The Double-Cantilevered Beam

The cantilevered beam: A diver's weight more easily deflects a diving board as he steps further out from the point at which it's attached. In similar fashion, a squeegee deflects *double*-cantilevered beams, more easily nearer the center than at either edge.

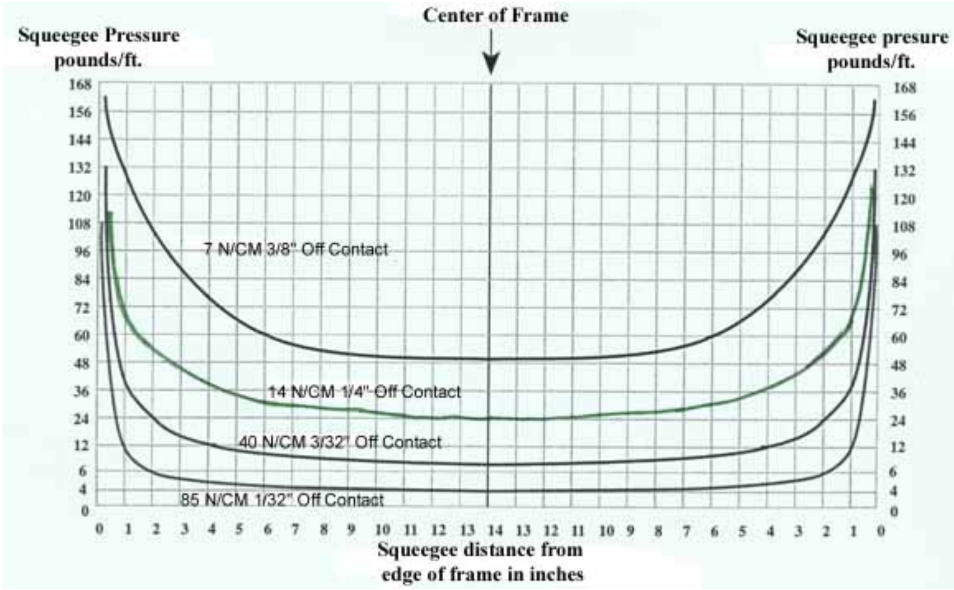
In our last session, I suggested that we think of our ink-transfer machine, the screen, from an unusual but practical perspective, as a cheese-grater-like cutting tool. From that point of view, we considered the concept of interface pressure as the key to keeping our cutting tool sharp, but along the way, we confronted a serious problem unique to screen printing: as ink is transferred from screen to substrate, it is subject to not one but two points of interface pressure. The first, and desirable, point is where the squeegee meets the mesh. The second and, as we discovered, *un*desirable point, occurs where the mesh/stencil meets the substrate. High tension emerged as the means to apply a nearly equal and opposing upward force to the downward force of the squeegee, successfully preventing the substrate from becoming a significant aspect in the pressure equation. Thus, to recap, the result was more control and an end to ink abuse: ink could be sheared from the mesh cleanly and deposited onto a garment surface rather than mashed into and through the fabric.

Unfortunately, as we'll discover this month, the dual-interface- pressure problem is not the only unique difficulty screen printers face. Other printing modes—lithography, flexography and rotogravure—lay ink down by *tangentially* contacting a cylinder to a cylinder. By design, such methods make it relatively easy to maintain even pressure across the print surface. But because most garment screen printers print flat-to-flat, they must accomplish that tangential contact by printing off-contact.

Imperfect by Definition

That fact makes screen printing inherently *in*consistent, as the visiting trainees I mentioned last month soon discovered when I asked them to guess by feel the tension levels at the center of and again near the edge of three sample screens. Without exception, their estimates included a higher tension figure for the edge as opposed to the center.

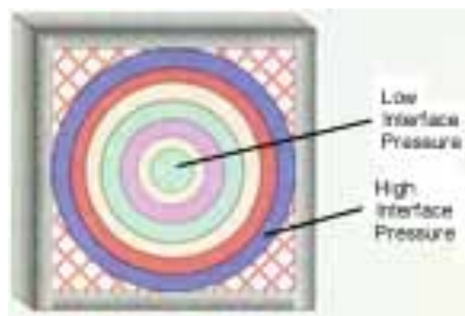
It was a trick question, though. Because the mesh offered more resistance to their downward pressure near the frame edge than at the screen's center, they assumed tension was inconsistent and were surprised to find that the tension meter showed uniform tension at all points within the normal image area of the screens. The inconsistency they sensed, however, is real, but is a result of the fact that mesh is expected to apply force to the squeegee at right angles to the direction in which it is tensioned. In this sense, our ink-transfer machine is unlike the rigid cheese grater it was compared to last month, and much more like a diving board.



Inherently inconsistent: The diagram demonstrates that screen printing is a non-uniform-pressure method of ink transfer, but clearly demonstrates that a dramatic rise in mesh tension yields a dramatic drop in inconsistency.(copyright Stretch Devices Inc, 1981 & 1989)

Near the edge of a swimming pool, where a diving board is attached, a diver's first steps fall on what seems to be a fairly rigid surface, but it comes as no surprise as he continues on toward the end, that the board sways down, giving under his weight. Such is a normal characteristic of what engineers call a *cantilevered beam*—that is, a beam suspended from one end. Now, if that diving board, and another just like it, were positioned on opposite sides of a swimming pool and then welded together at the ends to form a continuous bridge, the result would be a *double*-cantilevered beam. If we suppose a 200 lb. man could deflect our double-cantilever down one foot when standing in its center, we know from personal experience that his weight would have to increase considerably in order to deflect the board the same distance as he walked nearer either end.

As the chart above graphically indicates, the same holds true for another double-cantilevered beam, the mesh filament. The left and right edges of the chart represent the area of the mesh closest to its attachment point on the frame, while the center corresponds to the mesh nearest the screen's center—where the diving boards meet. Plotted on the graph is the minimum squeegee pressure necessary to bring a 28"-wide (I.D.) screen into contact with the substrate for each of three actual screens, measured at one-inch intervals: The top curve represents the results for a 7-Newton screen at 3/8" off-contact, the second, a screen at 14 Newtons with 1/4" off-contact and at bottom, a 40-Newton screen with 3/32" off-contact and an 85-Newton screen at 1/32".



A well-disguised variable: Depicted in three-dimensional terms, screen printing's natural non-uniformity results in ring-like interface-pressre variations along the length of the squeegee as it passes over the image area. The result is a similar variation in ink deposit.

Cutting the Curve

As we examine the graph further, however, we discover a hopeful trend in the differences between the plotted curves. As the tension gets higher and off-contact gets lower, the curve tends to flatten out, becoming more uniform across a wider area of the screen. Indeed, at 85 N/cm, that uniform area has spread within 2-1/2" of the 24" frame members, keeping the severe rise of the curve outside the bounds of the typical print image area. Though the curve never becomes completely flat, we can see that as tension goes higher and off-contact lower, we approach a point where (as was true, you'll recall, with mesh elongation) for *all practical purposes*, the ink feels the same interface pressure across the entire width of the squeegee. And again, a complex variable is made into a constant. This now produces uniform registration, ink-film thickness, color, and halftone dot size from the middle to the edge of the print. On textiles, uniform ink penetration and cure will also result.

Higher tensions, then, not only sharpen our cutting tool but also make our ink-transfer machine cut more consistently across our image area. And as our graph indicates, if our goal is to turn variables to constants, the only response we can make to those who ask "*How high is high enough?" i*s to pose another question: "*How well would you like to print?"*

Now that would be a passably good tagline to the end of our high-tension discussion ... if we were at the end. But my mission up to now has only secondarily been to recap high-tension-related quality-improvement concepts. Primarily, I've tried to lay the groundwork for discussion of the key role high tension plays in— as the title has suggested all along—*elevated production efficiency*. While quality is by no means unimportant to pursue, efficiency has much more to do with speed. No screen printer (at least no one I've ever met) would turn down an opportunity to turn out print jobs faster, as long as quality didn't suffer in the process. So I'm assuming that those same printers would be delighted if someone were to demonstrate that *dramatically elevating mesh tension* not only allows them to increase printing speed, but that as print speed goes up, quality—far from suffering or even staying the same—actually continues to improve.

I propose to do that from this point forward, answering the "*How high is high enough?*" contingent by rephrasing my response, asking *How FAST would you like to print?*

The Faster the Better

Since the advent of frame and mesh technologies which facilitate printing at tension levels approaching 100 N/cm, there has been a mounting body of evidence to support my contention that as screen tension goes up, reject rates and press downtime drop dramatically while press speeds increase. The result is enormous impact on that all-important subject that motivated the writing of this series: The number of saleable prints generated per hour, per day, per week and per month—in other words, our *yield*—quite possibly the most important statistic in a for-profit manufacturing operation. And thus, our high-tension investigation is about to come up to speed

Next time: Newman begins a demonstration of how image quality and production speed go hand-in-hand in four key functions of our ink-transfer machine.