Elevating Production Efficiency, Part 7

Out of the Stone Age

Last session, we observed something that seemed to contradict conventional screen-printing wisdom.

You'll recall the one-color "Wyoming," printed manually, first at 25 Newtons through 255 mesh and then, at my suggestion, printed at 85 N/cm through a special N115 mesh designed to handle high-tensions. I reported that printing speed (per hour) more than doubled in the 85-Newton scenario, while (among other benefits) screen wiping and the flood stroke were eliminated. But then I said something contrary to what any experienced printer might reasonably expect when I told you that finer detail was achieved with the *coarser* N115 mesh than with the 255.

I left you with that mysterious incongruity, hinting only that *something* was happening to dramatically alter the ink's transfer process and hoping that you would develop your own theory to explain this mystery.

Classic example: The author contends that ultra-high tension nearly doubles production, with no flash, no wipe and no mud. The shaded areas (see close-up) aren't overprinted - the black dots fall on virgin cotton through reversed-out openings in the red: registration only achievable at ultra-high tensions.

By Don Newman

Is He Stoned?

How *do* we explain the fact that fine detail like the "]" in the "Wyoming" artist's signature and the small circles in the Indian's breastplate (pictured in our Part 6 series) can be manually printed through N115 mesh with one quick squeegee stroke (65/90/65-durometer) and *no* flood stroke? It seems to defy common sense. Especially when I tell you that the N115's 83-micron filament is more than twice the diameter of the 34-micron filament found in the typical 255 or 305 mesh count. Everyone knows that, to get fine detail, one must resort to finer meshes because experience teaches that the ink simply can't get around those relatively fat threads of the coarser meshes.

No, I'm not asking you to deny what you've seen in your shop with your own eyes. What you've experienced, and the conclusion you've drawn are absolutely accurate. What I am telling you, however, is that your observation, correct though it may be, is based on your experience. And, for almost all printers, that experience is with low (7-29 N/cm) to medium (30-49 N/cm) tension. As we've been discovering all along in this series, at high tension—65 to 100 Newtons (for *now*)—the old assumptions and understandings simply don't apply. *Something* different is happening, mechanically and hydraulically, to the ink at 85 Newtons that makes possible the previously *im*possible.

To begin understanding that "something," we need to look at ink behavior. Many screen printing inks are engineered to exhibit varying degrees of *thixotropic* behavior. That is, when the ink is subjected to the interface pressure between the squeegee and mesh, the ink flows and, when it leaves the screen and is no longer under a force, it stops flowing abruptly. How abruptly the ink stops flowing is determined by its degree of thixotropy. The more thixotropic the ink is, the more abruptly it stops flowing.

The time during which the ink will continue to flow more freely is determined by the ink manufacturer depending on the way the ink is engineered to perform. For instance, process inks are designed to flow for a *very* short time after being sheared by the squeegee. Ideally, they stop flowing or "body up" immediately after they hit the substrate. This allows them to maintain their shape, keeping dot gain or growth of line width to a minimum after the mesh has snapped up from the substrate's surface. On the other extreme, inks intended for large-area coverage are non-thixotropic, and may be "timed" to flow a little or even a lot longer, in order to ensure even distribution and "leveling" of the ink after it is deposited on the surface. But in this case as well, the ink must have enough internal cohesion to body up at some point, or it would continue to flow past the point where it was stopped by the stencil edge, with resulting loss of edge definition or image sharpness.

With this ink-behavior information-or, *rheology*—in mind, let's get back to the mystery, and resolve it by comparing in detail what happens to these inks when printed at low and then at extremely high tensions.

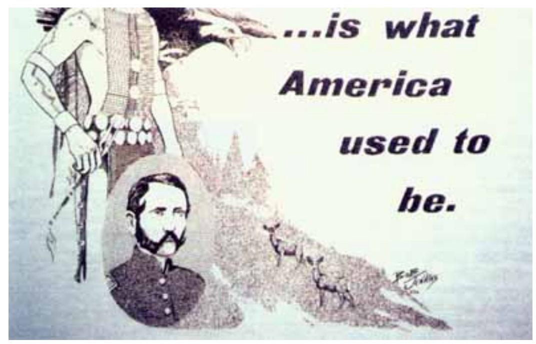
As we've established in previous installments, when printing at low tension, the upward resistant force of the mesh is no match for the stronger downward force of the squeegee. In this case, there's too little squeegee interface pressure on the ink, and too much interface pressure where the mesh and stencil meet the substrate. So when the ink tries to make its way around the mesh threads, the ink's flow is mechanically interfered with. The result is that the ink develops very little hydraulic pressure, and hence very little ink velocity at the moment that the ink comes into contact with the substrate.

Like Hitting a Stone Wall

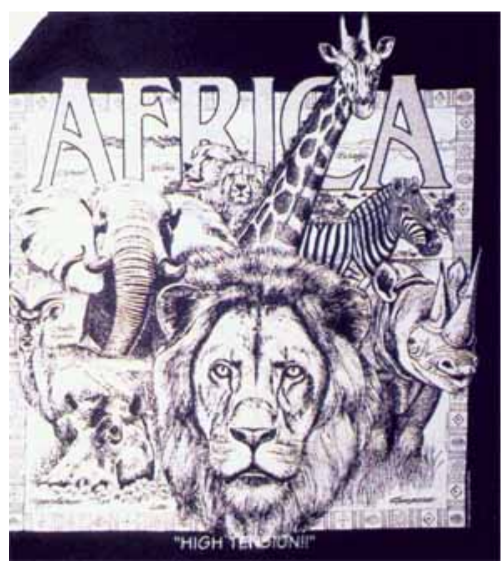
As the squeegee brings the mesh into contact with the substrate, the ink tries to get around and underneath the filament, but the mesh filament is squashed into and is fixed against the substrate, acting as a physical blocker to the ink's flow. As long as the mesh dwells on the substrate, without snapping back up quickly enough, the filament is physically stopping the ink in its tracks. Having lost all velocity, the ink sits still and then "bodies up."

In the above low-tension scenario, if we were to use a conventional coarse mesh count like 110 at around 20 Newtons, our "J" resembles a hook-shaped series of dots or a severely saw-toothed line rather than the unbroken line we would like to see. And the circle in the Indian breastplate wouldn't form a full circle, but rather, a series of broken lines. The other detail areas would also fill in. Although the solid area of the "Wyoming" letters would print well, the edges would be saw-toothed rather than perfectly clean and crisp.

And of course the larger the thread is, the more severely it will hinder the ink's flow, further degrading detail. None of this is any surprise to the experienced printer, whose quite-logical solution has always been a finer mesh count, with its 50 to 60 percent smaller-diameter mesh filaments. Indeed, who would suspect low screen tension as the source of these limitations?



Making the impossible possible: At 85 Newtons, a N115 mesh renders detail normally considered possible only with 200+ mesh counts.



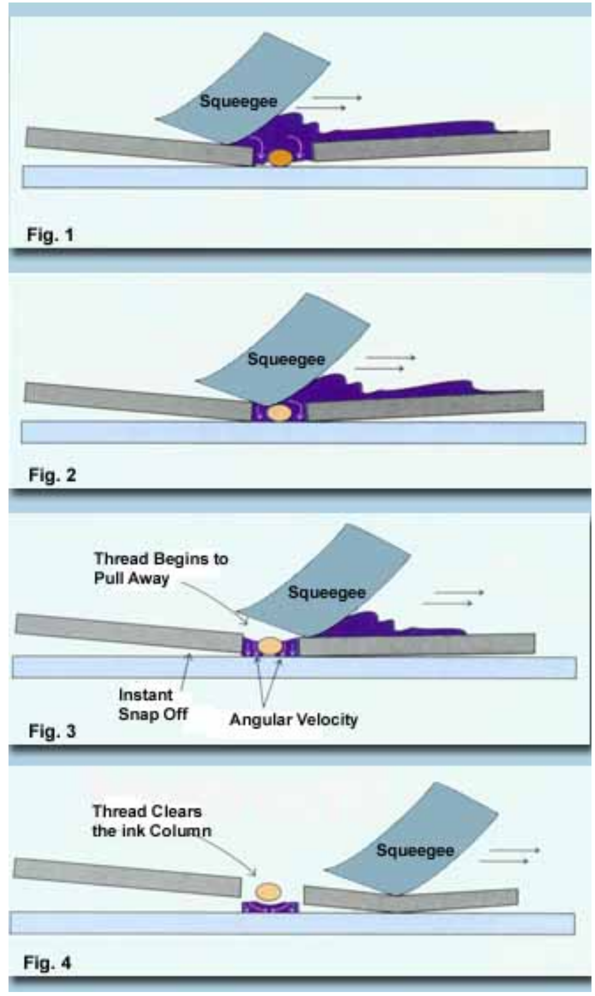
White on black: At 85 N/cm, "Africa" yield was over 20 dozen per hour (through an N88 mesh, 1/16" off-contact, 65/90/65-duro squeegee) with a hard fast flood and one medium squeegee stroke, with one wipe-down in eight hours.

End of the Blockade

Yet at 85 Newtons (with approx. l/64th-inch off-contact), we can get a clean, crisp, solid "J," full, round circles in the breastplate, sharp detail and halftone dots and smooth, even, large-area coverage—even though the ink must still find a way around and under those relatively fat threads in the N115 mesh. Why? Because we have dramatically faster ink velocity, increased squeegee speed, faster screen snap, and, finally, the development of *angular* ink velocity—changes in the ink transfer process that combine to cause and create the beneficial factors we have been discussing. These elements work together in the following way: The extremely taut 85-Newton mesh has sufficient upward-resistance force (2500 lbs. total screen force) to counteract the squeegee's downward force. The resultant squeegee interface pressure is maximized where we want it, on the ink, and minimized on the substrate, where we don't want it. The squeegee stroke now touches the mesh down ever-so-lightly to the substrate, *and,* moving on quickly, the mesh comes into contact with the substrate for only *milli*-seconds at the moment of actual ink transfer. And the squeegee can do so with much greater speed because the mesh now snaps instantly from the substrate.

Remember, in this "Wyoming" print, there is no flood stroke but only one very fast squeegee stroke. The high squeegee interface pressure exerts tremendous hydraulic pressure on the ink, beginning to make it flow *before* the ink comes into contact with the substrate. The ink, then, gains velocity due both to increased stroke speed and, being under much higher squeegee interface pressure, achieves far greater downward and angular velocity as the ink is forced through the open areas between the filaments. When the screen kisses the substrate, the ink is flowing down at the very instant the screen is also gracefully withdrawing upward. Ink, squeegee and screen are all in fluid motion, never at rest, during ink transfer. The ink, now moving with far greater speed than in the low-tension scenario, experiences a complex reaction best described as a "frictional attraction" to the filament surface, and actually follows the curvature of the thread around and underneath each side of the filament, allowing the ink on each side to re-connect. The friction generated between the ink and filaments creates an angular or rotational velocity. (See diagram at right) This frictional attraction occurs at low tension as well, but only to a very small degree.

The upward force of the mesh keeps the interface pressure between the mesh filaments/stencil and substrate very low. The mesh filament is *not* mashed into the substrate, nor does it dwell on the substrate. The powerful snap force in the screen instantaneously separates the mesh from the substrate without physically interfering with the ink's newly found angular velocity.



At ultra-high tension, the interrelated factors described above combine to defeat the mesh-filament interference typical in low-tension situations.

The ink initially accelerates due to increased stroke speed (Fig. 1). High squeegee-stroke speed increases ink speed prior to its entry into the inkwell. Interface-pressure is high between squeegee and ink (where it should be) and low between mesh/stencil and substrate, creating tremendous hydraulic pressure on the ink as it passes through the mesh opening (Fig. 2). The ink, flowing freely at high velocity, experiences a complex "frictional attraction" to the filament surface, creating rotational or *angular* velocity (Fig. 3), causing it to flow around, then - because the screen's stronger snap instantly pulls the filament free of the substrate - underneath the filament (Fig.4).

In contrast, at low tension, the filaments and stencil are mashed into and dwelling on the substrate surface, thereby cutting off the ink's path underneath the filament and eliminating the possibility for the ink to *develop* any angular velocity.

Simply put, at 85 Newtons, we've dramatically accelerated the ink's movement, while *getting the mesh filament the hell out of the way so the ink can flow properly, as it was engineered to do!*

As we saw last time, many benefits were available even to the one-color manual printer and, in the following case, we can see even more advantages for printers of multi-color work as illustrated by the "Classic Auto" print at the beginning of this chapter.

His production yield at low tension using 196 mesh averaged 120 to 168 pieces per hour. At low tension, the printer had three options, each a compromise. Option number-one would have been to print a solid red, then flash to prevent smearing and screen pickup when the black outline and halftone shading were overprinted. The obvious problem here is that the flash slows production and he's likely to have a thicker print with a heavy hand. Option number-two: print the black over the red wet-on-wet at relatively higher speed and live with the degradation as the print becomes increasingly muddy. This printer selected option number-three: printing a bit more slowly, wet-on-wet, he chose to wipe screens every 15 or 20 minutes in order to keep print degradation to a minimum. In addition to the frequent wiping, the printer's four-color rotary carousel had to be turned full circle with each print cycle in order to print the solid red first and trap it with black outline and overprint the red with black halftone dots in the shaded areas.

When "Classic Auto" was produced at 70 Newtons, through a N205 mesh, specially designed, like the N115, to handle ultra-high tension, the printer found that each color required just a single pass and no flood stroke. Further, he was able to drastically reduce ink cost by basing the colors back 65 percent.

A Rolling Stone Gathers No Moss

Because the screens were workhardened to near-complete stability, and could be printed virtually distortion-free at 70 Newtons (because off-contact could be kept at only l/64th to l/32nd inch), registration could then be maintained so accurately over the run that the printer was able to rework the art and reshoot screens for butt-registration. (Yes, those tiny black shadow dots fall perfectly and cleanly into same-size holes reversed out of the formerly solid first-down red, see detail on photo at the beginning of this chapter). Once that was accomplished, the screens could be printed with *no downtime for wiping* over an eight-hour shift. Most importantly, however, colors could now be printed without regard to *flashing or color sequence*—black first, then red on one cycle, then (back the other way) red first, black next, and so on, all day long. Therefore-an added benefit for manual printers—it was no longer necessary to swing the carousel all the way around between each print cycle, which saved much time and effort. The economy of this reversible color-sequence is further enhanced when printing a three-color print on a six-color carousel machine.

The result? A yield of 216 to 288 pieces per hour over an eight-hour shift, nearly *double* that of the low-tension version, producing excellent large-area coverage, sharp detail, crisp edges *and* superb, soft hand.

Out of the Stone Age

The implications are tremendous. At ultra-high tensions, conditions exist which not only don't harm ink performance, but actually improve it, currently allowing us to print as fast as we can load either manually or on automatic equipment (900 to 1100 pieces per hour, per eight-hour shift is the known maximum). Today, we can actually transfer the ink 300 to 500 percent faster than current printing machines and loading capabilities allow. Our ink transfer machine and process is no longer the slowest and most limiting link in the screen-printing chain. I eagerly await the development of automatic loading systems, which would allow machines to be engineered to comfortably print at 2000 to 3000 pieces per hour.

While the benefits I've described these past seven sessions are being realized in shops everyday, I would be less than candid if I expressed these ideas about high-tension printing without giving you a serious look, as well, at some possibly not-so-pleasant implications for you and your shop if you decide high-Newton printing is for you. The freedom to print dramatically faster and better while consuming less ink comes with the desire to negotiate an equally dramatic learning curve. If it didn't require knowledge, skill, training and hard work, then everyone in the entire industry would already be doing it. However, there's no free lunch.

Next time: Newman enumerates numerous challenging but necessary modifications those committed to ultra-high-tension printing must make in their screen-printing theory and practice to ensure success.

Don Newman, president of Stretch Devices, is one of the Industry's leading advocates - and a pioneer - of on-press production efficiency, primarily via the virtues of elevated screen tension.