Controlling High Quality Process Printing With UV Inks

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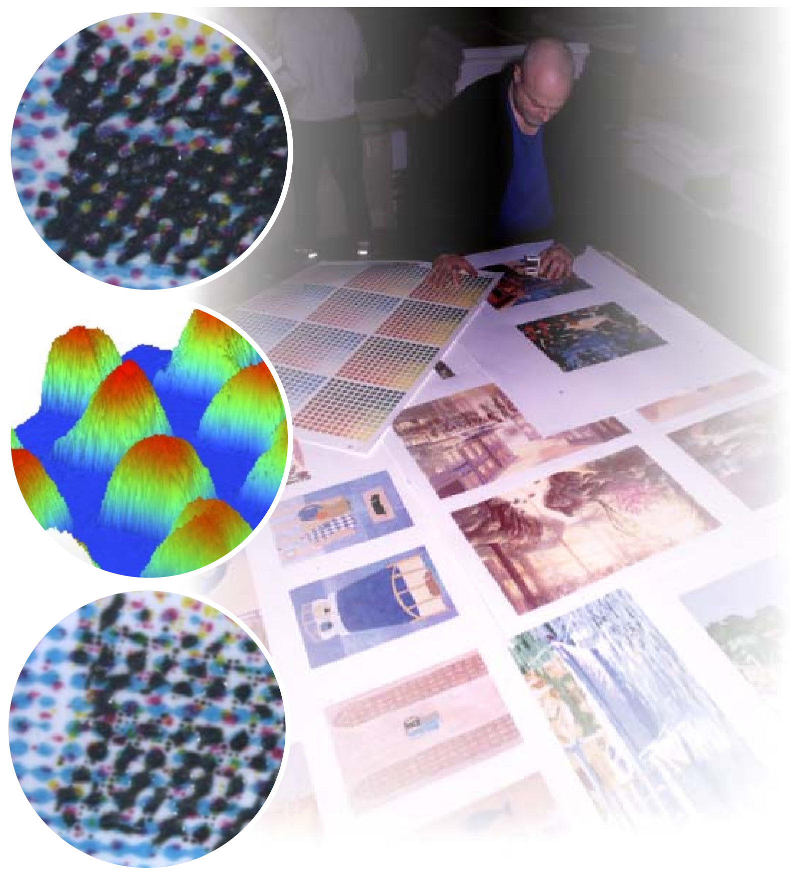

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Costly Speed Bumps on the Road to Process-Co

Confusion and misinformation have historically clouded the reasons behind some of the difficulties in screen printing the most accurate four-color process images with UV inks. Thanks to research conducted at two U.K. universities (Swansea and Leeds) plus research at Autotype International and Autotype Americas* the confusion has been stripped away. We now have a clear picture of the problems, their causes, and most important, how to bring them under control.

Many graphics printers who print commercially acceptable results with 4-color UV at 65-lpi are being pushed by the market into producing line counts of 75, 85 and 100+ lines per inch. Although the print buyers may not necessarily benefit dramatically from high line count printing, they know they can get it from digital and offset printing vendors, so they expect the same from screen printers. Everyone expects higher line counts to increase the difficulty factor and "misery index" of screen printing, but as some have discovered, it's not just difficult, it's seemingly impossible!

Too much and too little

What puzzles printers the most is that when they look closely at their setup, they find nothing wrong. If they print C or M or Y or K they see nothing but superb print quality, with test strips right on target. Yet when they look at the final print they notice some areas with too little ink ('skipping') and other areas with far too much ink ('stacking'), see *Figures 1a and 1b* at right.

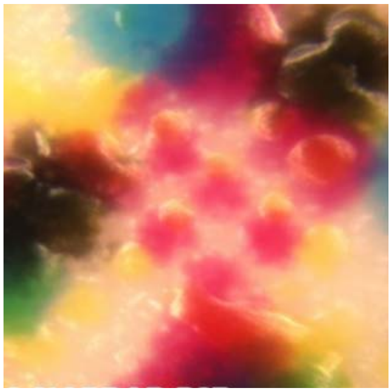

Figure 1a: Ink skipping

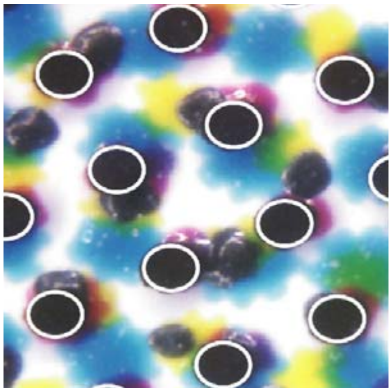

Figure 1b: Ink stacking

If you employ a workaround to reduce skipping (e.g. increasing squeegee pressure) you will get stacking. Conversely, if you try to reduce stacking you get skipping. You can adjust the press to make one job look good, but the next job looks awful. Nothing seems to make sense.

Dot-on-dot gain and loss

It turns out that these problems arise from one cause:
You are printing dots on top of other dots.

As you successively pile dots of 100% solids ink onto preprinted dots, the substrate becomes increasingly textured. Your third and fourth colors down will be most severely affected, and higher line count images will be most difficult to print.

The stacking gain shown in *Figure 1b* is the result of newly printed dots sliding around on top of the previously printed colors.

It's more difficult to show that skipping is a pure dot-on-dot effect, but extensive experiments show that it's the case. The more under-printed dots you have, the higher the chances of getting skipping.

The skipping/stacking theory

A new theoretical model for how screen printing works, developed by Autotype and Leeds University, can be used to explain both skipping and stacking. This short article doesn't leave room to explain the theory, but the diagrams in *Figure 2* (top of opposite page) show the state of the ink just before the stencil separates from the substrate. Note that the squeegee has already passed by and is not directly involved in how the ink comes out of the mesh with stacking or skipping. Instead the squeegee controls whether the ink fills the space beneath the mesh (giving stacking) or fails to fill it (giving skipping).

The theory shows that with conventional systems, if you avoid skipping you must get stacking, and vice versa. And it also shows that the only way to reduce skipping and stacking is to reduce the height of the previously printed dots.

Less is better

In general, fewer dots are better than more dots. So reducing the number of printed dots by employing GCR (Gray Component Replacement) can help - but it only helps a little.

To reduce our printing problems we need to reduce the

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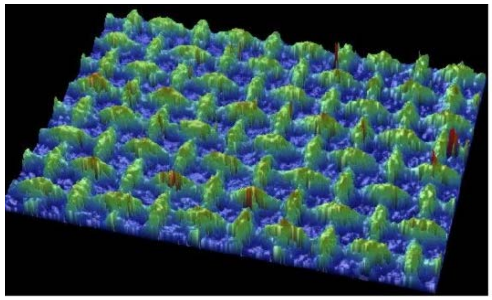

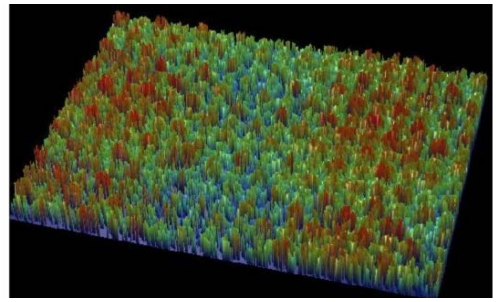

Figure 2: Extra ink (stacking) and too little ink (skipping) in the mesh and stencil

printed height of the dot. How can we do that?In solvent or aqueous systems, it's easy to reduce the height of a printed dot; you simply add more solvent or water. But with UV we do not have that option. The theoretical model developed by Autotype and Leeds University, shows that there is little scope for modifying the absolute performance from a UV ink. In general, the ink only alters the balance between skipping and stacking.

So what else controls the height of the printed ink? The answer is the mesh and the stencil. Unfortunately you've probably reached the limit of what you can do with the mesh. Most printers know that they should be using a high mesh count (typically > 390 threads/in) with the smallest practical mesh diameter (typically 31µm, as 27µm is often too weak for practical use).

This leaves us with the stencil.

Data obtained from the SPTF in the USA indicates that as EOM increases, ink deposit also increases. That isn't very surprising, but what is interesting is the discovery that stencils with EOMs of 5 microns and greater will deposit one more micron of ink for every extra micron of stencil profile. Stencils with EOMs of 3 microns or less do not have this effect on ink build.

In other words, the way to reduce your UV printing problems is to go to the lowest possible EOM. But there is another factor we must consider when making screens for process color printing: Rz value.

Rz: The rough and the smooth

One path to a low-EOM stencil is to do a simple 1+1 coating with an emulsion. But there's a problem with that. You get a very low EOM that produces a very poor print. Why? The surface roughness, or Rz value, is too high. This happens when the emulsion shrinks on drying and follows the contours of the mesh. A typical 1+1 emulsion can give you more than 20µm Rz, which is hopeless for good quality printing.

At the other extreme, a stencil that gives a glass like surface (very low Rz) can cause problems with 'vacuum blocking or sticking' to a smooth substrate, and you may get some printing defects.

Theory combined with practical experiments shows that an Rz of around 3µm is an optimal balance between the rough and the smooth. Yet even here there's a problem as there are two types of Rz that are important for print quality.

One type of Rz is a low frequency variation in profile that follows the contours of the mesh; this is typical of a direct emulsion. The other is a high frequency roughness that is created from the profile of the micro-matted base supplied with some types of capillary film. *Figure 3* shows the two types. Unfortunately, the conventional, low-frequency Rz makes it very easy for the ink to seep out underneath the stencil edge, and you lose print definition. You will also find that your dot gain is influenced greatly by the squeegee pressure, making it difficult to control to the quality you require. A law of physics shows that the high frequency roughness makes it very hard for ink to leak out, so you get much better edge definition and much less dependence on squeegee pressure.

Practical testing with such a micro-matted system shows two benefits. First, the dot gain curve for the monoprints is remarkably flat with increased tone in the highlight and shadow areas. Second, the skipping and stacking are reduced considerably and the quality of the print improves.

Color correction required

So, a stencil with a low EOM and low, controlled high frequency Rz will give you the best chance of achieving the quality you require. You have minimized the dot-on-dot problems, not eliminated them entirely. Once you have gone as far as you can go to resolve your skipping and stacking problems, you can address any residual color issues by applying color correction.

Although most good printers use dot gain curves with their imagesetters to linearize their films, these only apply to monoprints. Printed dot-on-dot gain will vary with the tonal variations (percent of dot coverage) already printed on your substrate. So if you print a 50% halftone screen onto a substrate that has already been printed with, say, a 40% halftone, you will see one degree of stacking gain. Print that same halftone onto a substrate printed with an 80% dot pattern, and the amount of stacking gain will be less, because 80% coverage is approaching a smooth substrate surface.

Because the gain varies for each type of dot underneath and because each part of the print has different amount of dot underneath, you just can't program a simple curve to fix the problem. The way out of the problem is to do a full ICC-style color profile. You print a standard test sheet made up of over 2000 different color patches. These are then scanned with a spectrophotometer and a bit of software then does the calculations that produces a color profile that says what amount of CMY & K should actually be printed to obtain the desired color. This color profile is then used each time you output a CMYK set.

This color profile will give you the best color accuracy and color gamut every time you print, **provided your stencil/mesh/ink/press combination remains constant.** This is another reason that the low controlled Rz stencil is essential. Such a stencil has the least dependence on variations in ink and press settings, so is the most likely to give you reliable color profiling time after time.

Applying all of this to production

You are not alone if you are having trouble in accurately reproducing printing high quality, 4-color process images. Only recently has a rational explanation emerged about exactly what's causing the problems, and from that explanation, it's clear what you have to do to minimize the problem:

1. Use the finest practical mesh (390/31 or better)
2. Use a stencil with the lowest possible EOM (3 microns or less).
3. Use a stencil with a low, controlled high frequency Rz of around 3-6µm. Remember, even at 6µm, the high-frequency Rz will prevent ink seepage under the stencil edge and give you the results you are after.
4. Use moderate GCR (gray component replacement)
5. Use a color profile to optimize your color fidelity and gamut

The tough challenge is combining #2 and #3. Typical emulsions can provide low EOM or low Rz but not the two together, and the Rz is usually of the low frequency variety. A typical capillary film is an improvement over direct emulsions in giving a controlled EOM and smooth Rz, but for high line count process printing with UV inks, their performance still falls short.

The understanding of these problems has fueled the development of Autotype Capillex CP, the first stencil material that incorporates both a low, controlled EOM and an optimized Rz into a film that prints with unprecedented consistency.

For details on this breakthrough stencil film, contact MacDermid Autotype at (800) 323-0632 or download the product data sheet in PDF format from www.macdermidautotype.com

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