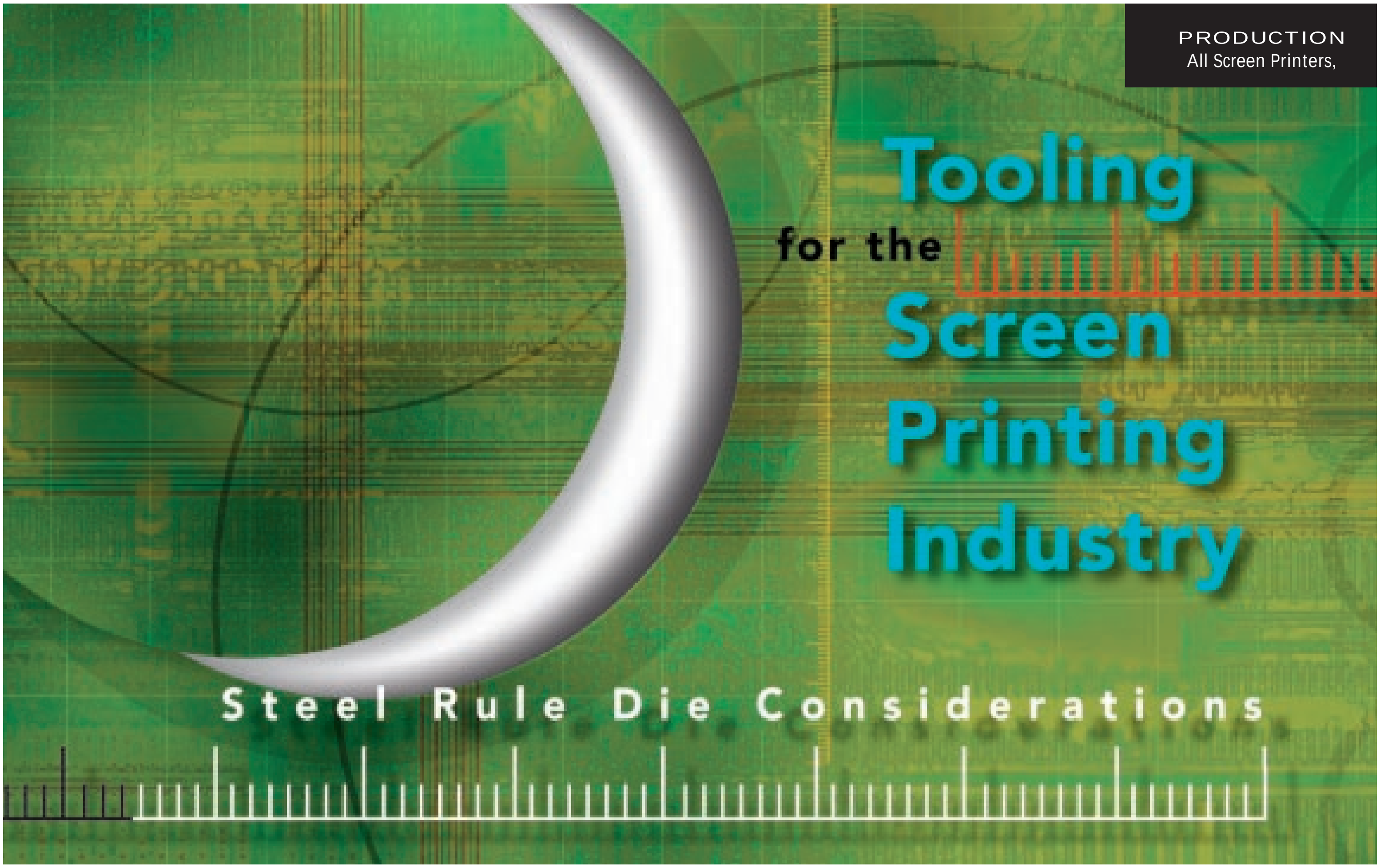

Of the 50,000 screen printers in North America, about a third “diecut” or fabricate their product into one shape or another. Some rout the product shape, others may lasercut or knife-cut on a plotter-cutter. A good percentage, however, die-cut — using either a hard tool or a steel rule die.

Diecutting is just as critical as printing, because if the part doesn’t fit the housing, the best graphics in the world are not going to make a thread of difference. Among screen printers, knowledge abounds regarding inks and coatings, screens and platemaking, however very little information is offered about diecutting. My intention is to begin to bridge that gap, so the screen printer can become a little more knowledgeable about the diecutting process.

I am not about to tell you that a steel rule die competes with hard tooling from a tolerance standpoint. The technology used in manufacturing steel rule dies in recent years, however, has improved significantly. Diebase materials and steel rules have also been improved. Suddenly, the steel rule die can now be used in applications where only a hard tool could be considered beforehand.

In recent years, a wide variety of plastics, adhesives and substrates have come on the market, and many have found their way into an application requiring diecutting. The steel rule die maker has taken on the variety of problems that have surfaced under attempts to fabricate these materials, and armed with new materials and techniques in the manufacture of dies, many of these problems have been addressed.

by Allen S. Gurka,
Allen Die Cutting Consultants

Many printers have sophisticated pre-press, graphics and printing capabilities. When it comes to diecutting, however, they are using a 50-year-old machine that may be entirely underrated for the type of diecutting they are trying to do.

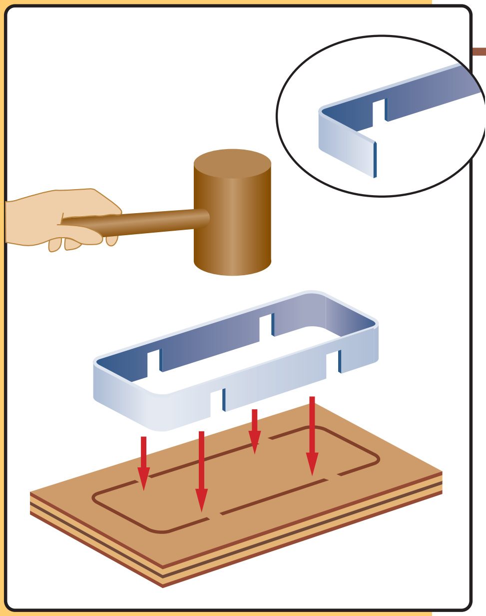

Figure 1

KNOWLEDGE BREEDS SUCCESS

To become more successful in any diecutting operation, it is best if we become more knowledgable about (a) the steel rule die, and (b) the diecutting process. Only then can we take an analytical approach to problem solving.

A steel rule die is no longer considered "cheap" tooling. We now use sophisticated lasers, CAD-CAM (computer aided design-computer aided manufacturing) systems and automatic rule processors to manufacture dies that fit well within the fabrication tolerances. It now becomes a "value-added" element in the production process, absolutely critical to the success of the product. The steel rule die is no longer regarded as a disposable item used to make a few prototypes or a prerequisite to purchasing a hard tool. Today there are dies running with millions of impressions, successfully cutting out parts for the car you drive in, the airplane you fly in, and the operating room in which surgery is performed every day.

The dies are commonly used to diecut products for Raytheon, Microsoft, Kodak, and the U.S. Mint.

In short, in recent years the steel rule die has gotten a lot of respect.

TRULY A HAND CRAFTED PRODUCT

Essentially, a steel rule die begins with a block of wood, usually high grade maple plywood about 3/4" thick and large enough to fit the total dimensions of your die. If you are from Thailand, you probably haven't got the vaguest idea of what North American maple plywood is. It is indeed, truly an American product. The image of your diecut shape is projected onto the surface of the dieboard either through CAD-CAM technology or it may be hand-drafted. Wherever there is a line, a slot is cut directly through the dieboard, top to bottom [see Figure 1]. The slot is broken every so often to allow "tags" that prevent the board from falling apart. These are appropriately called "bridges." The slot is critical in width … it must be .028" wide and not vary more than 1/10 thousandths of an inch. It also must be absolutely perpendicular to the board's surface. For many years, this slot was cut with a jigsaw blade — obviously a very challenging task. In the last 25 years, this slot has been cut with a laser beam, providing much more controllable circumstances. This has also eliminated the need to draw the image on the wood, as the CAD-CAM program now directs the laser beam to cut out the shape of the part.

Strip steel rule, with a hardened knife edge and measuring precisely .028" in thickness, is bent to conform to the shape of the die pattern and is inserted into the laser cut slot. "Notches" are put in the rule to allow it to "jump" over the bridges. They are only the height of the dieboard base and do not interrupt the cutting edge. Your rule is of level uniformity in height, usually .937". Therefore the rule does all the cutting, the shock being from the tip of the cutting edge through to the back which rests on a steel backer plate. The wood only serves to hold the rule dimensionally in place. A sheet of rubber is usually placed between the surface of the dieboard and the cutting edge, to "kick" the diecut sheet away from the die once it is cut.

LIMITATIONS/ADVANTAGES OF STEEL RULE DIES

What are some of the limitations with steel rule dies?

- The diebase is wood. Wood is susceptible to moisture and heat. This means a dimensional change in the die could be effected.
- The steel rule is only .028" wide. The "shock" of diecutting tough material could push the rule out of tolerance, called deflection.
- Joints and corners are not welded, therefore tough material may force them apart.

Elements that can be built into a steel rule die to make it an advantageous piece of tooling:

- Non-wood, more dimensionally stable diebases
- Hard edge, soft body cutting rule
- A choice of ground or shaved cutting edges, and a choice of bevels
- Use of side bevel rule
- Mini hard tools of any custom shape that can be inserted in the die
- Punches and mini-tools that side eject tiny slugs of waste
- Ejector plates to stabilize the material during the cutting process

- Creative ejection rubber that helps the process rather than hinder it
- Reknifeable blade replacement
- Ability to alter the die design at a later date (may be possible)
- Mated stripping tools to evacuate internal waste, off-line or in-line
- Light weight shipping

Obviously I am a proponent of steel rule dies. Due to their inherent flexibility, we can address many of the problems that the average screen printer might encounter in cutting various substrates.

The die itself can not solve all problems encountered. The use of the die in the diecutting process becomes critical in our understanding of what is happening. To do that, we have to look at the three items essential to the process: (1) the die, (2) the press used for diecutting, and (3) the material being diecut.

I find many printers have sophisticated pre-press, graphics and printing capability. When it comes to die cutting, however, they are using a 50-year-old machine that may be entirely underrated for the type of diecutting they are trying to do. It is very unlikely you will successfully kiss-cut a form of any size if your press is not level or if your press is not rated for the tonnage it takes to cut the form.

ASSESSING YOUR DIECUTTING CAPABILITY

Here are items you may want to review in assessing your diecutting capability:

- What is the tonnage rating of your press?
- Is there much wear in the crank arm, bearers and crank mechanisms?
- How level is the press?
- Are you cutting in the center of the press and using bearer dies or blocks for smaller forms?
- Do you have a good die-bolting pattern?
- Are you using a protective substrate on the cutting plate?

Relative to your material package, be aware of how many layers you are cutting through, counting the adhesives, and advise your diemaker accordingly. The use of a heavier three-point rule and/or the use of side face rule may be well advised. Also remember that certain inks and coatings are extremely abrasive and will wear the cutting edge on the knife in very short order. Also, if you change material suppliers, do not expect the same spec material from one vendor to cut exactly the same if bought from another vendor.

It is absolutely essential that the knife edge be kept sharp. The moment the die becomes a bit dull, cutting quality goes down the tubes rapidly. Using a substrate to protect the cutting edge from hitting the cutting plate directly is excellent insurance for longer die life. Learn how to inspect your knife edges and know when it is time for reknifing. A re-rule generally runs 60% of the original die cost. It is a very good idea to keep a die life log with every die, showing the number of impressions it has had, the material it cut, the press it was run on, and a sample of the first and last piece diecut.

FACTORS AFFECTING TOLERANCE

Tolerances are on everybody's mind. Design engineers often over-spec tolerances, even for a simple label that is surface mounted. More critical applications occur when the diecut panel has functionality and is used in a recessed area and overlays many buttons and critical L.E.D. areas.

Steel rule dies can generally be expected to be built in the plus or minus .005" tolerance area. Many factors including the wood base, the centrality of the rule's bevel, the deformation of the cutting edge upon sustaining a bend, and the quality of the kerf and rule being inserted all play a role in limiting tolerances to this range.

For the most part, end users of the fabricated piece are interested in the tolerances of the finished part, not the die. Therefore, customers who specify parts that must meet the +/-.005" criteria may well be candidates only for hard tooling.

Part of the reason is that there is a lot going on during the diecutting process. The cutting rule is experiencing "shock" creating "deflection" (which will be examined later). The ejection rubber is exerting its own forces, while the material is pushing the blades around in another manner. Even on materials no more than .010" thick, you may experience as much as an additional .005" deflection die to part. This means you may not be able to offer your customers a tolerance less than +/-.010. Given the perfect die in the perfect press with the perfect operator cutting material that behaves perfectly, you may experience "perfection" with a +/-.005" part. But do not expect part No. 5,000 to be the same as part No. 5. It is just not prudent to hold your production up to these expectations. When using steel rule dies, we have to deal in realities.

One overlooked factor is how much the cutting press can affect the size of the part. There are many types of presses out there. Some are roller presses, where the material is placed on a face-up die, a cutting surface, either soft aluminum or a plastic composite, is placed on top of that, and the press slides this working area under a set of rollers. Since the material is being "squeezed" on top of the die, any number of undesirable results can occur to create a deformed part.

Success is more probable with two level platen surfaces making contact with the die. Here again there are a variety of situations that affect the die-cut. Many times, parts are cut on a soft bed clicker press where the die impacts a soft bed cutting surface such as polypropylene. To affect a cut through, the die knives must "bury" into the soft surface. This creates "edge curl," where the material is dragged into the cutting surface by the penetration of the knife edge. When you flatten out your edge-curled part, you will have an oversized piece. I highly recommend a platen press with a hard steel cutting surface and finite closure adjustment that will allow you to "kiss-cut" with your die. Any material in between will most likely cut clean and be most representative of the shape for which the die was built.

When you ask your diemaker for a sample piece off the die, be sure you understand the type of press the diemaker is taking that sample on. Most diemakers use a soft bed sample press to insure they will not damage the virgin knives. However, if you are subjecting that first piece to a rigorous inspection process, you may be well advised to be aware of these limitations. This also presents some interesting dilemmas for the diemaker who is required to build a die that yields a part within certain specifications. Unless the diemaker can strike a part out of your exact production material on your exact production press, it may be virtually impossible to achieve such predictable results.

INCREASING DIE LIFE — SOME EXPERIMENTAL TECHNIQUES

There are some unique applications for steel rule dies and the steel rule that comprises the tooling, that is generally not practical with other types of tooling. One such application is the Teflon coating of the steel rule blades. Teflon is noted for its "non-stick" properties, and it may help repel adhesives that want to hang onto the blades. Teflon coating, however, is just that … a coating that will (a) wear off, and (b) coat the very tip of the knife thereby affecting cutting ability where a very sharp edge is required. Teflon© coating is a very effective approach in some cases. I recommend it be eletro-statically applied, rather than "sprayed on," for effective bonding purposes.

Another limited application for steel rule blades is titanium nitride. This is a hardening process that again is a coating, but electronically bonds itself to the skin of the steel rule. Since it is only a few microns thick, it does not affect the sharpness and since it is bonded, it will not wear off. In some cases we can triple the die life with this process, which is relatively inexpensive.

A third, and lesser applied application, is the introduction of mollidium, or "molly-coat" as it is called. This is a very fine coating that is bonded to the skin, and microscopically fills in all of the "pores" on the surface of the steel rule. It makes the steel very smooth and almost "slippery." Cutting resistance is greatly relieved due to abrasion, and die life can be greatly extended.

The last application I will mention here is cryogenic treating. The steel rule is given a nitrogen bath at several hundred degrees below zero and is literally "frozen." As a result, the molecular structure of the steel rule is changed, making the rule tougher instead of harder. Preliminary tests tell us that this is a very competent approach to greatly increasing die life. All of these processes add cost and time to the die, but the extended life may more than offset that.

OTHER CONSIDERATIONS THAT CAN IMPROVE THE DIE CUTTING PROCESS

Ejection of the Waste

We take on-press, in-line internal stripping pretty much for granted in the paper box industries. However in the specialty fields, many customers have never seen in-line stripping, and in fact resort to costly hand labor to meticulously remove internal waste before packing. They are just a thought process away from saving thousands of dollars in labor with an automated or semi-automated stripping system. It is cases like these where diemakers can begin to earn their salt in the specialty diecutting market. It is merely a transfer of information, but we are bringing new ideas to new tables across industries.

Breaker Knives

While it is commonplace to find breaker knives to cut up the waste between cavities on a die-cut boxboard sheet, rarely will you find them installed in a multiple-up specialty die. Yet the very same technique can save countless hours of clearing the web away from the diecut part. It is simply not a technique that is readily applied in the gasket, screen and plastic parts industries. Clearing the individual parts out of the diecut sheet can be a tedious affair, when breaking of the sheet away from the part is an obvious but overlooked efficiency.

Die Side/Print Side

We have an adage in the diemaking industry called "down is up, and up is down." The adage refers to what the industry often calls "die side/print side." Countless thousands of dies are made backwards each year for lack of understanding from which side you are cutting. Remember a die is a mirror image of the cut part, especially if it is a printed piece. Usually the die cuts into the face of the printed or molded part, so the die is "flipped" from your CAD drawing of the part. But wait … there is always the exception … when we are cutting into the back of the material? Always ask the question.

Side Bevel Rule

Side bevel rule will tend to be used more in the specialty market than anywhere else [see Figure 2]. There is often a need to avoid a "draft" on the part. It also may be necessary to transfer any crimping or buckling of the material to the waste, which can be accomplished by putting the bevel to the waste. It is necessary to understand from a diemaker's fabrication standpoint, that side bevel rule is not manufactured in as close a tolerance as center bevel. In addition, the bending of side bevel rule often causes the cutting edge to collapse, producing an unsatisfactory cut on the radius. There are ways to address this, and you should consult your diemaker.

Varied Diebase Materials

While the normal height for diebase material is often 5/8" or 11/16" thicker in the box industries, materials such as 7/8" are often used in specialty markets. The goal is to hold the rule from flexing, and hold it more securely with all but the very tip of the rule which is exposed only 1/16". The drawbacks are less rule penetration and less surface to provide adequate ejection.

Composition of Dieboard Material

Wherever heat or moisture might be present during the diecutting process, the use of the traditional plywood base may be impractical. We can then introduce substitute die bases such as Permaplex©, acrylic, epoxies, phoenolics and even steel. While more costly, they can often be laser cut, add years to the life of the die, and be impervious to conditions where wood might fail. While widely used in box industry dies, the application of these diebases in the specialty industry has yet to seek its potential.

Special Solid Milled Punches

Where milled punches were used only for rule joiners a few years ago (where two or more radii ran together, and steel rule would tend to jam up with waste and spread), today they have found application in diecutting millions of tiny shapes within the die, with never a fear of spreading or collapsing, and often incorporating waste self clearing features to expedite processing [see Figure 3]. Often being quite harder than the steel rule, their longevity made them quite cost effective.

Balancing the Platen

When flatbed diecutting, so little thought is given to the placement of the die and the distribution of the load [see Figure 4]. I have often seen dies placed off-center, and watched the platen flex to one side during the cutting stroke. Then operators wonder why only half the die is cutting through, and why one side of the die is wearing faster than the other. Of course the answer lies in centering the die precisely on the cutting plate, both front to back and side to side. A simple scribe mark on the press, aligned to a mark on the center edge of the die will facilitate this process. With very small dies used

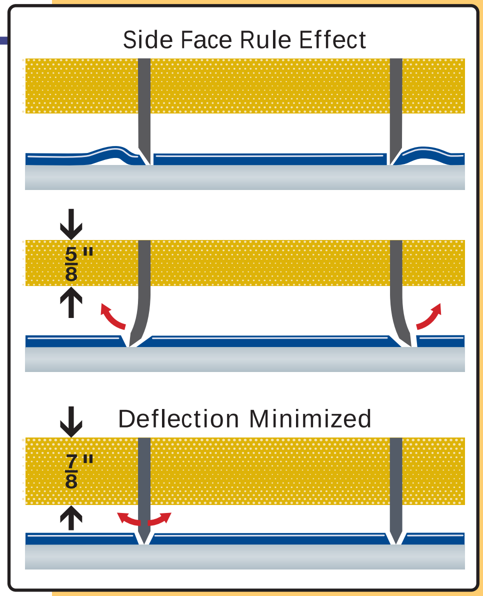

Figure 2

Courtesy Ken Specialties, Inc.

Figure 3

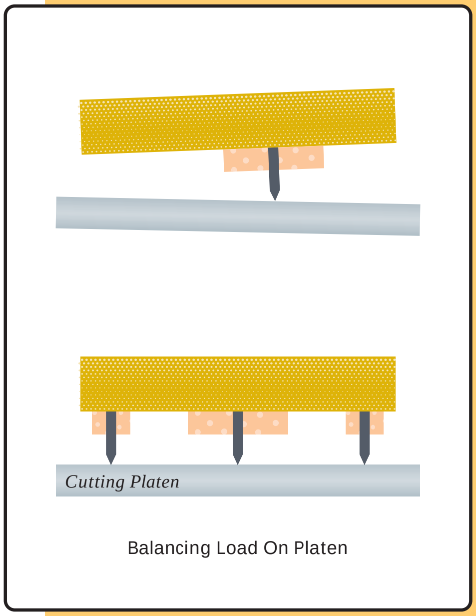

Figure 4

Ejector Plate Die

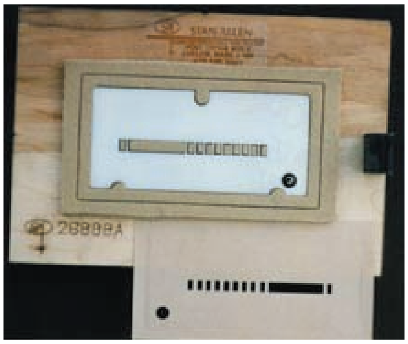

Figure 5

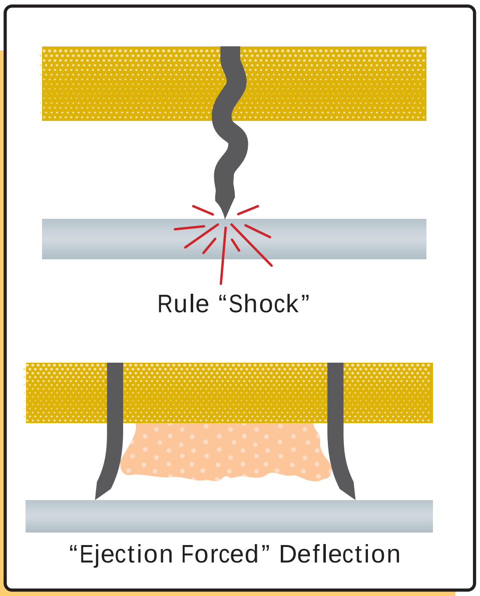

Figure 6

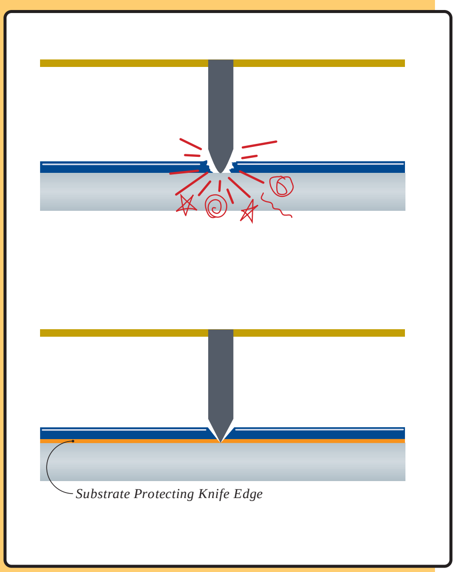

Figure 7

on an oversize press, scrap dies should be mounted on the far edges of the platen, well off the material track. This helps “balance” the platen load during impression, keeping it absolutely stable and level during impression. It also will immensely improve die life.

Ejector Plates

Often specialty materials will buckle and crimp as the steel rule penetrates the material [see Figure 5]. A clever approach is to hold the material flat during the impression through the use of an ejector plate. This spring loaded ABS or Delrin© unit is precisely laser cut to profile the inside of the cutting knife, and forces any buckling to occur outside the cut part area into the waste. It has been very effective in helping to maintain close tolerance on the cut part.

MAINTAINING TIGHT TOLERANCES

“What tolerance can you hold on the die?” vs. “What tolerance can I expect on my diecut part?”

These are two key questions, not always easily answered. As mentioned earlier, I feel the traditional wood-based laser-cut die with two-point rule can hold tolerances of +/-.005". When you start introducing three-point rule or heavier, that tolerance tends to increase. The key is in the difference between the die and the diecut part, this difference often called “deflection.” There is always some deflection during the cutting process due to the fact that a thin piece of rule is being hit with 50 or more tons of pressure top to bottom, and the “shock” causes a ripple in the rule that knocks it slightly out of tolerance [see Figure 6]. This is where the higher diebase is effective.

However, other factors come into play also … the material and the ejection rubber. Various materials are just plain tough to cut … certain rubbers, fiber, polycarbonates, polyesters and PVCs, laminated stocks and abrasives. They certainly are pushing that rule around in their resistance to the cutting process. In addition, these materials are often hard to eject out of the die. One tendency is to load up the die with more ejection material. The ejection, having to go somewhere when it is compressed, pushes against the rules. This contributes to an out-of-spec die.

Dull Die

Of note also is a dull die. Not only does a dull die produce poor edge quality, but the increased pressure needed to cut also increases deflection, pushing tolerances out again [see Figure 7]. If you are starting with a sharp die, keep it sharp by protecting your knives from the steel cutting plate. To do this, lay a thin, protective sheet of 3 or 5 mil mylar on the plate, attached with spray adhesive. The Mylar is still hard enough to affect the hardness of the cutting plate, but will prevent you from taking the keen edge off of your knives. The result is a longer lasting, cleaner cutting die … and a diecut part that more nearly stays in tolerance. If you are soft bed cutting, use a material that is hard enough to limit knife burying. When you force the knives into the cutting surface, you drag the material into the grove. This causes a part that is over-tolerance, with a poor edge to boot. A material such as Delrin© or PVC, is hard enough to more emulate surface cutting. Keep it groove-free, by planeing or turning on a regular basis.

TIPS IN BUILDING DIES FOR PLASTIC MATERIALS

Let's look at a few of the tips we have learned over the years in building dies for these plastic materials [see Figure 8].

First of all, polyester (vinyl) is equally as tough, if not tougher than polycarbonate. Polyester is more tinsel than other materials. It actually shatters like glass upon impact. That is why you can always tell when someone is cutting polyester because you will hear a crack upon impact. The die is merely scoring the surface. The die is stopped dead in its tracks due to the density of the polyester. But the surface impact has caused the rest of the cut to crack clean through, much in the fashion that you cut glass. The thicker the polyester, the more cracking that has to take place. As a result, the edge quality of polyester greater than .010 tends to degrade when examined under a glass, simply because it was broken away instead of diecut. Your tonnage is less in cutting polyester since you are scoring the surface. For lower quantities of pure polyester material, we recommend a shave edge cutting rule. However if there are any abrasive materials present, or if the number of parts is substantial, shaved edge rule will not stand up, and your edge quality of the cut will greatly diminish.

Let's look at polycarbonate, the bulletproof material. It's a much different substance. I'm not a chemist, so I can't tell you its composition, but I do know that we spent many years tearing our hair out over diecutting this stuff. Because of its screen printability, compatibility to various adhesives, and other safety workability considerations, polycarbonate has become quite popular for producing a variety of components today.

Polycarbonate doesn't shatter as polyester will on impact. It will, however, also stop a steel rule die in its tracks. We have found a chemical reaction actually takes place when you violate the material with a cutting or creasing rule. It actually becomes pliable and gummy for a micro-instant, reacting to the heat generated by the cutting action. As a result, you have to fully penetrate the material, unlike polyester. We often recommend a long bevel and a ground edge rule. Polycarbonate reacts to a saw tooth cut. Ground edge rule has tiny surface serrations that tend to profuse as the rule breaks down. Edge quality actually improves after the die has been run several hundred impressions, and then may degrade after several thousand due to just plain dullness. The long bevel rule tends to overcome the resistance to penetration, making the "snowplow" effect less a deterrent to the diecutting process.

While the steel cutting rule is attempting to push the polycarbonate aside during the cutting process, the polycarb is pushing back. Since the stuff is tough, it easily forces the rules, resulting in out-of-spec and distorted parts [see Figure 9].

One method to address this problem is to do all your pushing toward the waste. This is accomplished by using side face rule with the bevel toward the waste. The tiny 3-7 thousandths bevel on the flush side usually produces an acceptable part with very little edge draft. We have found "flush bevel" (i.e., no bevel on the flush side) to be very ineffective due to the fragility of the cutting edge. Polycarb is so tough, it curls the edge over after very little use. If there is any abrasive materials present, forget it.

Often when the two bevels oppose one another in the waste area, you have created so much pressure that you not only distort the rule in the die,

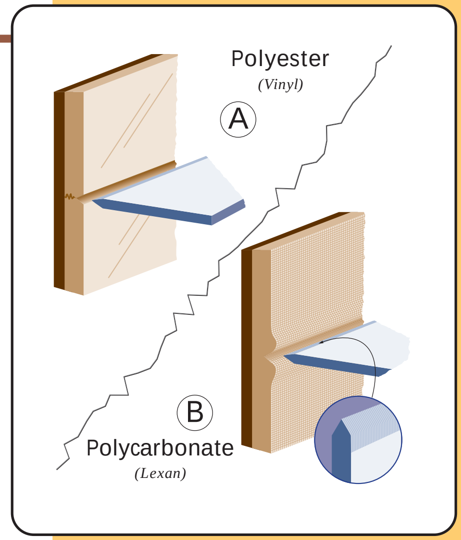

Figure 8

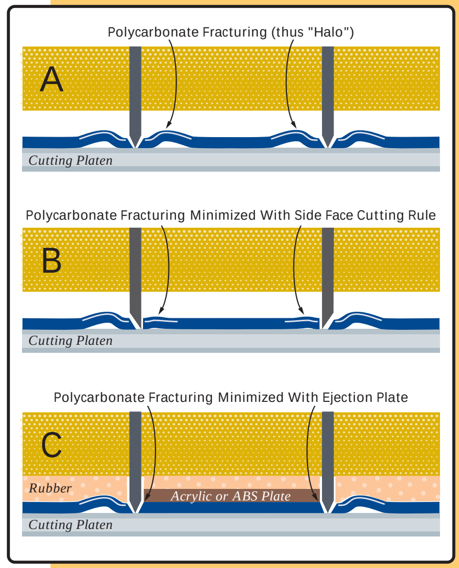

Figure 9

but cause a "crimp" in the part. The bevels are forcing the material toward itself with no place to go but up … thus the crimp.

Since the best approach is to hold the sheet as flat as possible during the diecutting process, we have instituted several techniques. One is the use of the ejector plate mentioned earlier. The plate is the first thing to contact the polycarbonate sheet, and it holds it absolutely flat as the rule penetrates the material. This process greatly limits crimping.

Wherever tiny ribs appear in the diecut part, they are susceptible to twisting, crimping, and distorting. In this case we insert thin strips of flat bar stock, often upside-down creasing rule, and spring load that with rubber ejectors, also. The steel bars hold the polycarb in place during diecutting of the ribs. As a result, with no place for the crimp to occur, a greatly improved part is the outcome [see Figure 10].

We have resisted welded joints. It draws out the temper, and there is often no way to get at the area to be welded. We will sometimes laser-cut a block area out on either side of the joint and insert a steel block to stabilize the joint area. We also may run a piece of flat stock such as low creasing rule, about six points wide, into the area at a perpendicular angle. We will "lock" that reinforcement rule from moving with "T" or "J" rules [see Figure 11].

Die Storage Conditions

The very best of diemaking techniques can be laid in shambles by the method used to store the die prior and between usage. One story I like to tell is about a close tolerance diecutter who was always pushing our outer limits in trying to get within +/-.002 on the die inspection reports. We did well overall, however the diecutter was getting as much as 20 mil variation on finished parts. We traveled north to see what the problem could be. His cutting equipment was pretty sophisticated, and his material quite stable. When we measured the dies in his plant, it was the tools that were 20 mil out of spec. Yet we had verification that these same tools were within a couple thousandths within our plant. Puzzling? Then he showed me his die storage area. He proclaimed it was state-of-the-art. Die storage bins were selected by computer. The bins were mounted on a ferris wheel type contraption. This device would rotate on up into the ceiling in a 60 ft. high silo. He was proud to tell me how much floor space he was saving. However it was a metal silo, uninsulated. On a warm day, one pass with a frozen pizza and it was cooked on the return. He was literally "cooking" his cutting dies. Not to mention freezing them solid on cold winter days. Do we now have a clue why these dies were out of tolerance? Remember, most diebases are wood, and wood contains moisture. If you dry it out, freeze it, or add more moisture, you will get some dramatically changed readings.

And please avoid the floppy bookshelf method of storing dies. Standing them up on end, while the pressman flips them from side to side looking for his pick of the day, just subjects those keenly sharp knife edges to brutal terror. Consider the hanging "J" bar method of suspending dies in the air, where one does not touch the other [see Figure 12]. A few simple removable pins are all that are necessary in the die to facilitate this very effective method of storage. Keeping your dies well protected in both atmospheric and abrasive situations, will lend to longer die life and a cleaner, more precisely cut part.

CONCLUSION

While the box-making diemaker must adhere his processes to a rigid set of standards as dictated by the requirements of sophisticated presses used in that industry, the specialty diemaker must be aware of the wide variety of circumstances that may be encountered in building dies for a variety of industrial applications. The diemaker's skills are continually challenged, as the steel rule die is brought into practicality for industrial situations where perhaps the tool was never before used.

It becomes exciting, stimulating and most challenging for the industry as a whole. ■

For further information, contact Allen Gurka at 413-589-9965 or email at diesrus@earthlink.net

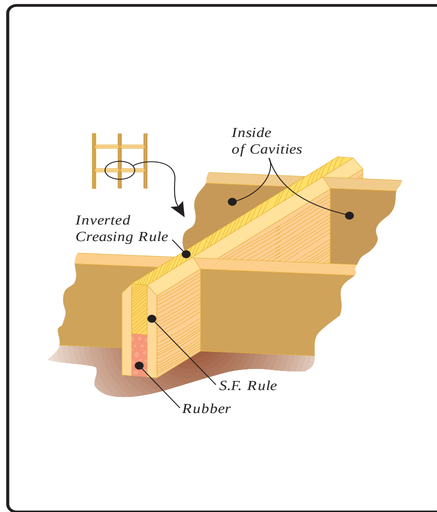

Figure 10

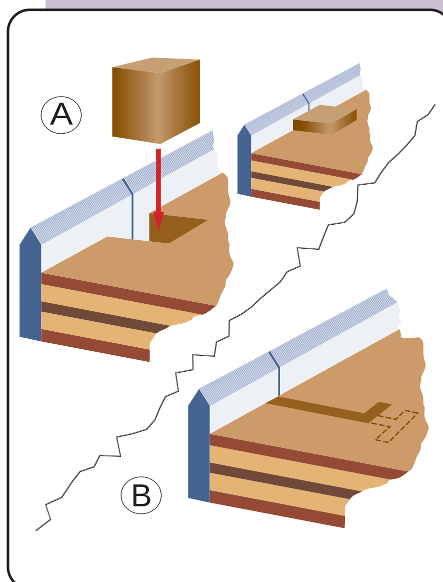

Figure 11

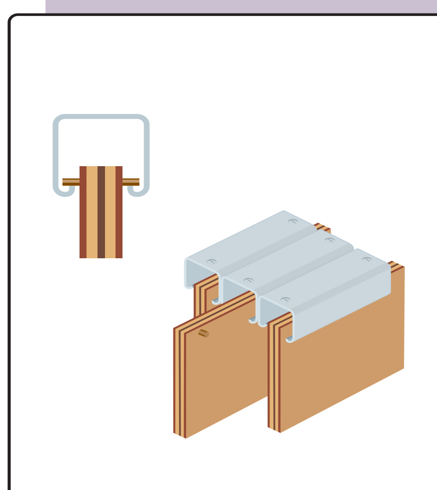

Figure 12