The
ABC's of Diemaking & Diecutting

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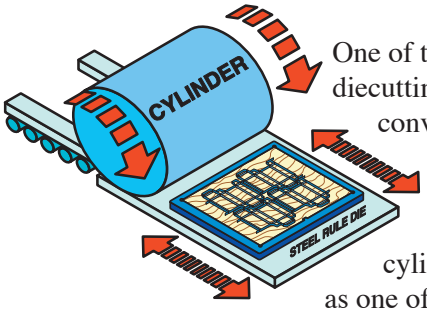
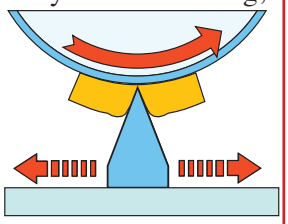
The Importance of Mixing Knife Bevels in Cylinder Diecutting.

"If you take risks you may still fail. But if you do not take risks, you will surely fail. The greatest risk of all is to do nothing." *Robert Goizueta*



One of the earliest forms of diecutting evolved from the conversion of a Letterpress Cylinder Printing Machine into a Diecutting Press. Gradually, the cylinder diecutter emerged as one of the most productive methods of converting sheets of material into finished products.

However, the productivity and the quality of the diecut parts are compromised by a characteristics of cylinder diecutting, which many believe is impossible to overcome. This problem is the uneven distribution of pressure in this form of diecutting.

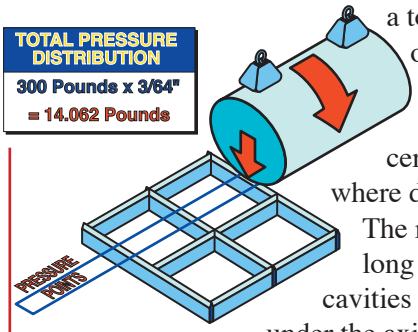


The cylinder diecutter is composed of large steel cylinder, which rotates, carrying a sheet of material to be diecut, and a flat steel die, mounted on the metal bed, which reciprocates backward and forward under the cylinder. ***See above***.

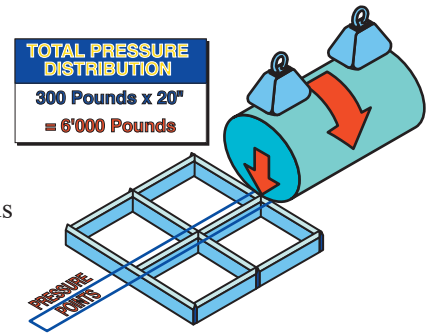
As the sheet is gripped and rotated around the cylinder the steel die is sequenced to trap the sheet of material against the rigid cylinder surface, cutting and creasing the material. ***See above right***. But what is the key problem?

The Pressure Distribution Problem in Cylinder Diecutting

As the cylinder rotates the steel rule die, with four cavities positioned under the cylinder so the three knives running in the machine direction are in contact with the cylinder surface. Using the standard industry formulation for calculating steel rule knife pressure, the total pressure on the total length of each knife in contact with the steel cylinder surface, 3/64", is multiplied by 300 pounds per inch, to give a total of almost 15 pounds of pressure. ***See left***.

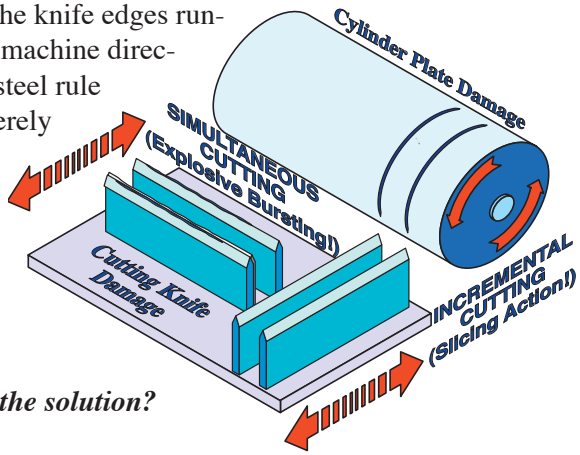


15 pounds of pressure is certainly not excessive, so where does the problem arise. The real difficulty is when the long knife between the four cavities is positioned directly under the axis of the cylinder so the full length of the 10-inch knife is in contact with the surface of the cylinder. Using the standard industry formulation for calculating steel rule knife pressure, the total pressure on the total length of this knife in contact with the steel cylinder surface, 20", is multiplied by 300 pounds per inch, to give a total of more than 6,000 pounds of pressure! ***See right***.



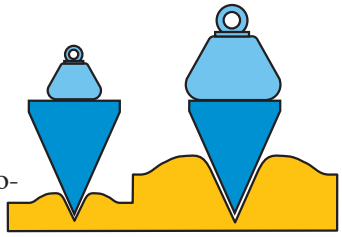
Now we have our problem!

Clearly the press must be made ready to cut all of the knives so they completely penetrate the material. As it requires 6,000 pounds of pressure to cut the longest lengths of knives running in line with the axis of the cylinder, the knives running in the machine direction, or around the cylinder, are subjected to the same degree of pressure. The results are disastrous. The knives cutting around the cylinder gradually indent and severely damage the cylinder anvil surface, ***see right***, and the knife edges running in the machine direction in the steel rule die are severely compressed, swaged, and damaged. ***See right***.

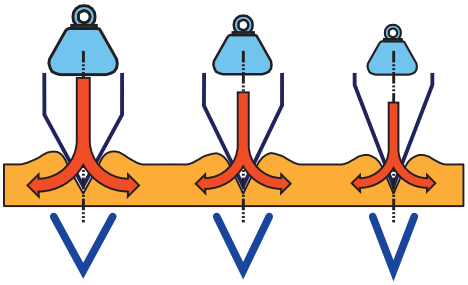


So what is the solution?

The Solution to the Cylinder Pressure Imbalance?

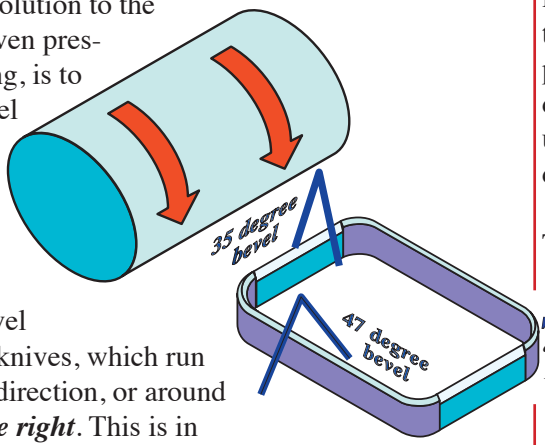


Understanding where pressure comes from also derives the path to the solution. Clearly diecutting is a displacement process in which the penetration of the knife wedge into and through a material generates great resistance in the material to this separation force, which generates the ***"pressure"*** we talk about in diecutting. The greater the caliper of the material, the greater the degree of displacement, and the higher the amount of pressure required to diecut. ***See above***.



However, this pressure can be adjusted and controlled. If the bevel angle of the knife is lowered, the amount of displaced material is obviously less, and the overall pressure required to diecut is reduced. ***See above***. In the same way, if the bevel angle of the knife is increased, the amount of displaced material is obviously increased, and the overall pressure required to diecut is much higher. ***See above***.

Therefore, the solution to the problem of uneven pressure in diecutting, is to use a lower bevel angle for those knives which run parallel to the axis of the cylinder, and to use a higher bevel angle for those knives, which run in the machine direction, or around the cylinder. ***See right***. This is in reality increasing resistance on the knives cutting around the cylinder and lowering resistance on those knives cutting parallel to the cylinder axis.



While this may seem a radical departure from traditional methods, this technique is simple, it is highly effective, and it generates improved diecut quality, with less waste and greater consistency of tool performance.

Summary

"The greatest challenge to any thinking is stating the problem in a way that will allow a solution." *Bertrand Russell*

This may seem an unusual remedy to those who have been running cylinder presses for many years. However, it is important to point out, this is not difficult to accomplish in terms of modifying the design of the steel rule die, and to press performance. Nor is it complex in terms of improved diecutting quality, of minimizing nicking and sheet break-up, and in significantly lowering steel rule die knife edge damage. This is hard to ignore.

This is simple, it is effective, and the results will amaze you.

Sound Diemaking Principles

"Leadership is the ability to translate vision into reality." *Warren G. Bennis*

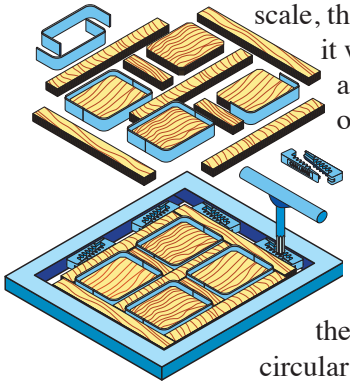
In the late seventies the pinnacle of diemaking technology was focused by an inspired innovator, Ray Miller, into a unique system of toolmaking manufacturing in Elkhart, Indiana. Through this decade Miller had single-handedly revolutionized the process, the business, and the professionalism of the diemaking industry. His technical curiosity, his drive to be the best, and his belief in an open, ethical, and in a fiercely competitive marketplace, led him to invite a small

emerging company to examine his outstanding manufacturing operation in detail. Shortly after he welcomed my partner and I, into his very impressive and deliberately intimidating office, he predicted we were going to be very successful in the United States, and we would emerge as one of his primary competitors!

The Challenge

He gave us a complete and comprehensive tour, he held nothing back and he answered every one of the endless questions we had. However, his competitive nature came to the fore as we were walking though an area containing the last remaining diemaker's circular saws. Ray turned and challenged me: ***"You told me you were a block diemaker, and a good one!"*** I assured him I was but with less confidence than I had felt before. He continued; ***"Can you precisely trim a panel just by the sound of the blade on the wood."*** I nodded, knowing I had just been painted into a corner.

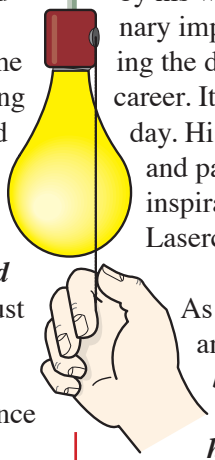
When making block dies it is necessary to set the distance between the side gauge of the saw and the blade with a scale, then cut a test piece and measure it with a vernier, and finally by adjusting the side gauge in or out, setting the correct width. The experienced diemaker would set the initial distance a little large and then position the front edge of the previously cut test piece between the side gauge and the revolving circular saw blade. As the gauge was incremented inward the sound the blade made as it began to bite into the wood would grow in volume. Just by listening to the pitch of the blade and the volume of the sound, a good diemaker could determine if the new setting would remove 0.002, 0.003", 0.005", or whatever dimension was necessary to achieve the correct width. Cutting a second piece of wood was considered to demonstrate a lack of skill and ability and would leave you open to ridicule!



Without delay Ray cut a test piece on the saw, I measured it, and then he asked me how much smaller I would like the piece. I told him, he adjusted the saw by sound only, trimmed the piece and handed it back to me. Naturally he got it right and he did so in several more tests. The we changed places and the process was repeated. Fortunately, I held my end up and after we had confused several of the people watching us, we recommenced our tour. As we walked toward the next area he said with a huge smile; ***"Now I am worried, you really are a good block diemaker!"***

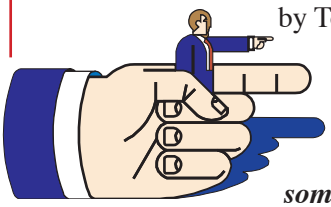
Summary

I had known Ray Miller by his reputation, by his writing, by his presentations, and by his extraordinary impact on the Diemaking Industry. However, spending the day with this man was one of the highlights of my career. It is difficult to quantify how much I learned that day. His generous advice, his openness, his enthusiasm, and particularly the vision he had for our industry were inspirational as we began to build and consolidate Lasercomb America.



As we left I asked him how I could thank him. He answered; ***"There are really no secrets in this business, when you get your company to the point you feel it is organized, have an open house for the rest of the industry."*** Three years later we followed his excellent advice.

Writing this all these years later I am reminded of a quote by Tom Peters: ***"Life is pretty simple: You do some stuff. Most fails. Some works. You do more of what works. If it works big, others quickly copy it. Then you do something else. The trick is always to be doing something else."***



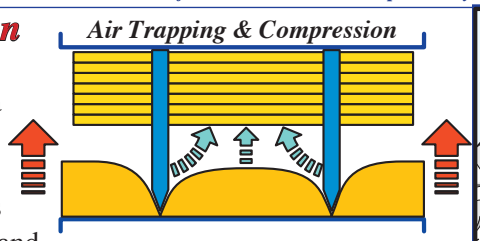
Dieboard Venting to Increase Press Speed & Improve Product Quality

"The key to successful leadership today is influence, not authority." *Kenneth H. Blanchard*

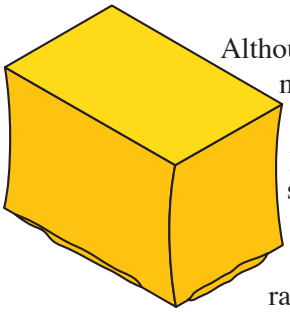
In diecutting there are many factors which can both improve and or undermine press productivity and product quality. One of the most potentially complex problems, which can change the shape of a part, which can generate a poor cutting profile, and which can cause inconsistent cutting, is air compression. Air Compression & Trapping is a frequently overlooked problem in high speed diecutting because there is no evidence of its impact, other than the diecut sheet breaks apart. However, its role and its impact is very real!

 Contact Kevin @ **1-909-337-6589 - 1-909-273-0958 cell**

Air Compression

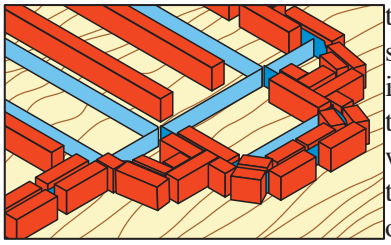


Air compression is a serious and complex problem in platen diecutting. As a press reciprocates and traps the material against the surface of the steel rule die, each panel of the die is filled with air. As the material is depressed onto the cutting knives in the die, and as the knives begin to first compress and then penetrate the material, the air trapped in each die cavity is compressed as the space it occupies gets smaller and smaller. ***See above***.



Although the compression of the air will not prevent the press completing each cycle the diecut part will display all the hallmarks of a product suffering severe distortion during diecutting. This will include wall concavity, shape distortion, and a ragged lower cutting profile. ***See left***.

In this instance it is not possible to fill the panels with a material to prevent the air being trapped in the first place as the full depth of the cavity is needed to accommodate the part as it is diecut. Therefore, the solution is venting.

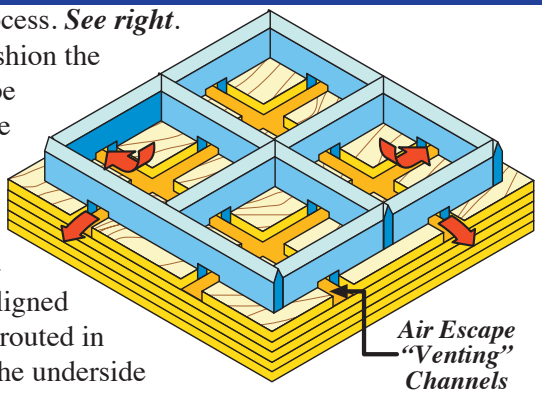


One of the more common practices is to add a couple of ejection strips to each large open panel in a design/layout. ***See right***. While this helps with pressure balancing and regulating draw and tensile stress in the diecut sheet, which of course helps to reduce the degree of sheet break-up, it ignores the primary problem of air compression and air management.

Venting

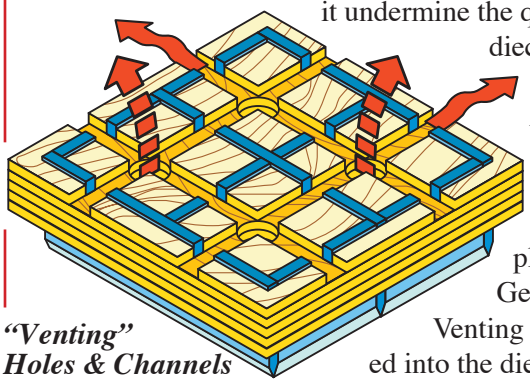
Venting simply means modifying the dieboard so the air has escape routs strategically located so that when air is compressed into an open panel in the design or the layout, there are outlets in the panel to enable the air to escape as it is forced into the cavity.

This can be done one the surface of the dieboard where routed channels in the top veneers can be aligned with the bridges in the steel rule allowing the air to escape during the cutting process. ***See right***.



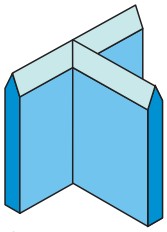
In a similar fashion the dieboard can be modified so the air can escape through shafts drilled into each cavity which are aligned with channels routed in the veneer in the underside of the dieboard. ***See below***. These vent holds can be integrated into the flex channels added to the dieboard to prevent the plywood base warping.

These simple modifications to the standard dieboard will ensure that air, trapped in each cavity during the cutting cycle, will neither undermine the cutting process nor will it undermine the quality of the diecut part.

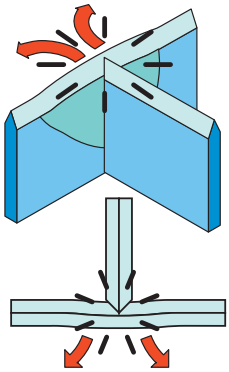


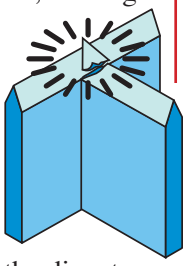
Adding venting channels and escape holes is a perfect application for the Gerber Profiler as Venting can be integrated into the die program.

Reinforcing a Miter Joint

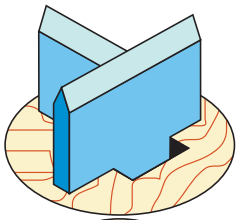


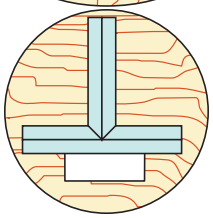
The most common joint in diemaking is formed be machining a section of knife away from one end of the steel rule to produce a protruding lip of knife edge, which when butted against the side of the knife it is joining, forms a continuous cutting edge. ***See right***. In most instances this configuration works well and is resistant to most forms of joint failure, however, when diecutting very dense, elastic, or a high fiber material, the stress of diecutting can cause the joint to flex under diecutting load.





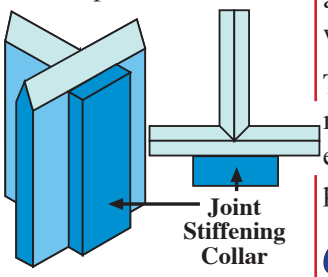
This is usually in the form of knife flex where the knife being joined flexes away from the miter knife, ***see above***, to create an ugly tag in the diecut part, or it can cause the miter to fracture and to fail. ***See right***.

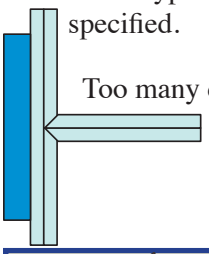




The solution is to add a gap in the die design at miter joint points, ***see left***, to accommodate a collar made from 2 point or three point thick creasing rule, ***see below***, designed to stiffen and protect the joint under diecutting stress.

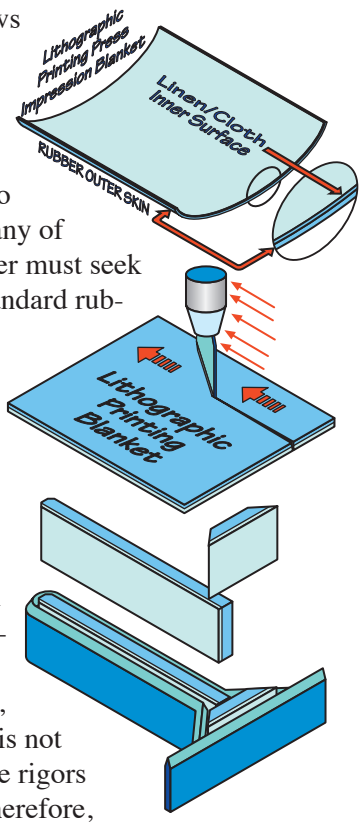
This works very effectively and should become a standard operating procedure when cutting precision components out of very dense, fibrous, or elastic materials. It is vital the specification for steel rule die manufacturing contains all of the standard joint configurations, but also all of the non-standard techniques designed to solve the type of problem specified.





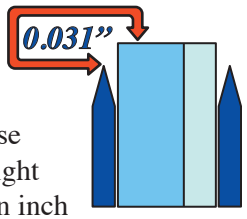
Too many diemakers are unaware of all of their joint protection options, even when using something as standard and as simple as the basic miter joint.

Lithographic Printing Blanket Ejection



The ejection discipline follows a simple 80-20 rule in that eighty percent of the process is simple and non critical but 20 percent of the process is complex and very important to on-press performance. For many of these applications the diemaker must seek alternative materials to the standard rubber products.

There are many incidents of narrow slots or acute angles in a normal steel rule die layout, and although the skill of the diemaker will ensure perfect jointing and cutting performance, the rubber used to eject the diecut part can severely undermine tool performance. For these applications, the standard rubber materials is not strong enough to withstand the rigors of high-pressure diecutting, therefore, the diemaker must seek alternative materials. Cutting strips from discarded lithographic rubber and canvas printing blankets makes one of the most effective ejectors.



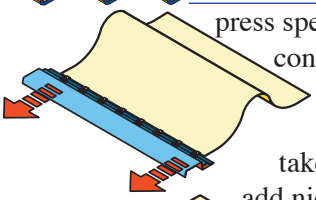
These strips are usually cut on a tangential plotter and are set to protrude above the cutting edge of the knife by 1/32 of an inch. (This material is so dense when used in this manner setting the height above the edge at the standard 1/16 of an inch would generate too much resistance.) ***See right.***

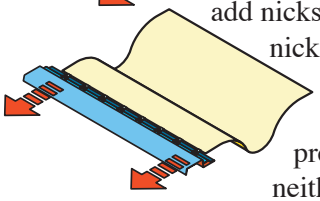
This material is considered by many professional toolmakers as the greatest secret in diemaking as it is such an effective ejector. It is simple to use, it is easy to shape, and it performs exceptionally well.

Question: Why does keeping the sheet flat improve Nicking performance?

"Leadership is a manager's ability to get subordinates to develop their capabilities by inspiring them to achieve."
John A. Reinecke

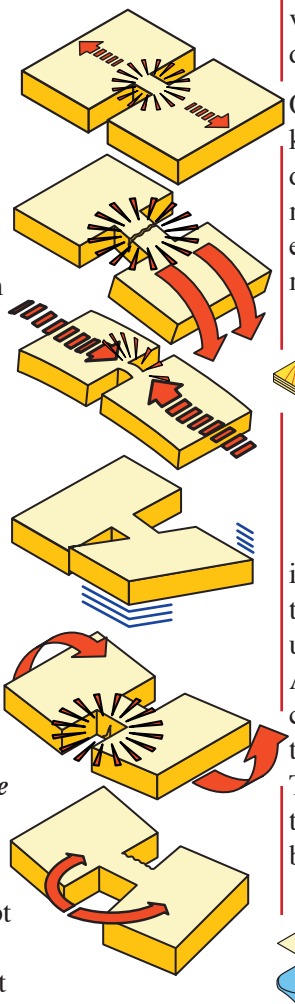
Who or what controls press speed? Clearly the press does. After concluding a make-ready the operator will increase





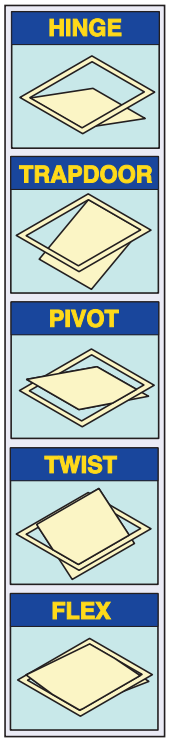
press speed until the sheet begins to consistently break apart. He or she feels they have two choices. Set the press at the reduced speed it takes to keep the sheet together, or add nicks, or increase the size of each nick ground into the edge of each knife? The correct solution to the problem of maximizing press sped and yield is of course neither of these defeatist alternatives. The secret of maximizing press speed is to minimize stress on the diecut sheet by eliminating stress, by minimizing sheet surface friction, and by eliminating all snagging points, which stress and fracture the nick/tags holding the diecut parts together.

The most pragmatic solution is to keep the sheet as flat as possible from feeder to delivery.



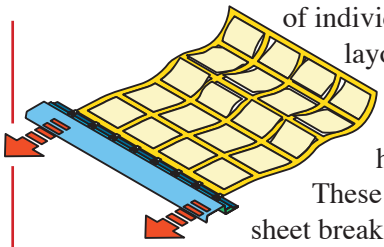
Sheet Stress Factors

When a sheet is diecut and accelerated from press unit to press unit it is subjected to a variety of stresses. These include upward flexing as the sheet is brought to a sudden halt in the stripping and blanking units, or downward flexing, caused by gravity as the sheet dips into the gap between tools. ***See above***.

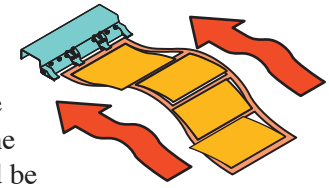


This rapid acceleration and equally abrupt deceleration, the distortion of the diecut sheet, and the flow of air around and through the diecut parts, puts considerable strain and stress on each nick tag. ***See above***. Note how these illustrations show flexing of each nick/tag as a primary source of failure, in addition, to the generally accepted factor of tensile stress.

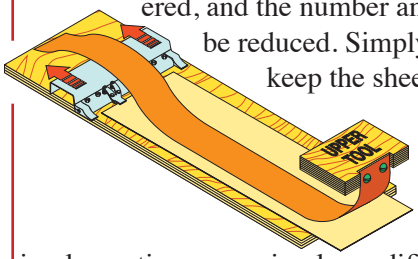
However, the factor which generates more sheet stress and sheet break-up is the flexing of individual diecut parts within the layout, ***see left, bottom of previous column***, and the flexing of the diecut sheet which has the same effect. ***See left***.



These represent the source of most sheet break up as the diecut sheet is accelerated across from the platen into the stripping tool and from the stripping tool into the blanking section of the press. Naturally, all of the cavities in each lower tool, and the gaps between tools and each press section, provide a dangerous obstacle course for the diecut sheet, particularly if individual parts are twisting, and the sheet is flexing upward and downward. ***See below***.

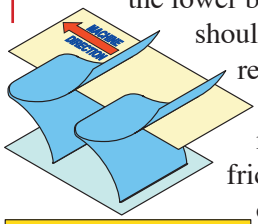


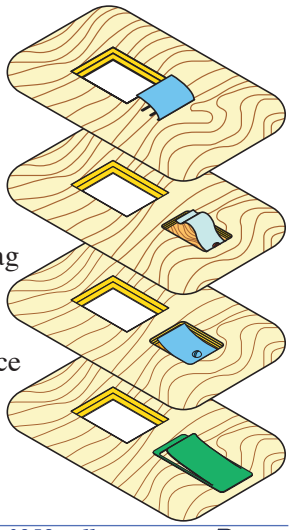
Obviously if it were possible to keep each individual part and the diecut sheet as flat as possible, the majority of sheet break up would be eliminated. The press could then be run at optimal speed, material wastage and down time would be significantly lowered, and the number and the size of nicks could be reduced. Simply stated, the solution is to keep the sheet flat at all times!



Sheet Control Tools

The stress on the diecut sheet is controlled by implementing some simple modifications to the press and to the tools. Both the male stripping unit and the male blanking unit should incorporate brakes or sheet pressers. ***See above***. At the outlet from the platen and from the stripping unit, a combination of a brake and a lower lifter should be installed to smooth out and realign individual diecut parts. ***See below***. This is called a funnel and operates in a similar fashion to the press brush mechanism. Finally, both the lower stripping tool and the lower blanking grid should be fitted with recessed flyers, ***see right***, to minimize the friction and the drag on the sheet as it is pulled across the surface of each tool.

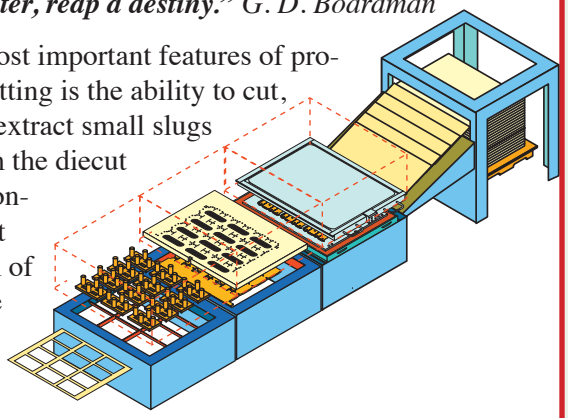




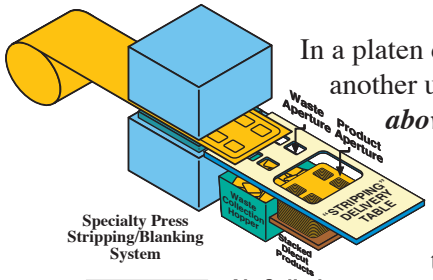
If you want to maximize press speed, keep the sheet flat!

Question: What is the Purpose of a Bolster Plate in Platen Diecutting?

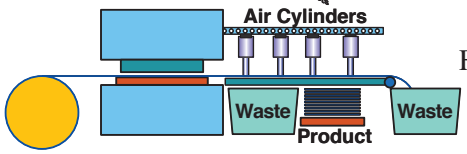
"Sow an act, reap a habit; sow a habit, reap a character; sow a character, reap a destiny." *G. D. Boardman*



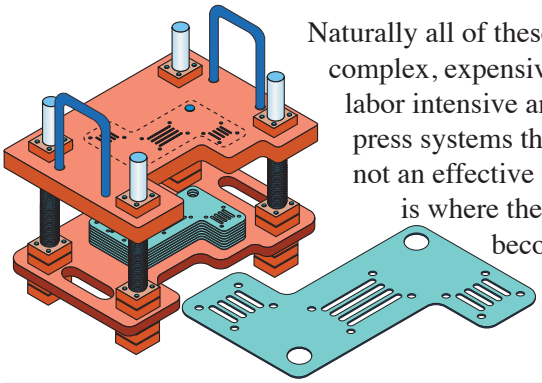
One of the most important features of productive diecutting is the ability to cut, remove, and extract small slugs of waste from the diecut part as it is converted. In fact in every form of diecutting the stripping or the efficient removal of waste from the diecut part as it is processed is the Achilles Heel of the process, and it makes the difference between profitability and loss. Many processes attack this problem by transporting the diecut parts & the waste areas of the web or material to another area for processing or ***"stripping."***



In a platen diecutter this can be another unit in the press, ***see above***, and on a specialty press the stripping unit can be integrated into the delivery table. ***See left***.

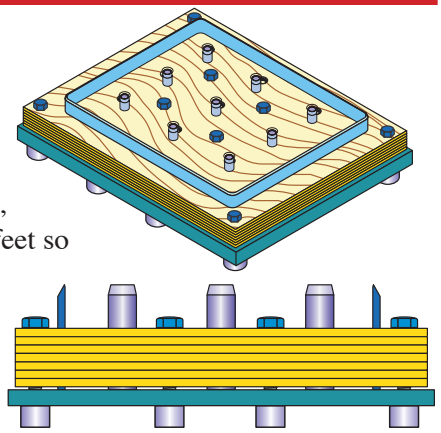


For some presses stripping the waste parts may require the creation of a special off-press, hand-operated fixture, which can strip several stacked components simultaneously. ***See below***. In the worst possible scenario parts can be individual removed by hand in what is obviously a very unproductive manner.

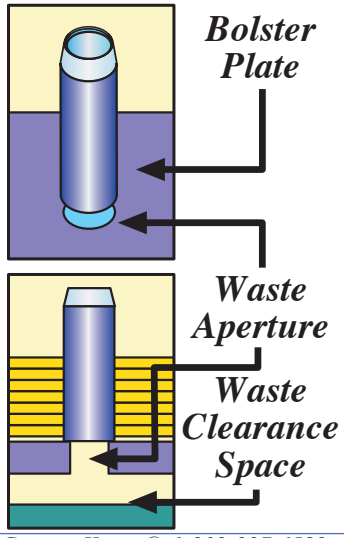


Naturally all of these options are complex, expensive, and/or labor intensive and for many press systems they are simply not an effective option. This is where the Bolster Plate becomes a life-saver.

The Bolster Plate

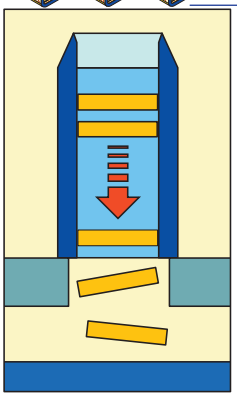


The Bolster Plate is a rigid steel plate which is mounted to the underside of the die, using spacer blocks or feet so there is a gap between the back of the tool and the surface of the bed the tool is resting upon. ***See right***.



The steel plate is machined with apertures, which align perfectly with each punch cavity in the die and the punch or steel rule shape, which is inserted into the dieboard. ***See left***.

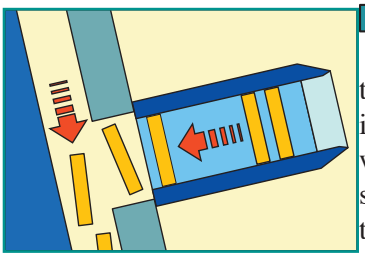
When the die and the bolster plate are joined together, the base of the punch set in the dieboard is resting upon the bolster plate with the internal tube in the punch aligned with the



slightly larger aperture in the bolster plate. ***See left***.

Stripping is now greatly simplified. As each impression is taken and each slug is driven down through the internal cavity in the punch by each successive impression, the waste slugs are eventually pushed all the way down through the punch and the bolster plate.

These waste slugs simply fall into the gap between the tool and the bed of the machine, ***see below***, where gravity takes over, or they can be extracted more efficiently using a vacuum system. As a precaution it is not unusual to countersink the rear of each bolster plate cavity, ***see below left***, to ensure each waste piece has maximum clearance so it can fall free from this combination tool.



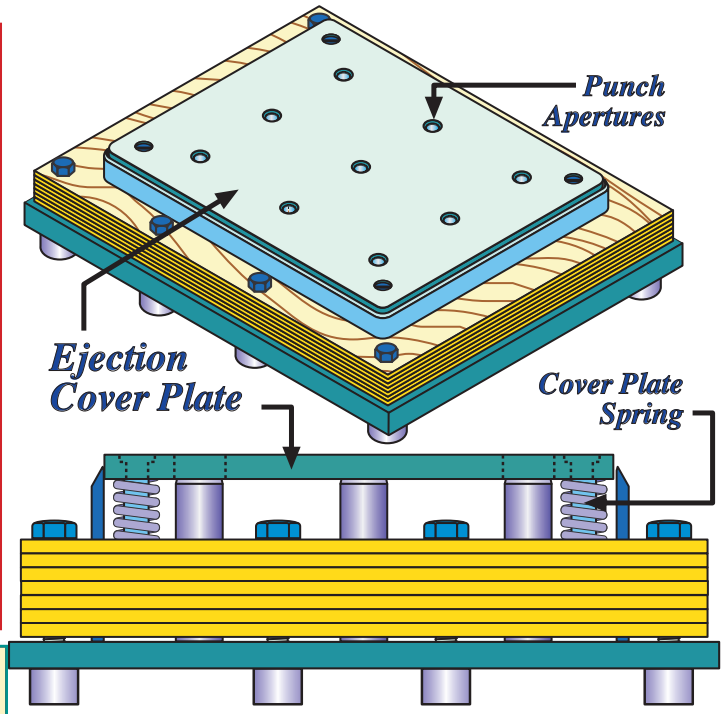
However, countersinking is restricted if it weakens the bolster plate, particularly where there are concentrations of extraction holes in one area of the tool.

Another often-used application is to integrate a stripping or ejection plate into the bolster plate. This is a piece of steel plate which is machined to precisely follow the inside profile of the steel rule die and is set on spring-loaded fixtures bolted through the die and into the bolster plate. ***See top of next column.***

This provides a highly efficient ejector, which reduces part diecutting distortion, it eliminates the flexing of the steel rule when using standard ejection rubber, and it provides a powerful ejection force which remains consistent for the length of the production run.

Summary

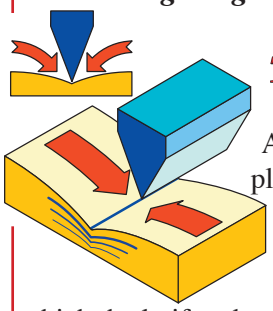
The Bolster Plate is one of the most common methods of integrating a stripping device into a steel rule dieboard. Clearly it is not designed for every process, however, where it can be used it is simple to design and fabricate, it is easy to install, and it is effective in use. The answer to the question of what is the purpose of the bolster plate in diecutting is straightforward. It allows the removal of internal waste with minimal effort and with an inexpensive addition to the steel rule die. The last word on the subject should be to state that the securing of a bolster plate to a steel rule die not only stiffens the die, the integration of the two tools improves diecutting performance, and enhances the quality of the diecut part.



The Productive Benefits of Mixing Knife Bevels in a Steel Rule Die

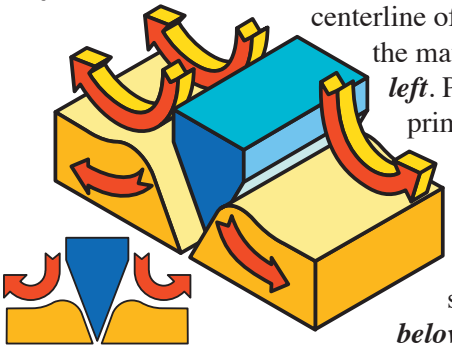
"Any activity becomes creative when the doer cares about doing it right, or better." *John Updike*

The Principles of Diecutting

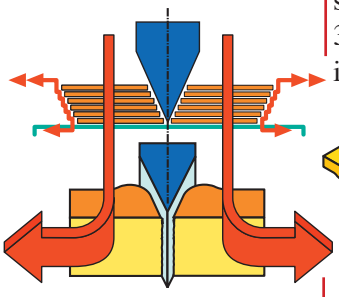


Although it is common to describe the platen diecutting process as a cutting action, the knife is in reality a sharpened wedge. The cutting action is actually a combination of pinching pressure, in which the knife-edge depresses and eventually fractures the surface of the compressed material. ***See left.***

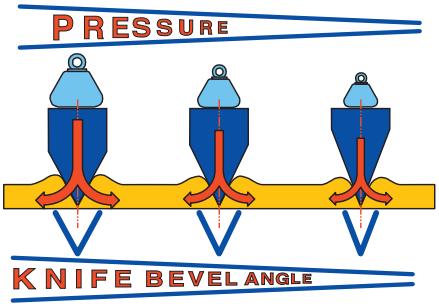
As the compressive force of the knife edge continues downward, the sharpened wedge is driven vertically into the split in the surface and gradually the bevel faces of the wedge, drive/displace the material laterally away from the



centerline of the knife-edge, until the material splits apart. ***See left***. Platen diecutting is primarily a displacement action in which the vertical pressure of the blade is converted into a lateral splitting action. ***See below right***.



In diecutting, pressure is actually a measurement of the resistance of a material to penetration and separation by a knife with a specific bevel angle. Therefore, as the bevel angle is increased, the pressure required to diecut also increases, and when the bevel angle of the knife is decreased, the pressure required to diecut is also lowered. ***See below***.



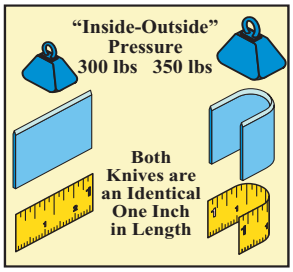
Therefore, choosing a specific knife with whatever bevel angle machined into the steel strip sets a specific pressure loading for the steel rule die. This pressure setting may be effective, however, there are many instances where the selection of a knife bevel is critical to on-press performance, and mixing knife bevels is essential to ensure quality and consistency of output.

There are basically 10 reasons to mix knife bevel angles in the steel rule die. These are:

1. ***Inside/Outside Diecutting***
2. ***Pressure Leveling & Balancing***
3. ***Eliminate Flaking & Delamination***
4. ***Strengthen Nick Holding Power***
5. ***Knife Concentration Compensation***
6. ***Kiss Cutting Control***
7. ***Faster Material Penetration***
8. ***Improve Cut/Crease Performance***
9. ***Eliminate Pressure Ridging***
10. ***Improve Scoring Performance***

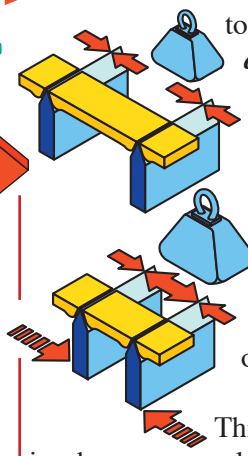
The Benefits of Mixing Knife Bevels

These are the key benefits in diemaking and in diecutting of mixing and integrating different bevels of knife in the same die.



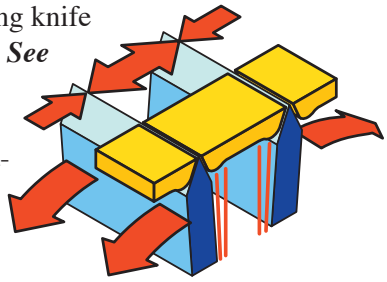
01 Inside/Outside Diecutting

The Standard calculation for pressure in diecutting states that for every linear inch of knife 300 pounds of pressure is required, however, when the same inch of knife is bent into a "U" shape, the pressure required to diecut has risen to 350 pounds. ***See above***.



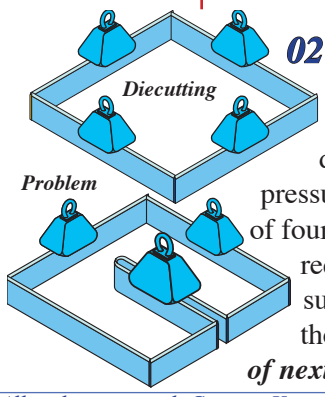
This is because as knives are moved closer together the material which must be pushed lateral from each knife displacement action is unable to compress to absorb the penetration of the wedge, and the pressure to diecut increase, ***see left***, and/or the knife blades deflect outward. ***See left.***

This is called inside/outside pressure and it is why a narrow slot in a rectangle requires more pressure to diecut than the surrounding knife on the perimeter of the part. ***See below left***.

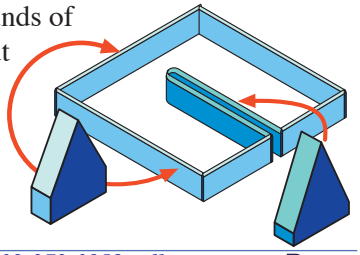


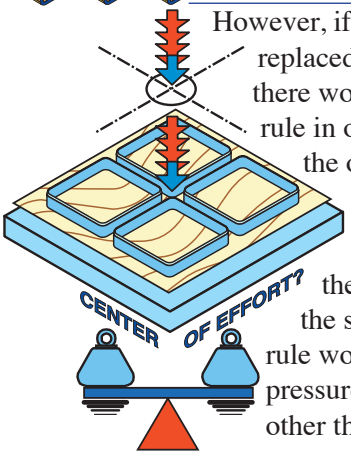
The pressure build up in cutting the narrow slot is because of the proximity of two knife bevels compressing the material between the blades. The solution is to use a much lower knife, just for the slot rule. ***See below right***. This is a perfect example of where mixing knife bevels is the only effective solution for this type of problem

02 Pressure Leveling & Balancing



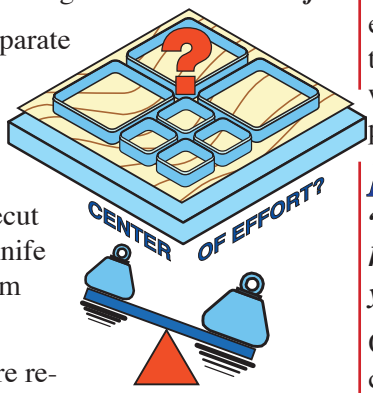
Given that for every inch of knife in a steel rule die demands 300 pounds of pressure, a balanced layout of four rectangles would require the same pressure to diecut each of the four parts. ***See top of next page, column 1.***





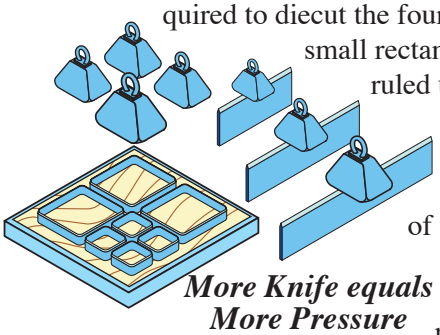
However, if one of the rectangles were replaced with four smaller rectangles, there would be a greater amount of rule in one segment of the die than in the other three. ***See below right***.

This would create severe problems for the diecutter as the pressure required to diecut the segment of the die with more rule would be much higher than the pressure required to diecut each of the other three segments. ***See below left***.

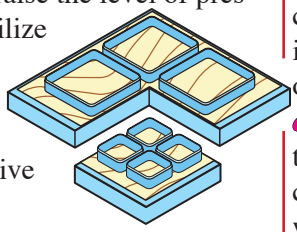


As the diecutter is unable to separate the application of pressure for the two halves of the die, ***see below right***, the diecutter will experienced considerable difficulty getting the design to diecut evenly, and in preventing the knife edges in one part of the die from being severely damaged.

As before to reduce the pressure required to diecut the four small rectangles they must be ruled using a lower bevel of knife, with a higher bevel of knife being used for the balance of the steel rule die. This will lower the pressure on one section and raise the level of pressure on the other, to balance and stabilize the pressure across the steel rule die. ***See top of next column.*** As before this is a perfect example of where mixing knife bevels is the only effective solution for this type of problem.

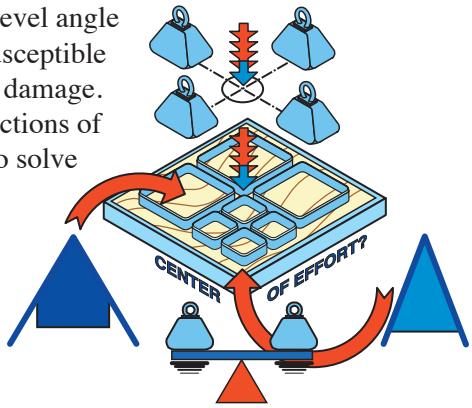


More Knife equals More Pressure



Summary

Many diemakers and diecutter have been taught incorrectly that mixing knives and knife bevels is a mistake, however, the opposite is true. Mixing knife bevels in the manner described and in the other examples in this series is often the only effective solution to balance diecutting pressure, to convert good quality parts, and to eliminate rapid damage to the cutting tool. The reason, however, we do not use a lower bevel knife for the entire steel rule die design, is the lower the knife bevel angle the more the tip is susceptible to compressive edge damage. Therefore, we use sections of lower bevel knives to solve specific diecutting problems, while the balance of the die protects these low bevel knives from over-compression.



If you are not mixing different bevels of knife in the same dieboard you are missing an important technical advantage which will simplify make-ready, which will improve diecut part quality, and which will protect the effective cutting life of the steel rule die.

Education: The Foundation

"You should have enough education so that you won't have to look up to people; and then more education so that you will be wise enough not to look down on people."

One of the most frequently asked questions directed at a consultant is what is the most important thing they can do to improve performance? The answer is as obvious as it is critical. ***"Get everyone to know what everyone already knows!"*** This may seem trite but it is one of the most powerful and yet simple solutions to performance variation. One of the key problems every company faces is the variability in knowledge, skill, and experience between members of the same team.

Our unstated base line goal in manufacturing is ***Procedural Uniformity and Performance Parity***. Before employing a consultant, before spending money on expensive training initiatives, and before experiencing another frustrating day of poor performance, consider this simple solution. ***"Get everyone to know what everyone already knows!"*** Everything is already in place. If everyone had similar knowledge, comparable skills, and shared competence, the organization would be world class.

Summary

"It's what we learn after we think we know it all that counts." *Kin Hubbard*

The effective organization is based upon an internal customer-supplier chain, it is based upon mutually supportive problem solving, it is based upon education and training derived from cooperative trouble shooting, and it is based on team building and an alignment of critical goals and competence.