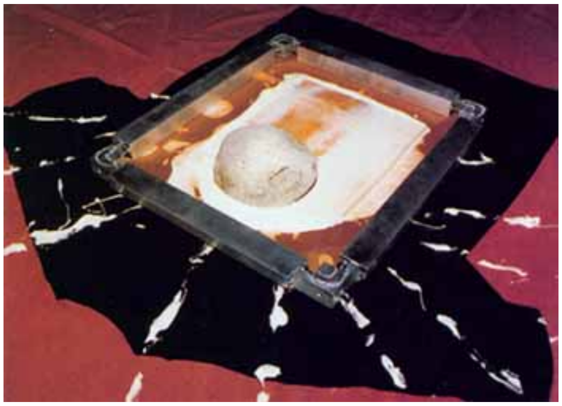
Like a Rolling Stone



Rock 'n' roll: What durometer did you say that squeegee was? Seriously, though, compensating for low-tension with increased off-contact and squeegee pressure can be like printing with a stone.

Earlier in this series, I made the point that, by comparison to its sister- printing modalities, screen printing lags far behind when it comes to production speed. Why the big difference?

As I pointed out last time, other printing disciplines (litho, flexo and roto) transfer ink from a rigid cylindrical printing plate to a substrate that is either wrapped over another cylinder or sandwiched between the plate and a roller. In either case, the speed at which the ink-bearing plate releases from the substrate is, by design, *mechanically dependent* on the speed at which the press runs. In other words, the faster the press, the faster the plate and substrate meet and then release from one another.

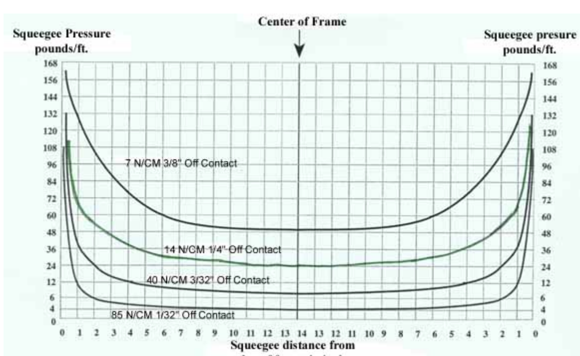
Bending to the Task

Unlike the litho plate, the screen printer's ink-transfer machine cannot be entirely rigid because, of course, its screen mesh must retain enough flexibility to allow for off-contact printing. With that as a given, screen printing's speed is limited by the fact that the squeegee cannot be allowed to go any faster than the screen can release from the substrate as it passes. Some call it snap. To others, it's peel. But for every screen printer, screen/substrate separation is the key production-speed factor, due to the nature of the process. Another factor is the *reciprocating* nature of flat screen printing. Time is lost as the squeegee returns from end of the stroke to start position.

Historically, of course, screens have been anything *but* rigid. As a result, print speeds have been generally slow and inconsistent. For example, what happens when we attempt to print, say, a few lines of black type on a white shirt at low tension — less than 25 Newtons, or under 650 lbs. total screen force for a typical 18" X 20" I.D. printing frame? Not much, of note. The screen doesn't have much difficulty popping back up off the substrate as the squeegee passes.

But what if we want a few lines of white type on a black background ... on that same white shirt (a large reverse print); or a large area of opaque white ink on a black shirt? Suddenly, we've got a huge area of tacky ink to lay down, and you know what happens. Because the screen force is weak, the ink acts as an adhesive, substantially delaying snap speed or even — if tension is low enough — preventing peel entirely.

Complicating things (as we learned in our discussion of interface pressure), the squeegee, like a sort of large rolling stone, is smashing and abusing everything — from ink to stencil to substrate — in its path.



Telltale curve: In low-tension situations, the squeegee runs ahead of the mesh peel, mashing and smearing the mesh into the ink and creating a halfmoon-shaped release line that actually resembles the curve on our "non-uniform-ink-transfer" chart. (*copyright Stretch Devices, Inc*.)

Shooting the Moon

In low-tension situations, particularly as screens get larger, the squeegee may easily run ahead of the mesh peel, mashing and smearing the mesh into the ink and creating a half-moon-shaped release line that follows the squeegee at a distance. And it's no coincidence that this half-moon pattern resembles the curve on our "non-uniform- ink-transfer" chart (see above).

Meanwhile, of course, the print head may not be lifted until the half-moon completes its slow course - unless the printer is willing to live with an even more severely smeared and blurred print. For the manual printer, this means either adjusting each squeegee stroke speed to be synchronous with the peel rate of each individual screen or, for sake of printing rhythm, going with the slowest stroke for all the screens. For the automated printer, there is no choice: the machine cannot cycle until the *slowest* print head lifts. As a result, printing one large area of color - a large white underbase on a black shirt, a large, solid, opaque color, or a tacky fluorescent, puff or metallic - can have a drastic impact on productivity. The entire machine's cycle time can be substantially slowed down, typically 20-50 percent, sometimes more.

To avoid such slow-downs, printers often significantly increase the off-contact distance as a means of assisting the mesh in its efforts to pull itself out of the muck left in the rolling stone's path. But this only partially improves snap, and does so mostly on the edges with little improvement near the center of the screen. It also severely erodes quality by further enlarging and distorting the image and (as illustrated in our diving-board discussion, *Printwear, Feb. '94*) introduces more inconsistency into the interface-pressure equation along the length of the squeegee, causing non-uniform ink deposit, substrate penetration and more rejects. Either way, the number of saleable prints - our all-important *yield* - suffers. Additionally, raising the off-contact distance fatigues the manual printer and prematurely wears out the stencil, squeegee and mesh due to massive, excessive squeegee pressure.

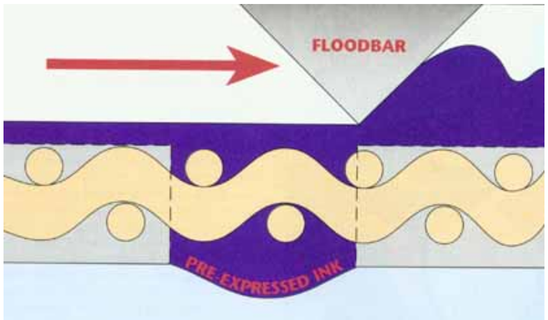
Small wonder then that most screen printers have traditionally assumed print speed to be dependent on the ink's adhesive properties and percentage of substrate coverage. At this industry's typically low and medium screen tensions, the assumption is warranted, and visually summed up by the "Simpsons" prints.

Our "before" sample was printed at 7 Newtons (or 250 lbs. of total screen force on a 25" X 36" frame) and required one flash. At a rate of 350 pieces per hour, the job was plagued by mis-registration and poor opacity, plus noticeable smearing and bleeding. Screens had to be wiped after every 200 shirts. Dreadful, right?

These squeegee-stroke problems actually begin with the flood stroke. At lower tensions, the same inconsistency we observed last month in our discussion of squeegee and substrate interface pressure also comes into play during the flood stroke. As the floodbar moves across the mesh surface, it displaces the ink. The ink has to *move* somewhere.

Something's Gotta Give

Though it's no rolling stone crushing things in its wake, the floodbar has plenty of rock-like inflexibility. Under pressure, if anything is going to move in this floodbar/ink/screen sandwich, it's the mesh. At low tension, the mesh deflects downward near the center where it's weakest, leaving a thicker flood coat than intended in the image center. Seeing that, the printer's natural response is to increase flood pressure. The result? Now things may be right in the center, but he's scraping the ink too thin at the edges. That changes the pressure relationships between the floodbar, ink and mesh, causing considerable variation in the amount of ink that is introduced into the individual mesh apertures (ink wells). As flood speed is increased, this variation is exaggerated, resulting in a whole range of under-filled, adequately filled, and even over-filled ink wells, with ink bulging or *pre-expressing* from the underside of the screen. This pre-expressed ink is a contributing factor in the smearing and blurring that occurs, and is a prime source of excess ink build-up on the bottom of the screens which later require wiping.



Flood-bar pre-expressing: It causes under-filled, adequately filled, and even over-filled ink wells; the ink bulges from the underside of the screen resulting in excessive smearing and underscreen build-up.

Seeing is Believing

Now let's take a good look at the Simpsons "after" print. You may be surprised that I've selected Bart's morn to model the differences between low- and high-tension printing results. There's nothing particularly complex or difficult about the image, though the image is printed on rough canvas, which is a difficult substrate. Four-color process work or a 14-color design on black would certainly be more *spectacular*. But it is bread-and-butter prints like this that the vast majority of printers print to make a living.

As it turns out, the difference high-tension makes in printing speed is spectacular enough on its own. At 50 Newtons it's a dramatically different picture: numbers were boosted by 57 percent to 550 pieces per hour, yet crisper detail and better large-area coverage were achieved through faster squeegee and flood stroke, because, at 1800 lbs. of total fabric force —700 percent more force than the 7-Newton screen — the mesh simply overpowers the ink. Just as with the squeegee stroke, the interface pressure between floodbar, ink and mesh becomes more consistent across the image area. The result is a far more uniform flood coat, and more nearly identical amounts of ink in each mesh/stencil ink well, even at increased flood speed.

During the squeegee stroke that follows, we've counteracted the squeegee's pressure with sufficient upward resistance from the mesh to prevent excessive interface pressure between mesh and substrate. Our rolling stone is no longer mashing the mesh into the substrate, abusing the ink, smearing the print or causing the mesh to dwell in the muck that remains. The more powerful mesh more easily resists the ink's tack and snaps more quickly from the ink on the garment.

Now, by saying this, I don't mean to minimize the efforts of ink manufacturers in their search for easier-to-print inks. The ink's adhesive and cohesive qualities still play a role — we will still see a difference in the amount of *off*-contact and printing speed required to print a huge open area of ink as opposed to a few lines of type — but that role is now enormously diminished in the speed equation. In other words, when we identify and arrest the *real* low-press-speed culprit — low screen tension — we find that the ink is often a mere accomplice.

At this point, those who last time asked *How high is high enough?* could fairly object: *All of that's well and good, but we're talking about 50 N/cm. If we can increase production 57 percent at 50 Newtons, who needs 100 Newtons?* My answer? *Everybody*!

Before and after: Smearing, poor coverage, registration problems ...*all* can be symptoms of insuffcient Newtons. thus, elevated tension can lead to quality - not just efficiency - gains.

Another Cliffhanger

The explanation, of course, will have to wait 'til next time. But here are some points to ponder in the interim. Our discussion of high tension's effects on squeegee and flood speed is only part of the production speed story. Elevated screen tension produces positive effects just as dramatic elsewhere, within our ink-transfer machine. And as we'll soon see, the combination of these effects at tensions approaching 100 N/cm can make the 57 percent increase noted above look like settling for less.

Next time: Newman introduces and begins an examination of tension-related effects on two more production-speed factors: stroke length and ink velocity.