MINIMIZING HALFTONE MOIRÉ

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Whenever the topic of four-color process comes up among screen printers, there is one topic discussed in every conversation: Is it possible to minimize or eliminate halftone moiré? For those of you who have never printed four-color process, moiré patterns are undesirable patterns that appear in an image as wavy bands, checkerboards, stripes, lines, or squares. They are caused by the overlapping of regular patterns that result in the formation of new patterns. These new patterns are not regular and consistent. They seem to mysteriously appear and disappear, sometimes within the same image. They often seem to appear in areas that are most important to a design. At the very least they are annoying. In most circumstances, however, they can render a design unusable.

The subject of moiré has plagued all printers since the invention of the halftone over a century ago. There has been a great deal of study done in other areas of graphic arts, but our industry is particularly hard hit with this phenomenon, and knowledge of its causes and corrections is not well understood. In this month's column we will look at some major causes of moiré and what we can do to reduce or eliminate them.

If there was ever a single basic reason to standardize and control your printing operation, moiré would be the one. Without some established practices and methods in your shop, you will continue to suffer the ravages of moiré patterns. Where do we begin?

Start with the Art

Since all full-color continuous tone artwork must be converted to halftones in order for process color to work, we should study the art for possible sources of moiré. Look very carefully for any regular pattern or texture. If the image was painted on canvas, there is a good chance of moiré. Try to identify any patterns like wicker, screen windows or doors, coarsely woven fabrics, or woodgrain textures. These frequently cause moiré in the final image.

A major problem is when art that is to be separated has already been printed. If it has, there is a halftone pattern already present that will interfere with the new halftone screening. If this is the case, there are two ways to get around the problem. The first is to get the printed piece in as large a format as possible. Poster size or larger is best. This is then photographed and a 4" x 5" transparency is made. When the poster is reduced to the transparency size, halftones become so fine as to disappear. The transparency can then be scanned with no further problems.

The second method is to mount printed artwork on a scanner and defocus the image. This creates a blurry digital image in the computer. A technique called *unsharp masking* is then applied to the image while halftone screening is taking place. This increases the sharpness of the image without bringing back the original dots. The new halftone conversion is completed without interference of the old printed dots.

When evaluating original art, avoid color gradations that progress from a dark color to white. Be particularly careful of single colors gradating to white. Examples would be the sky blending toward the white horizon or into clouds. Many popular marine images are also subject to undesirable color blends. In this type of situation there is a very great chance of moiré as you get closer to white. The reason for this is that the halftone dot is decreasing in size as it approaches zero tonal value (white). The thread of the mesh begins to block small halftone openings resulting in moiré.

Examine colors in the art carefully. If the tones are not pure and clean, there is a good chance of difficulty. The reason is that dirty colors are made up of three or more process color inks–usually one or two major components, and the third and fourth in very small amounts. These small "contaminant colors" are subject to the thread blockage described above. If you have dirty colors, the art can be corrected at the separation stage to eliminate the contaminations.

Halftone angles and tone range

Selection of the proper halftone angles is critical in helping to minimize moiré. Each of the contrasting halftone colors (magenta, cyan, and black) must be separated by 30°. The noncontrasting color, yellow, is placed at 15° between two of the contrasting colors. Noncontrasting means that it is difficult to visually differentiate detail between the color and the background. Since the foundation of four-color process is a white background, yellow is the only color of the four that does not contrast against white.

The correct relationship between halftone angles is pretty much guaranteed with conventional camera separations. With laser-scanned separations there is rarely any problem either. With separations done on the personal computer and output to either a laser printer or imagesetter, there can be problems. The color-to-color relationship mentioned above can be rotated throughout the range of 0° to 90° as long as we maintain the 30° relationship between each contrasting color and 15° between the yellow.

The next consideration is placing halftones on the screen mesh. This is where a great deal of difficulty comes in. Since the mesh is woven on a 0° and 90° relation between the warp and weft threads, we must avoid setting our angles on these two positions. The reason is really quite simple: the mesh threads will be aligned right down the middle of a row of dots. This can block that row and prevent ink from flowing through, which changes the value of the dot and our eye sees the pattern as moiré. There is a second angle to avoid, 45°. The reason that we can't use it is that dots aligned on this angle will fall directly on the knuckles of the screen mesh, resulting in blockage and moiré.

Unfortunately, the standard angles used by 95% of all color separators are 15°, <u>45°</u>, 75°, and <u>90°</u>. We can see that two of the angles are going to cause moiré. This requires the color separator to choose a different angle set on a scanner. Since every scanner is different, not all angles are available at the line counts that we want to use. You can provide a range of angles for the operator to select from. Acceptable limits are 4°-8° off the standard lithographic angles. If we were to select 90°, the acceptable rotation ranges would be 82°-86° for a negative rotation and 94°-98° for a positive rotation. All other angles must also be rotated this same amount.

The angular relationships are somewhat confusing and difficult for some people to understand. Trying to explain the need to the color separator is important. It requires more effort on his part to adjust the scanner to give you the angles you need, and many color separators are reluctant to make the changes. I have talked to many printers who complain of having their requests for angles ignored and receiving film at the standard litho angles. This is another good reason to stick with a separator who is knowledgeable about the screen printing process.

Mesh selection

In the early days of process printing there were many different formulas for selecting the relationship between the screen mesh count and the halftone line count. Over the last 15 years we have tried them all–and a few that we haven't heard of. I am now of the opinion that there is no set-in-stone formula that you can use with guaranteed success. For textile screen printing there are three mesh counts of choice: 305, 355, and 380.

Excellent results can be obtained with halftone dot counts of 45, 55, and 65 lines per inch. My personal favorites are 355 and 380. They have a thinner thread diameter than the 305, which makes it easier to print finer highlight dots. Since these dots are the most prone to developing moiré, the thinner thread is beneficial.

All of the formulas based on mathematical multiples of the line count to the dot count are limited in their success. There are two reasons for this. The first is that the actual mesh count of the fabric varies with tension. The higher the tension, the lower the threads per inch. This is an excellent reason for keeping tension between all screens constant. If you vary tension between runs, the thread count will vary, increasing the chances for moiré.

The second reason that formulas do not work is that they are based on one halftone dot (e.g. 1/65, 1/55, etc.) being divided into the mesh count. The error in this thinking is that the dot area of each halftone cell can change from 5% coverage to 95% coverage in the same given area. This continuously variable dot size creates varying interference patterns that result in shifting variable moiré. This shifting moiré is different for each angle that you choose. In other words, you may have moiré at a 48% dot at 50°, but no moiré at a 20° with the same 48% dot. This is one of the main reasons why moiré is so elusive. You may have half a dozen jobs where there is no problem. Then you will get a job where the right combination of dot size and angle over a very large area generates a massive moiré.

My best advice is to go with the highest possible mesh count to dot count. Stick with the 355 and 380 fabrics. This even applies if you have coarse halftones like 45 line. The higher the mesh count to line count, the better. This means that there are more threads dividing a dot opening, therefore less chance of any one thread blocking the hole.

Exposure

Overexposure plays a big role in moiré. It will change the size of the dot opening. This is primarily due to the problem of halation, or the undesirable light travel and undercutting of the image. Since the mesh acts like a fiber optic strand, long exposures result in light travel down the threads and undercutting as this light radiates from the strand.

Be very accurate with your exposure. Select a light source high in UV output in the 365-420 nanometer range. This is the range where the stencil is most sensitive. High-intensity light in these wavelengths will result is a fast and accurate exposure. Long exposures with low UV light sources will cause you much grief.

The second thing to avoid is low vacuum. Many printers are under the impression that a reading of 25-27 on their vacuum gauge indicates a good drawdown. Wrong! It only indicates a good vacuum at the vacuum port. Make sure that you have bleeder lines in your frame and that Newton's Rings are present when the vacuum is at its highest level. The Newton's Rings are visible as a rainbow-like texture located between the bottom of the frame glass and the surface of the film positive. If you put your face next to the glass with your right cheek about an inch off the glass, you should be able to easily view the texture.

Many times if you experience a slight moiré you can eliminate it, or minimize it, by reducing the exposure time. Start with 10% reductions. It won't always work, but it can sometimes get you out of a jam.

Conclusion

This is by no means a complete list of the causes and corrections of moiré. They are, however, a good start to some of the more common ones. Since moiré is a regular interference pattern caused by the intersection of regular patterns, it lends itself to systematic investigation to determine its source. This is often hard to do because we are all under such time constraints to get our work done. In controlling moiré your best weapon is careful observation and consistent production processes. If you vary things like mesh count, tension, and exposure, you can almost always be assured of problems. Document your observations when they occur so that you have some way of dealing with them in the future. Do not feel that you have solved the problem of moiré at any time. Until new technology comes about that will handle halftone screening differently, moiré will be with us. With as much experience as we have had with color separations, moiré is still one of the most persistent challenges we face.