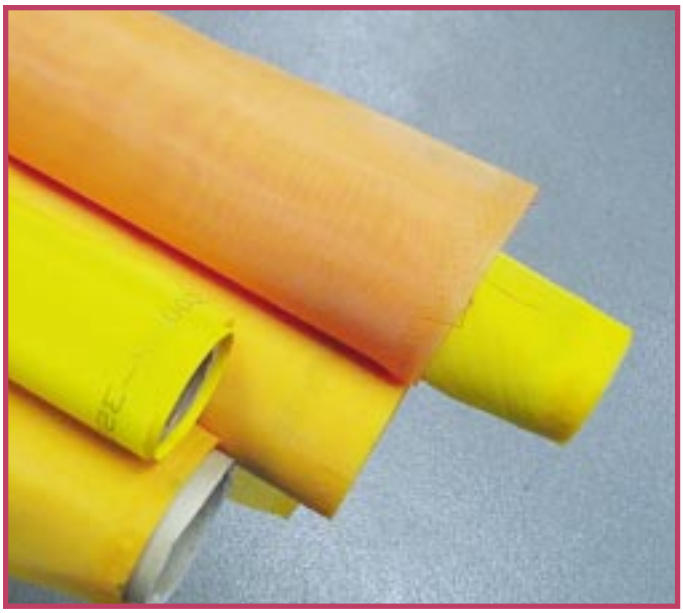
1. Document the actual mesh dimensions on three different lots of fabric of the same mesh count from one manufacturer to determine the degree of variation present.
2. Determine how much these differences in mesh dimension affect the ink deposit under standard conditions.
3. Demonstrate the relationship between ink deposit and color changes with a transparent ink, and to determine the degree an ink deposit must change to generate an unacceptable color shift.

EXPERIMENTAL METHOD

The screen printing company supplied SPTF with three different pieces of fabrics with different lot numbers that had shown differences in the process. The transparent ink used in their production was used in the testing in an attempt to duplicate the color shifts that had been experienced at their plant. The mesh was a 390/34 twill weave fabric and the ink was a reddish orange ultraviolet (UV) curable screen printing ink for vinyl.

Two separate tests were performed, one with the screens tensioned to 20 N/cm and another at 27 N/cm. The mesh dimensions (mesh opening area, thread diameter, mesh count, and fabric thickness) were first measured on free fabric using an image analysis system (Figure 1), mesh counter and electronic thickness gauge. Three screens were then rapidly tensioned to 20 N/cm on a pneumatic clamp system set up in round-robin configuration, and glued on 23” x 27” frames. A capillary film was applied to all the screens, and imaged with a 10 x 10 cm square. Mesh

SPTF’s short study of ink deposit and color shift produced from bolt-to-bolt mesh variation makes a solid case for implementing incoming quality checks on mesh for close tolerance applications.



dimensions were again measured on the tensioned screen before printing.

A 20" semi-automatic press was used to print all screens under standard set-up conditions.

Both the 20 N/cm and 27 N/cm screens were printed with an off-contact of 60 mils on the glass substrate and 80 mils on the other substrates. The squeegee pressure was set at 12 lbs. for the glass substrate and 14 lbs. for the other substrates, with an 8 inch, 75 durometer squeegee for all.

The first substrate printed was a ground glass substrate, to allow a wet ink deposit measurement to be made with SPTF's Electronic Micro Gauge (the EMG is profiled in SPTF's report entitled *Guideline to Wet and Dry Ink Measurement, Part I*). Three other substrates including a white vinyl, white coated paper and Leneta card were also printed and cured to track color shift. A second set of screens tensioned to 27 N/cm was tested the same way.

RESULTS

The data can be divided into three areas: mesh dimensions, ink deposit and color differences. Each were evaluated individually and then considered together in order to make conclusions on the significance of these findings. The three lots of fabric have been assigned a letter for identification (X, Y, Z) rather than using the actual lot number given by the manufacturer.

The measured mesh dimensions can be found in Table 1. Each lot number has measurements at free mesh, 20 N/cm and 27 N/cm. Comparing fabric thickness readings, the X and Y lot are basically identical, while the Z lot is around a micron thicker. Mesh opening area also shows the Z having larger openings than the other two fabrics.

Figure 1

Table 1 MEASURED MESH DIMENSIONS

Assigned code to identify Lot#	Tension	Fabric Thickness (microns)	Mesh Open Area (microns^2)	Thread Diam. Average (microns)	Mesh Count Warp (t/inch)	Mesh Count Weft (t/inch)	Mesh Count Average (t/inch)
X	Free	62.5	636	41.8	393.7	381.0	387.4
	20 N/cm	58.1	827	40.5	370.8	373.4	372.1
	27 N/cm	57.0	907	39.2	358.1	365.8	362.0
Y	Free	62.8	642	40.4	388.6	383.5	386.1
	20 N/cm	58.4	842	39.4	373.4	375.9	374.7
	27 N/cm	57.2	912	41.1	355.6	368.3	362.0
Z	Free	65.6	697	39.8	391.2	381.0	386.1
	20 N/cm	59.1	905	40.8	360.7	363.2	362.0
	27 N/cm	58.1	968	40.6	353.1	355.6	354.4

• Fabric Thickness measured with electronic thickness gauge equipped with a screen printing probe.
• Mesh Opening Area and Thread Diameter measured on SPTF image analysis system at 500X.
• Mesh Count measured using 50X mesh counter.

Mesh count also tracks with the X and Y being very similar, and the Z having a lower mesh count at the 20 N/cm and 27 N/cm tensions. Thread diameter is the same for all three. Overall, the X and Y lots seem to be similar in dimensions, but lot Z has a slightly thicker fabric thickness along with larger openings and lower mesh count. Although the mesh elongation was measured, it is not shown here because all three lots elongated similarly.

A chart showing the wet ink deposit measurements for the different screens can be found in Table 2. The X and Y lot produce virtually the same wet ink deposit on the 20 and 27 N/cm screens. The 20 N/cm screen of the Z lot also measured the same as the other two lots. The only ink deposit that differs significantly is the Z lot at 27 N/cm, which is around one micron thicker than all the other deposits.

While these wet deposits were on glass they do show trends in deposit from the mesh on a standard substrate. It is valid to use this information to draw conclusions from the deposits on the other substrates as well. Dry ink deposit measurements on the other three substrates could not be measured as accurately due to the lack of uniformity in substrate thickness.

The last set of data (Table 3A, B, C and 4A, B, C) shows the resulting DE (Delta E) or average color difference between all the screens on three substrates. For those not familiar with color measurement, the DE number is calculated based on spectrophotometer readings and indicates a color difference between two samples. A zero would indicate the colors are the same. Progressively higher numbers show that the compared colors differ in some way (although this number does not specify which attributes differ). By using DE to compare the same ink

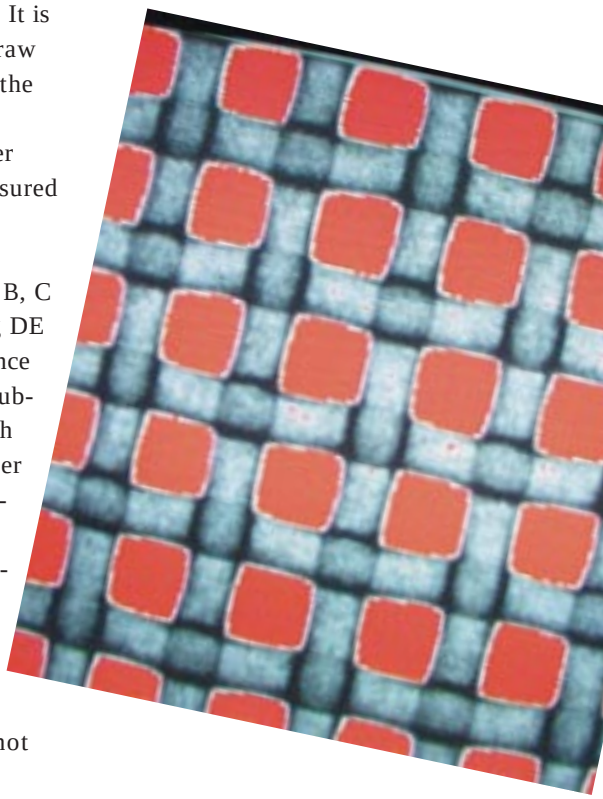


Table 2 **WET INK DEPOSIT ON GROUND GLASS**

Lot Number	Tension	Wet Ink Deposit on Glass (microns)
X	20 N/cm	16.78
	27 N/cm	16.98
Y	20 N/cm	16.94
	27 N/cm	17.26
Z	20 N/cm	16.90
	27 N/cm	18.04

WET INK DEPOSITS ARE AVERAGES OF 50 DATA POINTS TAKEN FROM 5 PRINTED SAMPLES MEASURED ON SPTF'S ELECTRONIC MICRO GAUGE.

Table 3A **VINYL SUBSTRATE**

Lot#	Tension	DE
X	20 N/cm	Standard
Y	20 N/cm	1.54
Z	20 N/cm	0.91
X	27 N/cm	Standard
Y	27 N/cm	0.84
Z	27 N/cm	2.25

Table 4A **VINYL SUBSTRATE**

Lot#	Tension	DE
X	20 N/cm	Standard
X	27 N/cm	1.00
Y	20 N/cm	Standard
Y	27 N/cm	0.89
Z	20 N/cm	Standard
Z	27 N/cm	2.94

Table 3B **PAPER SUBSTRATE**

Lot#	Tension	DE
X	20 N/cm	Standard
Y	20 N/cm	1.05
Z	20 N/cm	1.20
X	27 N/cm	Standard
Y	27 N/cm	0.31
Z	27 N/cm	2.57

Table 4B **PAPER SUBSTRATE**

Lot#	Tension	DE
X	20 N/cm	Standard
X	27 N/cm	0.73
Y	20 N/cm	Standard
Y	27 N/cm	0.69
Z	20 N/cm	Standard
Z	27 N/cm	2.08

Table 3C **LENETA CARD-coated area**

Lot#	Tension	DE
X	20 N/cm	Standard
Y	20 N/cm	0.51
Z	20 N/cm	0.69
X	27 N/cm	Standard
Y	27 N/cm	0.37
Z	27 N/cm	2.54

Table 4C **LENETA CARD-coated area**

Lot#	Tension	DE
X	20 N/cm	Standard
X	27 N/cm	0.41
Y	20 N/cm	Standard
Y	27 N/cm	0.55
Z	20 N/cm	Standard
Z	27 N/cm	2.00

Standard indicates that the print produced from this mesh was entered on the spectrophotometer as the reference color that samples from the other two meshes were compared to.

printed through different fabrics, we can identify color shifts resulting from different ink thicknesses.

Two types of comparisons are shown for each substrate. The first shows the color differences of lot Y and Z from the color printed by lot X (used as the standard) at each tension level (3A, B, C). The second comparison shows the same lot number at the two different tensions (4A, B, C). The spectrophotometer used was a 8°/d sphere, and samples were measured with the specular included, using a large sample port.

The 20 N/cm screens do not produce much color difference on the Leneta card surface (3C), but show a bit more difference on the vinyl (3A) and paper substrate (3B). The vinyl shows the Y lot to be different from the X and Z. The paper substrate shows all three lots generating small color differences from one another. The discrepancies might be the result of the ink transferring at different rates to the various substrates. However, the color differences seen with the 20 N/cm screens are not large enough to cause the color match to be rejected on any of the lots.

In the case of the 27 N/cm screens, all three substrates show the X and Y lot to track closely in color, while the Z lot caused an unacceptable color shift. In fact, the range of the DE values for the Z lot runs between 2.25 to 2.57.

For those more experienced in color measurement, it is interesting to note that the differences in the DE values were primarily caused by a shift in the chroma attribute. The thicker ink deposit caused the color to appear more saturated or brilliant.

Probably the most interesting observation is in comparing the same lot at two tension levels, 20 N/cm and 27 N/cm for each substrate (Table 4A, B, C). These two tensions produced essentially the same color for the X and Y lot but not on the Z lot. When comparing the 20 and 27 N/cm screen of the Z lot, we see a color shift occurring as a result of increased tension. This suggests that the Z lot changes significantly at tensions above 20 N/cm resulting in a change in ink deposit and color.

Combining the information from the three data sets will allow for an explanation. The mesh dimensions show that the fabric thickness and mesh openings are bigger on the Z lot than the other two lots. While the Z lot 20 N/cm screen does have bigger dimensions than the other 20 N/cm screens, it is close to the 27 N/cm screens of lots X and Y. This would imply that changes in the mesh dimensions up to this point do not change the ink deposit and subsequently, the color. The wet ink deposit data and color data corroborate this.

However the dimension changes of the Z lot at 27 N/cm have extended beyond this point, and as seen in the ink deposit, increase the laydown by approximately one micron. The thicker fabric thickness and larger mesh openings not only create a larger mesh cell for holding ink, but probably allow for more of that ink to transfer to the substrate. These two conditions would explain why this mesh printed more ink. As the color data show, the additional one micron of ink creates an unacceptable color shift in this transparent ink.

APPLICATION

The screen printing company involved in this test discovered that bolt-to-bolt variation was affecting their process prior to SPTF's study.

They have worked with their mesh supplier and arranged for the supplier to send only those lots that meet a certain specification. This control of incoming products has helped them to produce repeatable color matches. But a great deal of time and testing was necessary to first pinpoint the problem, and then define a window of acceptability for the mesh specifications to accomplish consistent color matching in their application.

How can this help you? Well, unless you have done the level of testing this screen printing company has, and unless you have your process in control so the problem can be narrowed down effectively, the information presented here *cannot* be used to run to mesh manufacturers and demand more consistent mesh. However, once your process is in control, and a solution to a color matching problem is being sought, this may be one area to consider. Incoming quality control checks on new mesh are valid. These measurements can help identify problems before they end up creating costly mistakes. Bolt-to-bolt variation of mesh is a real variable that can cause significant differences to the

Figure 2

final print in some high tolerance applications. *Bolt-to-bolt mesh variation is not a variable to criticize, but one to accept and take responsibility for through the use of incoming quality checks. Remember, if you can't measure it, you can't complain about it!*

The two measurements that are easy to make on mesh used for sensitive applications are fabric thickness and mesh count at final tension. An electronic thickness gauge (Figure 2) can be used to read the fabric thickness (when using the special procedure outlined in SPTF's Practical Application Bulletin *Using Electronic Coating Thickness Gauges Effectively in Screen Printing*). Mesh count must be manually counted using a microscope or mesh counter (Figure 3). Once measurements are made and recorded on a lot of fabric, the next lot received of the same mesh count, thread diameter and manufacturer should be checked against these numbers. They should be similar. The information collected can serve to alert you to any major differences before going to press and can provide a reference to check if there is a problem with a color match (resulting from an ink deposit shift).

Figure 3

CONCLUSIONS

With the color of transparent inks being very sensitive to variation in thickness, a one micron difference in ink deposit can make a difference. For color matching applications, this is a vital fact of which to be aware. Using fabric from different bolts, even if mesh count, thread diameter and manufacturer are the same, may cause changes in ink deposit. Keep in mind, there are many other variables that can affect ink deposit. All of them must be controlled to attain consistency and predictability. *Simply blaming the mesh when something goes wrong is not at all what this short study suggests.*

While the ink tested in this investigation was not process ink, these inks are also transparent. For this reason similar ink deposit differences would affect these inks in much the same way. Four-color process printing also has the factor of stencil thickness to potentially add to this variation. Understanding the relationship of ink deposit to color change is a critical element of successful color matching.

RECOMMENDED READING:

Changes in Polyester Mesh During Tensioning, SPTF Technical Research Report

Guideline to Wet and Dry Ink Measurement, Part I, SPTF Technical Research Report

Using Electronic Coating Thickness Gauges Effectively in Screen Printing, SPTF Practical Application Bulletin

Estimating Ink Deposit in Screen Printing, SPTF Practical Application Bulletin

Color Matching: Controlling Your Accuracy, SPTF Practical Application Bulletin

Rapid Tensioning of Polyester Mesh, SPTF Research Report

All reports available on the SPTF CD-ROM. Contact SPTF for more information.