The Cheese Grater

Visible evidence: If screens would suddenly go out of shape, sag and make printing impossible at seven or ten Newtons, the ink-transfer machine they comprise would be *perceived* as broken.

By Don Newman

At the in-house Product and Printing Training Center provided by the author's company.

Last month, I proposed controlling mesh elongation to achieve tension stability. Below begins an expanded examination of the role high tension plays in making the frame and tensioned screen a suitable *ink-transfer machine*. I want to re-examine the subject of high-tension printing because, though elevated tension levels are acknowledged now by many as an important part of the printing screen's performance equation, I believe its critical significance is often woefully underestimated.

That was illustrated recently when I asked 12 students* to try and guess the tension levels (in Newtons per centimeter) of each of three screens. Like many experienced printers and technical sales representatives who have preceded them through the years, they could tell immediately by pressing on the screens that one was strung at a lower tension, another at a higher tension and the third somewhere in the middle. But their estimates of tension level were, as usual, extremely inaccurate—and all on the high side.

Most surprising to the group was the low-tensioned screen. Guesses ranged from 10 to 18 N/cm, but in fact the screen didn't even register on the tension-meter scale, having little more tension than was required to overcome the effects of gravity and prevent the screen from visibly sagging. The 2' X 2' screen only had about 2 N/cm, or 50 lbs. of total screen tension.

The lesson was, of course, that our senses deceive us when it comes to screen tension. When you look at screens tensioned to 5, 10, 50 and 100 N/cm, your eye tells you they're all perfectly flat. You thump them with your finger and they may all sound drum-tight, especially when coated with emulsion. You deflect them with your hand, and they all offer considerable resistance. Thus, to your finger, and to your eyes, they're tight.

Historically, screen printers have assumed that screens meeting these tests were tight enough to print with, and of course, in one sense, they were right: *You can, without question, print with one to seven Newtons*. It isn't that printing with low tension doesn't work, it's just that it doesn't work nearly as well or as *efficiently* as does printing with high tension.

If screens would suddenly go out of shape, sag and make printing impossible at seven or ten Newtons, the ink-transfer machine they comprise would be perceived as broken. Printers would then be compelled to print at higher tensions. But as it is, there is no clear-cut division between a healthy and an unhealthy screen. As a result, though most printers appreciate that there is a difference between low and high tension, it doesn't look, sound or feel like higher mesh tension *alone* could make a *significant* contribution to the industry's search for ways to print better and faster.

Over 40 N/cm is thought by many to be the point of diminishing returns for printing benefits. In fact, many screen printers today assume a "cap" or upper limit on the tension one must achieve in order to take advantage of high-tension printing benefits. This latter assumption, however, is as much a misconception as the assumption that screens that feel tight will print right. I would suggest that a point of diminishing returns may be found well in excess of *130 Newtons*. This will not, however, become apparent until the printing machines begin to substantially increase their speeds...which they will.

Completing the Picture

As you'll recall, my message last month was that at high tension, meshes may be workhardened to the point that, even on lengthy print runs, tension loss can be limited to as few as one or two Newtons, and that such loss would have virtually no affect on registration and print quality.

Notice that the statement is conditional: its validity is entirely *tension-dependent*. We can see why by putting screen tension, normally described in N/cm, into less theoretical, more practical terms. When a screen registers 14 Newtons, for example, its mesh is subject to approximately 100 lbs. of force per linear foot. This may be best pictured by imagining a foot-wide piece of mesh stretched over a frame with a 50-lb. weight hanging from each end. For every foot of additional mesh width, we hang another set of weights. We can figure the total amount of force applied to a 2' X 3' screen, then, by totaling the weight applied to both the length and width: in this case, 100 lbs. per linear foot X 5' (the length + the width) = 500lbs. of screen force. As the number of N/cm doubles, so do the lbs. per linear foot. At 28 N/cm the force increases to 200 lbs. per foot X 5 = 1000. Doubled again to 56 N/cm, it jumps to 400 lbs. per foot, totaling 2000 lbs. And 100 Newtons equals 4000 total lbs. of force.

Now we can see that there is an enormous force difference between low and high-tension screens, much more than can be perceived by eye or by the finger's touch. With that in mind, perhaps now we can begin to imagine many of the enormous differences higher screen tension can make in both printing speed and quality. If a 2' X 3' screen tensioned to 7 Newtons loses 3.5 Newtons during a print run, the screen force falls from 250 lbs. to 125 lbs., a loss in force of 50 percent. But the same screen stretched to 56 Newtons with a similar 3.5 N/cm loss falls to 52.5 Newtons, dropping from 2000 to 1870 lbs of force, a net loss of 130 lbs. or only 6.5 percent; the loss drops to only 3.5 percent at 100 Newtons.

Last month, we discussed that as screen tension drops during the print run, the image gets bigger and registration is lost. Thus, the ultimate stability of even a well-workhardened screen depends very much on the degree to which it is tensioned. So, when we ask *How high is high enough?* we have forgotten that our original goal in raising tension was to turn screen variables into constants. Given the above, we readily see that the percentage of variation grows smaller and approaches zero as tension increases. Therefore, in light of our constant seeking mission, a better question might be: *How high can we go?*

The cutting edge: Cutting tools work best when they're sharp. Any carpenter will tell you that a sharp tool cuts cleaner - leaving a smoother edge - and *faster* than a dull one.

Fresh-grated ink?: Like a screen, a cheese grater is flat and has lots of evenly spaced and sized holes which, as do the openings in screen mesh to ink, meter cheese through it's matrix in consistently sized chunks.

Cutting to the Heart

This concept applies with similar dramatic results to the process of ink transfer. To understand how, we've first got to take a look at our ink-transfer machine. What sort of machine is it?

As unlikely as it sounds, it's a cutting tool. Try to visualize the screen as a sort of oversized cheese grater. Though a cheese grater does not cut in the same way a screen does, it illustrates several important screen characteristics. It's flat, and it has lots of little holes, evenly spaced and sized, which, as do the opening in screen mesh to ink, meter cheese through it's matrix in consistently sized chunks.

Cutting tools work best when they're sharp. Any carpenter will tell you that a sharp tool cuts cleaner—leaving a smoother edge—and *faster* than a dull one. Even a reasonably competent house framer wouldn't begin a day's work without first making sure his saw blades were sharp-edged. Since printers certainly don't view screens in the same light, sharpening their screens has never been a priority, and— I know what you're thinking— it's not at all clear how one might go about sharpening it.

The key to the screen's cutting efficiency is a concept called *interface* pressure. Now, by that I don't mean squeegee pressure, because that only describes half of the mesh-deflection equation. Interface pressure is, simply, the pressure that results when two or more mechanical objects come together. By its nature, though, interface pressure is not as simple a subject in screen printing as in other printing disciplines.

In lithography, flexography and rotogravure, ink is transferred from one round surface to a second round surface. Screen printers, though, must push or sieve ink through a flat, permeable surface onto a flat substrate. This means that, while other printing modes have but one point at which interface pressure is generated, screen printers must contend with two: one where the squeegee and mesh meet, the other where the bottom of the mesh/stencil meets the substrate. In order for ink to be *cut* from the mesh onto the substrate, there must be some nearly equal opposing force in that mesh, to match the squeegee's downward pressure. If a squeegee pushes down but does not have a nearly equal force pushing back up from the mesh, then there is, in fact, hardly any squeegee pressure at all on the ink, where it's needed. Unfortunately for many lower-tension printers (7 to 20 Newtons), that equal and opposing force turns out to be the substrate. As the squeegee begins to push the mesh down toward it, the ink in the screen experiences little or no interface pressure. Then suddenly, all in one shot, maximum pressure is applied to the ink, but only when the squeegee forces the screen into contact with an immovable object: the substrate. The ink, then, is not deposited softly onto the substrate but mashed into and even through the garment fabric.

As screen tension goes up, though, interface pressure on the ink sandwiched between the squeegee and mesh increases while screen-to-substrate interface pressure decreases. This gives the ink more *hydraulic* pressure and speed during transfer, resulting in the numerous characteristics that comprise a superior ink deposit.

Cutting Out the Competition

If we take the substrate out of the pressure equation by lowering interface pressure between it and the mesh to as close to zero as possible, the squeegee can touch the mesh down lightly on the substrate and shear the ink off onto it's surface unsmeared, unimpeded, unsmashed—unabused—by the mechanical pressure from the bottom of the mesh and stencil.

Next time: Newman reveals how elevated tension overcomes non-uniform squeegee pressure, and begins a demonstration of the positive impact high-tension in our "sharp" cutting tool has on four key processes that govern the improvement of image quality and production speed.