Taking the Hocus Pocus out of Anilox Specifications:

By: David J. Lanska MBA
Narrow Web Sales Manager
Stork Cellramic, Inc.

Oh No ! Once again we find ourselves at that all too familiar crossroads. It is time to buy anilox rolls for a new press or a new job coming up. What specifications do we choose? What combination of cell dimensions will get us the densities we are striving for? How will we decide among the myriad of choices available? Last time I checked, a warm front had come through and my crystal ball was a bit hazy. Perhaps instead of picking numbers out of the air, it would be better to take a systematic approach to roll selection that will achieve our print goals with the specific ink, substrate and plate systems we have already determined.

Since ceramic is the standard for most new rolls and resurfaces, this discussion will focus on the parameters of laser engraved ceramic anilox rolls. There are three main variables to determine: engraving angle, linecount and cell volume. The combination of these variables determines the quantity and precision of the ink lay-down.

Engraving angle or pattern refers to the special orientation of cells in subsequent rows of engraving as referenced from the horizontal axis of the roll. As a roll is rotating and traversing past the focusing lens in the laser cabinet, elaborate control systems monitor the position of the roll surface at any given instant. At the appropriate times, when the rotational and horizontal spacing is correct the laser fires, concentrating its energy on a particular spot of roll surface. The laser bursts (pulses) occur thousands of time each second and are just long enough to remove and reform ceramic to create the contours of the cell cavity.

The engraving angle determines the shape of the cells. Since the lasing occurs at extremely high frequencies and on a microscopic level, it is impossible to make out a given burst of energy, or the cell that results from it with the unaided eye. Under magnification, it becomes apparent that the cells at different angles have different shapes. A 45 degree pattern looks diamond-shaped, while the 30 or 60 degree patterns create hexagonal shaped cells. If the rows of engraving are close enough, the cells overlap to eliminate the diagonal cell wall completely, thus forming a series of angular grooves commonly referred to as a trihelic engraving.

All cells are initially round craters formed by a highly concentrated burst of energy. The engraving process is reminiscent of using dynamite to blast holes in a farm field. Concentrated bursts of energy remove dirt to form the crater. In the process, some of the "dirt" is redeposited on the surface on the edges of the crater. The size and depth of the crater are determined by the hardness of the surface, the energy of the blast, the concentration of energy (spot size), and the placement of the blast. If, for example, the energy is focused above the surface, the resulting crater will be shallow and dished. If it is below the surface, the crater will be much deeper with steeper walls.

As cells are formed in subsequent rows of engraving, the walls of cells in the previous row become molten for a fraction of a second as adjacent cells are created. The walls shift slightly (are re-cast) to form the cell shapes (hexagon, diamond, trihelic). Both 30 and 60 degree patterns produce tightly packed hexagonal cells. The 60 degree pattern is by far the most common in spite of the fact that on water and solvent inks they can often be used interchangeably and on viscous UV inks, many printers have noted less pinholing with the 30 degree angle.

The 45 degree pattern produces the diamond shaped cell, which typically has the largest part of its opening oriented along the rotational axis of the roll. Because the 45 does not efficiently occupy the roll surface, there are often large land areas (that do not carry ink) rotationally between cells. Because the cells are not tightly packed, there are actually about 15% fewer cells per square inch of surface area than with the hexagonal patterns. Without changing linecount or cell volume specifications, printers can have immediate improvement in print quality by switching from 45 to 6o degree anilox rolls because of the finer distribution on ink afforded by the greater concentration and closer proximity of cells in a 60 degree pattern.

The trihelic grooves are typically not used for printing applications. The lack of a diagonal cell wall affords easier release of liquid than conventional cells, making them ideally suited to the application of heavily viscous adhesives and overprint varnishes. These materials readily flow out of the grooves in a manner reminiscent of rain channeled out of the treads of Goodyear Aquatread® tires. While recent attempts have been made to market extremely fine trihelic engravings for process work, the trihelic is not properly suited to delivering controlled ink flow to highlight dots because ink is not contained within individual cells. Instead, it free-flows onto the plate surface, causing dirty plates and muddy print.

Linecount (LPI or lines per inch) refers to the number of cells per lineal inch as measured along the engraving angle (because that is where the cells line up in closest proximity to each other). The higher the LPI, the greater the number of cells in a given surface area and the smaller the cell diameter. It is important to note that as we increase LPI, we increase the concentration of cells in both the rotational and traversal directions. Doubling the LPI effectively quadruples the number of cells in each square inch of roll surface.

As LPI increases, smaller droplets of ink are spaced closer together onto the plate surface. Smaller ink droplets tend to dry quicker and produce smoother solids. The vastly increased shear numbers of cells at higher LPI's provide for smoother transition of color and increased tonal ranges on vignettes.

If increasing LPI gives so many benefits, why not have every roll engraved to 1500 or even 2000 LPI? As cells get smaller, it becomes more difficult for them to carry and deliver an adequate density of ink. This has been overcome, to some extent, by new engraving processes including YAG and multi-hit technologies, which make it possible to engrave ultra-high linecount patterns (900 LPI and up) with greater carrying capacity than conventional CO_2 engraved cells at 600-800 LPI. YAG (Yttrium Aluminum Garnet) is a crystal laser with a much sharper burst of energy that focuses to $1/10^{th}$ the spot size of gas lasers. As such, it offers more complete ceramic vaporization with less melting, resulting in deeper, steeper walled cells with greater carrying capacity. Multi-hit engravings utilize elaborate laser control software to relocate (the position of) cells that have already been engraved so that one or more subsequent bursts of laser energy can be directed at the same cell. This process incrementally adds depth, smoothes the cell walls in a glazing type of action, and thereby adds volume and improves the release characteristics of the cells.

The traditional approach to specifying LPI was to have the anilox linecount be at least four times the plate screen. Over time, however, the plate technology has improved to the point where it is possible to produce plates with 1% highlight dots on 200+ line screens. The ability to produce such an incredibly fine dot structure necessitated the need to revise the multiplier to at least five times the plate screen. Consequently, if we want to run 150 line plates, the lowest linecount we should run will be 750 LPI. This helps prevent the occurrence of dot dipping, insures each plate dot is inked and supported by the wall structure of several cells.

Cell volume refers to the ink carrying capacity of a cell multiplied by the number of cells in a given square inch of roll surface. The common unit of measurement in North America is BCM or billion cubic microns per square inch. One cubic micron would be 1 micron wide by 1 micron long by 1 micron high. To get a perspective on the scale we are dealing with, a micron is .000001 meter (a millionth of a meter). Put another way, a micron is a fraction of a thousandth of an inch. (There are 25.4 microns per .001").

Volume is determined by the depth, diameter, and profile of the cell. It is possible to adjust cell volume by producing cells with the same cell diameter (same LPI), but engraved to different depths. The ratio of the depth to the cell diameter is commonly referred to as the "depth-to-opening" ratio. There is a lot of conflicting information about the "optimum" depth-to-opening ratio, however, a recent study of over 6000 densitometer readings presented at this year's FTA Forum found that solid ink density continued as high as 52% D-to-O regardless of ink viscosity, substrate or anilox linecount. Ink density did not plateau and the trend lines indicated that density would continue to climb beyond 52%. This evidence clearly refutes the claim that ink densities would fall off when engraving deeper than the "optimum" range.

Another common misconception is that deeper cells more readily plug than shallow cells. During multiple press runs with multiband rolls, no significant plugging or difference in cleanability was noted with D-to-O ratios from 24-52%. No anilox roll is immune to plugging as evidenced by the number and variety of approaches employed for removing ink from anilox cells. As linecount increases and cells get smaller, it becomes increasingly difficult to clean them regardless of D-to-O.

The consistency of the engravings is yet another issue frequently raised, but photomicrographs of the cells at 25% and 52% D-to-O revealed no significant differences in wall thickness, cell opening, or ceramic recast.

Volume is an important factor in the amount of ink delivered to the plate and on to the web. It is important, however, to differentiate between cell volume (how much ink the cells can hold) and delivered volume (how much ink will transfer out of the cells.) Many factors can affect ink transfer including ink flow characteristics (viscosity, pigment load, and pH), doctoring method (doctor blade, rubber nip roll, closed chamber system), characteristics of the doctoring system (durometer of the rubber roll, thickness and type of blade material, nip or doctor blade pressure), press speed, surface tension of the platers and substrate, and absorption rate of the substrate.

If 10 identical rolls were shipped to 10 different printers, chances are each would end up with different results because of the many press variables that combine to determine precisely how much ink will transfer from the rolls. For printers to obtain predictable results, it is necessary for them to eliminate as many variables as possible. This means running doctor blades instead of nip rolls, routinely monitoring and making needed adjustments to ink pH, and making the commitment to cleaning anilox rolls regularly and thoroughly. It means training (and regularly retraining) operators to properly adjust press components rather than overtightening blades and other components. It also means putting together a roll inventory predicated on standardized purchase criteria. It means taking a systematic approach to ordering, monitoring, and maintaining press components.

Everyone seems to be looking for a magic answer; a one size fits all anilox that can do everything well regardless of ink system on substrates as varied as pressure sensitive, film and board stock. We want the full spectrum from laying down a deep rich solid to the finest highlight dot, with smooth transition of color through the endless tonal ranges.

This is asking a lot from the components of the ink train; specifically the ink, plate and anilox roll. An anilox roll geared toward laying down a large volume of ink on a solid coverage area is not necessarily the right tool to precisely lay down a 1% dot on a 200 line plate. It is analogous to driving in a railroad spike with an 8 ounce hammer or using a 5 pound sledge hammer to gently tap in a finishing nail to hang a picture. Each hammer is designed to do a specific kind of work and performs that function admirably. When asked to do work they are not designed for, each hammer performs poorly. In the case of the anilox roll, we are asking the cells to carry large quantities of ink for the solid areas, and still print clean dots in the highlights.

The fact is it doesn't take a crystal ball, a magic wand or fairy dust to obtain litho quality print results with flexo. It takes a methodical approach to press component selection, set-up and maintenance and the commitment to follow it. Can you get an anilox roll that will deliver high densities and fine highlights? Absolutely! To achieve this combination, however, requires replacing wall thickness with carrying capacity. The result is an ultrahigh linecount engraving with high cell volume. Because the walls are thinner, steeper and deeper, there is less material available to stand up to aggressive cleaning systems and practices. This means revising cleaning processes and may ultimately mean more frequent roll replacement. Do you disassemble and rebuild your car engine after each 500 mile trip? Probably not, but mechanics in NASCAR certainly do. The high performance requirements of race car driving are incredibly more demanding than commuter travel. So too is the case with "high performance" anilox rolls. They require a level of commitment in proper set-up and maintenance that transcends that of rolls produced just a few years ago.

So where do you start? Look at the print quality you are currently achieving. Get a feel for the artwork you have coming in. What changes will be necessary down the road? Higher or even hybrid plate screens? Finer image resolution to 1% or less highlight dots? At the same time you are concentrating on nailing the highlights, are the designs screaming for bright, bold color?

Granted, not every printer has to worry about all of these issues. The print quality and graphic demands of some market niches may be adequately and profitably served with roll-to-roll printing with low linecount chrome anilox rolls. To maintain continuity i such a case, the cell specifications for existing rolls should be used as the order criteria for new rolls.

Once you understand what you are trying to achieve, you can use your current results as a baseline in the same fashion as you might use a banded anilox roll. A banded roll is a test roll engraved with more than one set of anilox cell specifications. This allows you to see the effect of the cell specifications on actual samples printed with the ink system, plate material, and substrate the job would be run with. While most anilox manufacturers will provide banded rolls, the results are of greatest value when the engraved bands are established specifically for the test rather than provided off the shelf. While a custom banded roll provides the best and most complete test data, you can use the print results from your existing anilox rolls to provide a benchmark from which you can establish specifications for new anilox rolls.

For example, let's assume at a given viscosity of magenta, a 900 LPI engraving with 1.5 BCM cell volume delivers a solid ink densitometer reading of 1.6. If an upcoming job requires a density of 2.0, (a 25% increase) the traditional approach would be to check the shelf for an anilox roll with at least 25% more cell volume (ink carrying capacity). You would look for an anilox roll at about 1.9 BCM (a 25% increase in cell volume). Chances are, the roll you would choose would be a 600 LPI with a 2 BCM volume, because that would provide the desired increase in delivered volume required for the job. This approach would, however, result in a reduction in print quality as there would be about 450,000 fewer individual ink droplets per square inch, delivered to the plates. The problem would be magnified if you wanted to run the upcoming job on 150 line screen plates.

What you might do instead, is purchase a 1000 lpi engraving at 2.5 BCM. Even taking into consideration a slight loss of ink release (transfer) efficiency you would still deliver a comparable amount of ink as the 600, (25% more than your existing 900 lpi roll), delivered with a much finer distribution from 190,000 more cells per square inch. You would have achieved your density goals and your print quality goals from a purchase decision based on the known quantity (the linecount / cell volume of your existing anilox roll) taking into consideration the quality demands of the impending job. In other words, if you want to reach you goal, you need to know what your goal is and where you are in relation to it.

Obviously, there are a lot of considerations when specifying anilox rolls. You have to establish engraving angle. You strive to achieve certain ink densities, which means determining required cell volume. You have to review plate specifications for current and future jobs, which will guide your choice of linecount. The actual choice of linecount/volume specifications may require banded roll testing or may be benchmarked based on known print values produced by current anilox specifications. Each anilox manufacturer can also provide some guidance based on experience, previous testing, or actual print results from other customers with similar print, ink and substrate characteristics. Specification decisions for all press components should be systematic and geared to achieving print goals. When you take a methodical approach to print operations, you may find that you really don't need that crystal ball after all.