Take Control Of Your Screens For Printing 4-Color Process With UV Ink

INTRODUCTION
THE STENCIL
THE MESH
THE LIMITATIONS

Ross Balfour
Research & Development Manager
SAATIchem
901 North Business Center Drive
Mount Prospect, Illinois 60056
Tel: (877) 296-7697 or (847) 296-7697
Fax: (847) 296-7408
Email: info.us@saatichem.com

PART 1 • INTRODUCTION

The complexities of screenprinting four color process are further complicated when using UV cured ink, by extra demanding requirements in controlling ink deposit.

It’s not enough to have to deal with the relationship of dots per inch with mesh count, or carefully selecting the angle of dots on each seperation so you avoid not only mesh/dot moire, but even dot to dot moire between the overlaid colors. Now you also have to avoid the problems that can occur from printing halftones with an excessive ink deposit. Problems will occur when printing third and fourth colors if ink transfer from the screen to the substrate is severely affected by excessive ink deposit from the first two colors down. This is due to the high solids/low shrinkage characteristics of UV cured inks.

In terms of detail, highlight dots represent a major challenge. For instance, a 10% dot on an 85 line halftone is 0.004” across. To put this in perspective, if it were the size of a quarter, a 2” X 3/8” squeegee would be nine feet thick and forty two feet high. Therefore, in order to give ourselves the best chance of being able to successfully reproduce over seven thousand of these 0.004” dots per square inch of print, and to do it consistently with a carefully controlled ink deposit, we need to be in total control of our screen making process.

The basis of this presentation then is to outline the properties of mesh/stencil combinations which are most suitable, and identify the variables which need to be controlled in order to successfully print four color process with UV cured ink.

PART 2 • THE STENCIL

A screenprinting stencil performs four functions. Two are important for any type of screenprinting, since the stencil must first reproduce the image which is to be printed, and then be resistant to abrasion and chemical attack. The last two functions however are particularly important for high quality halftone printing with UV ink. The stencil will increase the quantity of ink which is printed, and is also responsible for controlling image accutance, more commonly referred to as print edge definition.

Photostencils fall into four main categories. The first is known as Indirect Film, where the stencil imaging and development process is carried out independently of the screenmesh. The stencil is applied to the mesh with gentle pressure and dried prior to removal of the backing film. Although capable of high quality reproduction, the thin edge of the finished stencil is very fragile and easily damaged and therefore unsuitable for long print runs, or for printing some difficult substrates.

The second type of stencil is known as Direct Film or Capillary Film. In this case, a much thicker layer of photographic emulsion is adhered to a wet screenmesh through capillary action. After drying and removal of the backing film, exposure and development produces a much stronger and more firmly adhered stencil than in the previous case, but still with the image quality associated with a film based product.

With the third type of stencil, known as Direct/Indirect, the film is laminated to the mesh with a layer of photographic emulsion instead of water. Once this sandwich has dried, processing is the same as for capillary film, but with the advantage that an even more firmly adhered and durable stencil results. The downside is that the stencil making process is more complicated, particularly in larger formats, and is also more costly.

That brings us to the last, and most commonly used type of stencil which is known as Direct Emulsion. In this case the mesh is coated with a light sensitive emulsion, which when dry is imaged and then developed in the same fashion as capillary film. This is by far the least expensive method in terms of material cost, and results in the most durable stencils. However it is also capable of producing much poorer print quality than any of the film based systems, unless the correct choices are made in terms of stencil materials and methods of processing, and bringing several variables under control.

The two most important stencil parameters which affect print quality, because of their influence on both ink deposit and print definition, are stencil profile and Rz value. See Figure 1.

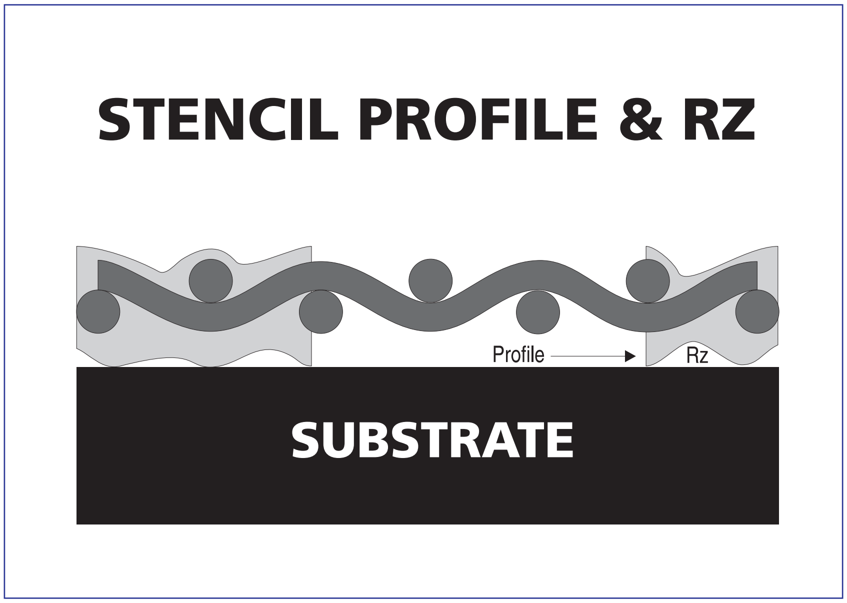

Figure 1

Regardless of which type of stencil system is used, if fine halftones are to be reproduced, an important area where total control is required is during exposure. Producing a screenprinting stencil, even for use with the fine mesh counts used for printing UV cured inks, involves exposing a coating which is very thick in comparison with those used for other photographic or imaging processes. Because of this, depth of cure through the stencil becomes a real issue. Poor through cure, or under-exposure, will cause one or more of the following problems. Loss of detail in shadow areas during development, excessive pinholes, scum leaking into and then blocking image areas, premature stencil breakdown during printing or clean-up, and last but not least difficult or impossible reclaim. Remember, we are talking expensive screenmesh here.

Overexposure in comparison will cause your dots to shrink, leading to moire in the highlights and a lack of density in the print, and eventually loss of parts of your image altogether. In order to optimize the exposure process it is important that the equipment used is capable of producing high resolution stencils without the need to underexpose.

A minimum of 20” Hg of vacuum in the vacuum frame is required to ensure good enough contact between the artwork and emulsion during exposure. This prevents the undercutting of the image that occurs when light leaks under the positive. A good point light source fitted with a metal halide, or diazo, bulb is also recommended to produce optimum results, since there is a good match between the output of the bulb and the maximum sensitivity of most stencil materials. It is also important that the placement of the lamp, and the reflector design, is optimized so as to ensure even coverage of the image area during exposure. Even coverage is essential for accurate reproduction as well as stencil durability. If coverage is very uneven then the exposure latitude of the stencil material may be exceeded, and areas of the screen may be either under or over exposed, and sometimes even both on the same screen!

Another important variable related to exposure is drying. Both capillary film and direct emulsion coatings require very thorough drying prior to exposure, since any residual moisture present in the coating will react preferentially with the photosensitive resins which are supposed to harden the stencil. When you expose a damp screen you end up with a stencil which exhibits the symptoms of having been under-exposed, except that no improvement is seen on increasing exposure time.

Processing variables aside, the ideal stencil for printing halftones with UV ink should be thin and flat, and the parameters we need to control in order to achieve consistent, high quality results are stencil profile and Rz value. For optimum edge definition a stencil with a smooth flat underside is required, ie a low Rz value. This is because the stencil, as well as reproducing the image, also has to act like a gasket and prevent the ink from bleeding beyond the image area under pressure from the squeegee. The ragged edge of poorly defined dots can induce moire, flattens contrast due to dot gain in the highlights, and loses any seperation between midtone and shadow areas.

Minimizing stencil profile is important not only because of it’s contribution of extra ink deposit, but also because of it’s affect on durability. High profile stencils are more prone to breakdown in shadow areas, where the image depends upon small isolated spots of stencil clinging to the mesh. Mechanical abrasion, and sometimes loss of adhesion, causes heavy midtone and shadow areas to develop a spotty appearance which sometimes takes the form of a dark moire pattern.

Ideal values are shown in Figure 2, stencil profile should normally be in the range of 2-10 microns, ideal Rz value is normally in the range of 4-8 microns. Smooth or polished sustrates require an Rz at the top end of the range to prevent cob-webbing or splattering of the ink due to static. For rough substrates, the lower the Rz the better.

Stencil Properties Required for Printing UV Ink

Stencil Should Be Thin & Flat

•

Stencil Profile : 2-10 microns
Stencil Rz value : 4-8 microns

Figure 2

With capillary film, as long as the correct film thickness is selected, both stencil profile and Rz should automatically fall in the range of optimal values. See Figure 3. With direct emulsion the situation is not so simple. Simple wet on wet coating methods, which work so well for coarse and medium mesh counts, usually fail to transfer enough emulsion onto and through the fine mesh counts which are typically used for printing UV cured inks. The small percentage of open area, which is what restricts ink transfer, also prevents emulsion from passing through the mesh and building up on the print side of the screen. Even when using a high solids content emulsion, the shrinkage that occurs on drying may prevent us from achieving Rz values in the optimum range. See Figure 4.

Capillary Stencil, Profile & Rz On 380 PW 34

STENCIL	PROFILE	Rz
15μ Capillary	2μ	3μ
20μ Capillary	8μ	2μ
15μ Capillary w/Emulsion	10μ	3μ

Figure 3

Emulsion Stencil, Profile & Rz On 380 PW 34

STENCIL	PROFILE	Rz
40% Solids 2+3 Sharp Edge Coater	2μ	12μ
50% Solids 2+3 Sharp Edge Coater	3μ	10μ
40% Solids 2+3 Dull Edge Coater	7μ	10μ
50% Solids 2+3 Dull Edge Coater	9μ	8μ

Figure 4

This problem is most evident with mesh types which are the best at minimizing ink deposit, particularly if you are using a sharp edge emulsion coater. In these circumstances, an additional coat of emulsion after drying can cut the Rz value in half, hopefully bringing it into the range we require, whilst adding barely a micron to the stencil profile. See Figure 5.

Emulsion Stencil, Profile & Rz On 380 PW 34

STENCIL	PROFILE	Rz
40% Solids 2+3 Dry +2 Sharp Edge Coater	3μ	5μ
40% Solids 2+3 Dry +1 Dull Edge Coater	8μ	5μ

Figure 5

Needless to say, maintaining constant stencil thickness and Rz values from screen to screen is all important if consistent print results are to be obtained, and if direct emulsion is the stencil of choice, then the use of an automatic coating machine is highly recommended to remove variables from the coating process.

PART 3 • THE MESH

Before deciding which type of mesh to use, important consideration must be given to tensioning. Consistency of tension from screen to screen is of paramount importance when printing four-color process, and as with any type of multi-color printing, registration problems will occur if different tension screens are used. This is due to the higher off contact requirement for lower tension screens causing image enlargement.

As a minimum, 20N of tension is suggested. Printing with low tension screens can cause poor ink release as the screen seperates from the wet ink film, and dot gain may occur if the squeegee drags the stencil in the wet image. Increased off-contact can counteract this to a certain extent, but then the image will print too big, and the excessive squeegee pressure required will cause premature stencil wear.

Now screenprinting mesh comprises two parts, firstly threads, and you need enough of these to fully support the detail in the stencil, and secondly holes, and it is the size and number of these that controls your ink deposit. Normally mesh-count is the dominant factor in determining ink deposit. Above 305 mesh however, when we are dealing with the types of mesh designed for printing UV cured ink, ink deposit is no longer determined by mesh count. Thread diameter and the weaving construction itself become the over-riding considerations.

Fine mesh, which has traditionally been woven in a twill weave configuration, with the finest counts such as 460 being double twill, is now available in plain weave. In twill weave, the threads pass over one/under two, in double twill it’s over two/under two. Plain weave mesh by comparison, with it’s over one/under one configuration, has a much lower percentage open area since a thread is being inserted into every space in the weave. This not only shrinks the size of the mesh openings, but also results in a thinner fabric. The net result is that plain weave mesh prints less ink than twill weave mesh woven from the same thread, just what we need when printing four-color process with UV cured inks. If we take 380 mesh woven from 34 micron threads as an example, changing weave construction from twill to plain reduces ink deposit from 11 microns to 7 microns. See Figure 6.

Comparison of 380 Plain & Twill Weave

	FABRIC THICKNESS	% OPEN AREA	INK DEPOSIT
380 PW 34	56μ	13%	7μ
380 TW 34	63μ	17%	11μ

Figure 6

Another area where plain weave mesh is capable of superior results is image definition. With twill weave mesh, the 'footprint' of the mesh on the substrate, ie the area where the surface of the threads contact, is quite substantial. In some circumstances it interferes with the flow of ink, and can cause poor print quality. With plain weave mesh since only the crown of the mesh knuckle contacts the substrate, interference with ink flow is kept to a minimum, and substantial improvements in print quality can generally be seen.

Plain weave mesh suitable for printing four-color process with UV cured ink is now available in 355, 380, 420 and 460 mesh counts. The 355 and 380 mesh is even available with a choice of 34 or 31 micron thread diameters. The result of this is that by selecting the appropriate mesh, ink deposit can be varied from 7 microns, up to 15 microns, depending on your application or color-matching requirements, while still realizing the benefits of better print quality conferred by using plain weave fabric. See Figure 7 for mesh specifications.

Comparison of 355, 380, 420, & 460 Plain Weave

	FABRIC THICKNESS	% OPEN AREA	INK DEPOSIT
355 PW 31	48μ	28%	15μ
355 PW 34	55μ	16%	9μ
380 PW 31	48μ	20%	10μ
380 PW 34	56μ	13%	7μ
420 PW 31	49μ	17%	8μ
460 PW 27	43μ	18%	8μ

Figure 7

PART 4 • THE LIMITATIONS

When it comes to screenprinting halftones, the fact that we need the mesh to provide support for the detail in our image means that we are not going to be able to print a tonal range of 1% to 99%, see Figure 8.

At the highlight end of the tonal range, when the openings in our stencil become smaller than one mesh opening plus one and a half

Minimum Size of Highlight Dot Is 1 Opening + 1.5 Threads.

Minimum Size Of Shadow Dot Needs 2 Openings + 1.5 Threads For Stencil.

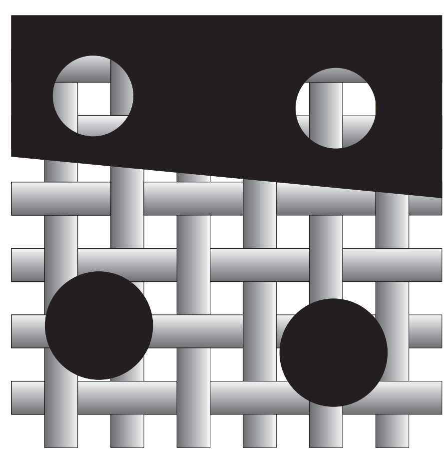

Figure 8

SAATIchem

thread diameters, then they can be obscured by falling on or very near a thread. Trying to print dots this small invariably results in a moire pattern, despite the fact that all the rules concerning angles and dots per inch have been observed. This limit of how fine a highlight we can satisfactorily print, depends mostly on mesh count, and to a lesser extent on thread diameter, but using 380 PW34 mesh as an example, the minimum stencil opening which will consistently print without moire is 85 microns in diameter. This corresponds to a 4% dot for a 65 line halftone, 7% for 85 line, and 10% when we go to 100 line.

At the shadow end of the tonal range, the limit is reached when the small specks of stencil that have to block the flow of ink, and differentiate between the shadow tones, become smaller than two mesh openings plus one and a half thread diameters. Smaller than this, and they may adhere to only one or two threads and lack sufficient adhesion to withstand the rigors of processing. For instance, when trying to print a halftone which is too fine for the mesh in use, what usually happens is that the tonal range will collapse after the mid-tones. Once we exceed the detail carrying capacity of the mesh, we can print only one tonal value, and that is 100%. Again the mesh count, and to a lesser extent thread diameter are the important factors in determining the limit of what can be satisfactorily printed. In this case however, unlike the highlights where thinner threads are better, thicker threads extend the printible tonal range by offering improved adhesion. The upper limits for 65, 85 and 100 line halftones printed with 380 PW34 mesh correspond to 93%, 88% and 82% dots respectively. More extensive information for 380 mesh is shown in Figure 9.

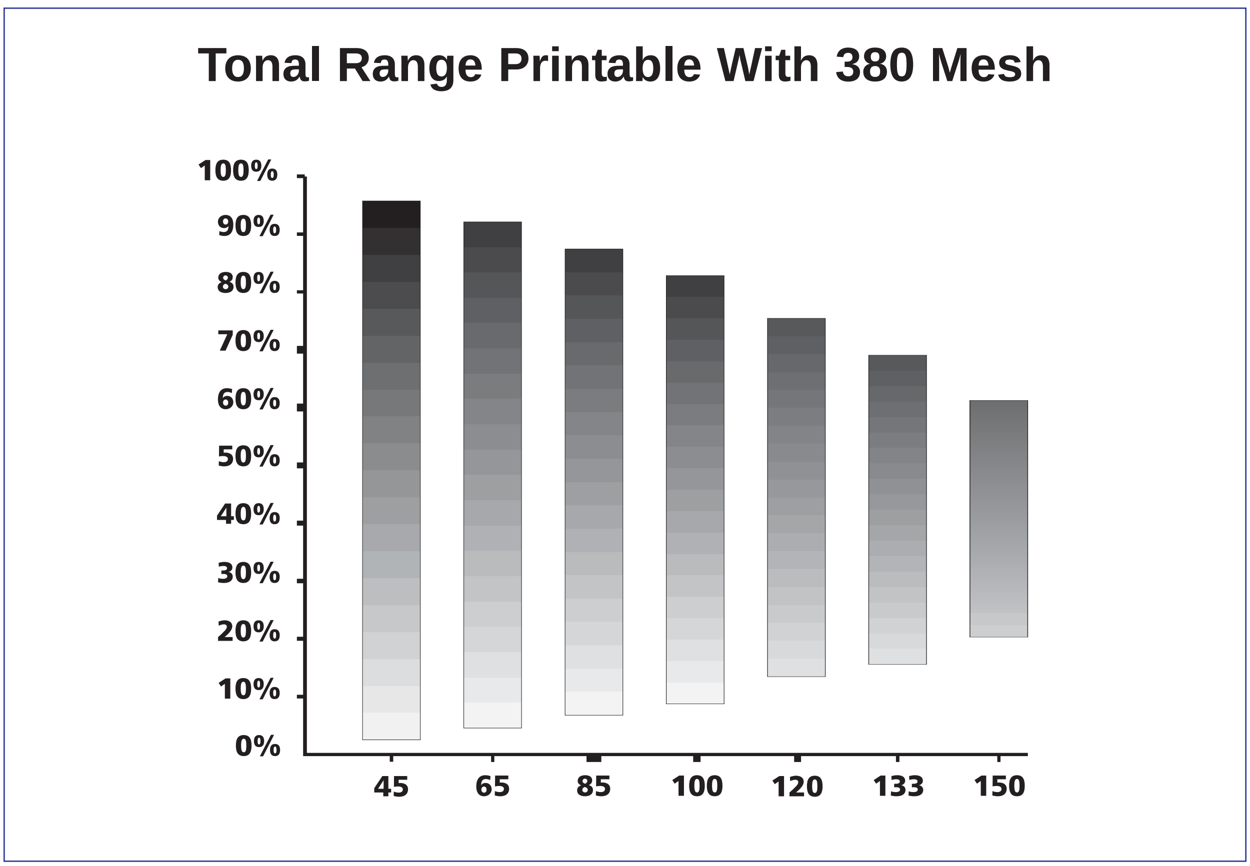

Figure 9

When selecting the optimum mesh type to use, both ink deposit and tonal range are usually taken into account. In Figure 10, there is a comparison of both ink deposit, and minimum highlight dot which can be printed through plain weave mesh from 355 up to 460.

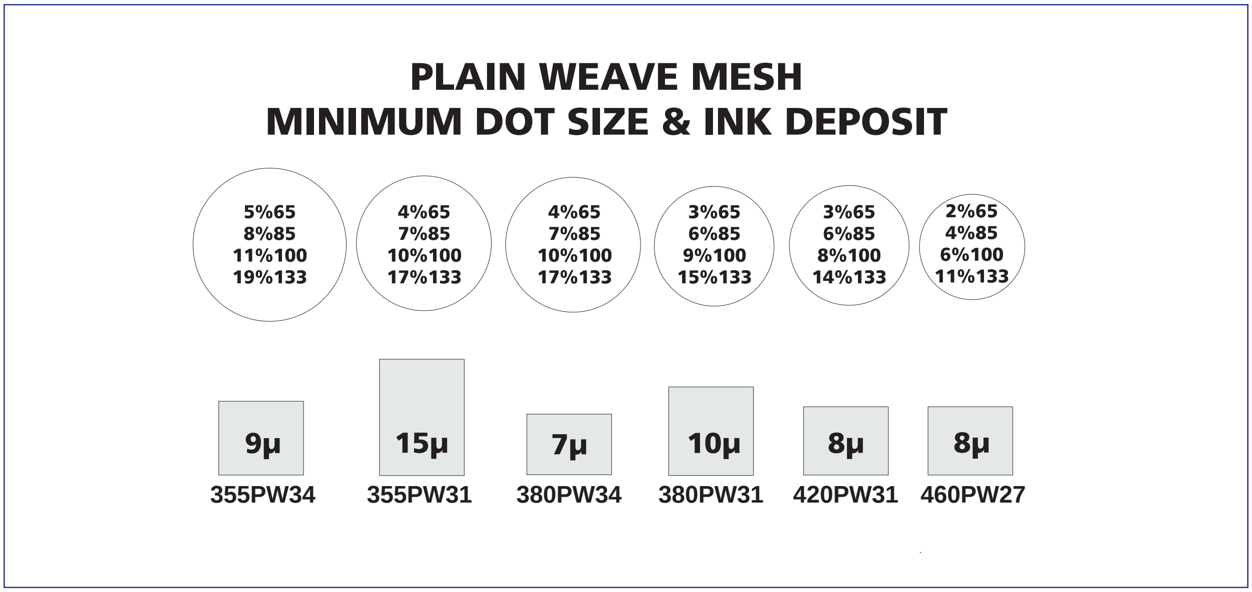

Figure 10

Two developments in methods of color seperation, one established, and one very new, offer improved results for certain types of four color process printing with UV cured inks. The first method, which is widely used, is known as GCR or Gray Component Replacement. It enables a reduction in ink deposit in areas of the print where yellow, magenta and cyan all occur together. GCR will eliminate an equal amount of all three, which in some areas removes one of the colors entirely if 100% GCR is used. The missing gray is then restored with the final black printer, see Figure 11.

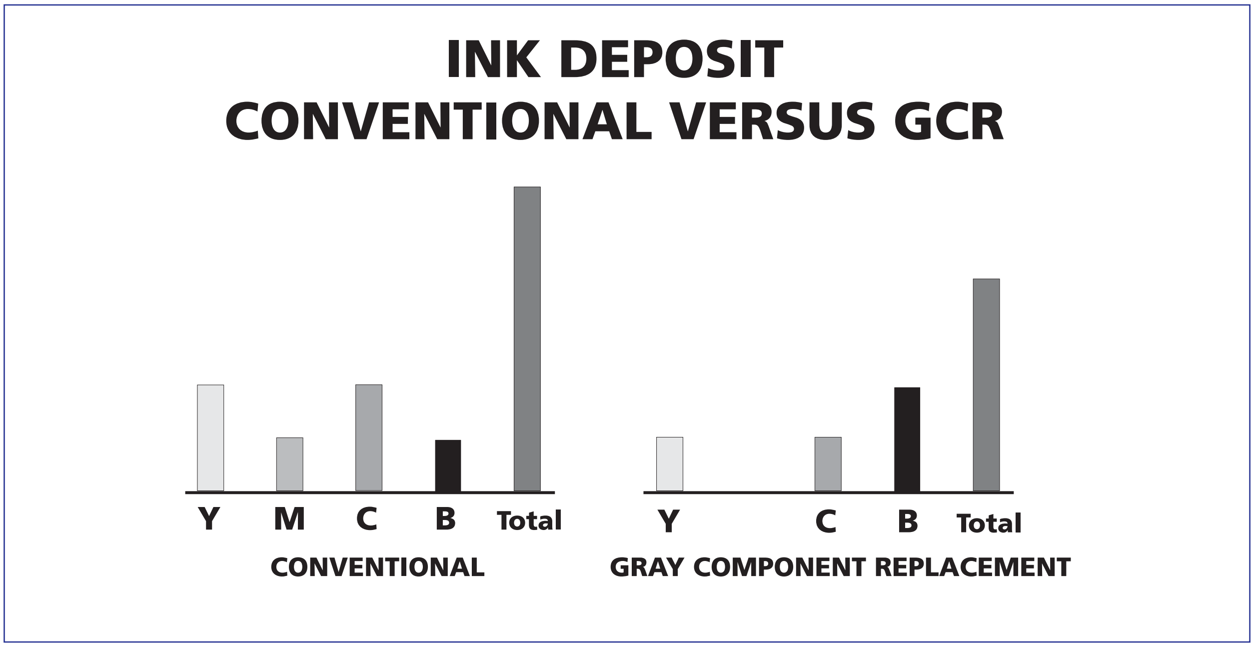

Figure 11

The second development, which is still being refined, is a new method of producing seperations and is known as frequency modulated halftone, or stochastic screening, or random dot. The seperations produced by this method are based upon randomly distributed, very small uniform sized dots, which simulate tones by increasing in packing density. This differs from conventional seperations, where the dots are equally spaced and simulate tones by changing size. These random dot seperations, because they have no angles, offer wider latitude in avoiding moire, and are also capable of reproducing a wider range of tones. On the downside, they require an extremely high resolution stencil, and exquisite control over screen exposure if the image is not to be lost altogether. They may also be less suitable for reproducing certain types of artwork, as they sometimes suffer from a grainy appearance in highlight areas. However, this alternative technology offers promise in overcoming some of the problems some of the time, and may provide the opportunity to expand the use of screenprinting into otherwise difficult applications.

Ross Balfour is the Research and Development Manager for Saatichem, a division of SaatiPrint (Como, Italy), a global manufacturer of screenmaking products. He directs the research and development of emulsions, screen preparation products, and screen-reclaiming products from Saatichem's facility in Chicago, IL. Ross is a graduate of the Royal Society of Chemistry in London and has twenty years of experience in the printing industry.