The
ABC's of Diemaking & Diecutting

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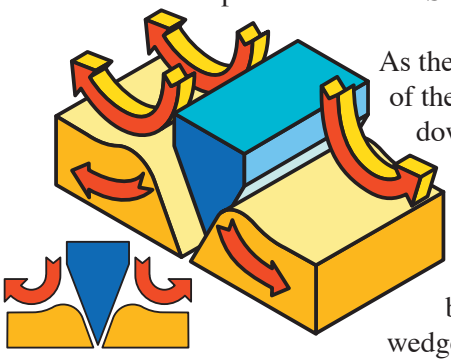
The Productive Benefits of Mixing Knife Bevels in a Steel Rule Die

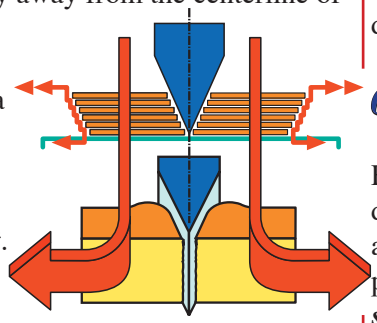
"Any activity becomes creative when the doer cares about doing it right, or better." *John Updike*

The Principles of Diecutting

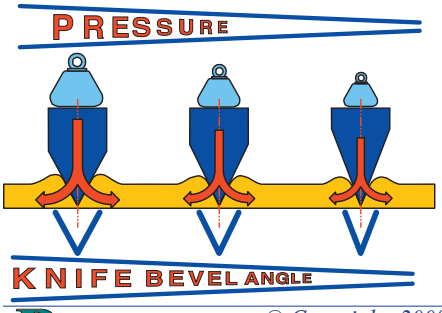
Although it is common to describe the platen diecutting process as a cutting action, the knife is in reality a sharpened wedge. The cutting action is actually a combination of pinching pressure, in which the knife-edge depresses and eventually fractures the surface of the compressed material. ***See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



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 above***. Platen diecutting is primarily a displacement action in which the vertical pressure of the blade is converted into a lateral splitting action. ***See 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 left***.



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.

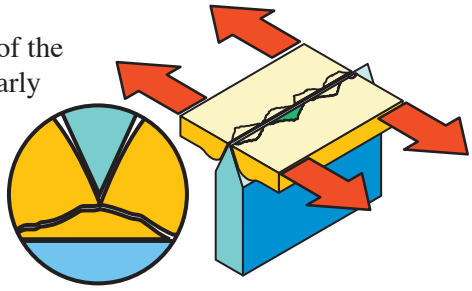
There are basically 10 reasons to mix knife bevel angles in the steel rule die. These are:

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***

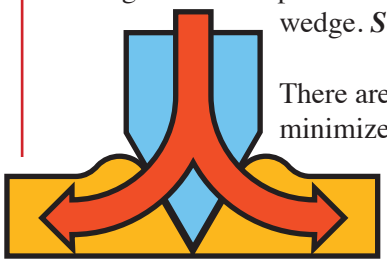
The Benefits of Mixing Knife Bevels

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

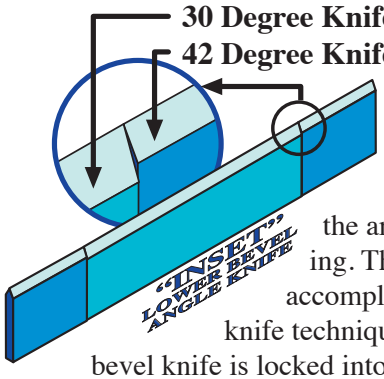
03 Eliminate Flaking & Delamination



Flaking or chipping of the diecut edge, particularly at right angles to the paperboard grain, ***see right***, is caused by premature lateral separation of the paperboard in the final stages of the displacement action of the cutting blade/wedge. ***See left***.

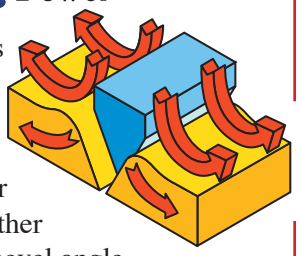


There are various remedies designed to minimize or prevent flaking, however, the most effective is to attack the root cause of the problem, excess lateral displacement.

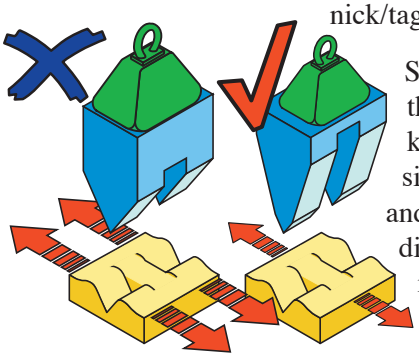


The solution is to reduce the lateral displacement force which is causing premature shearing delamination by lowering the bevel angle of the knife in the area where flaking is happening. The most effective method of accomplishing this is to use the inset knife technique where a section of lower bevel knife is locked into position in the dieboard. ***See above***. As before this is a perfect example of where mixing knife bevels is the only effective solution for this type of problem.

04 Strengthen Nick Holding Power

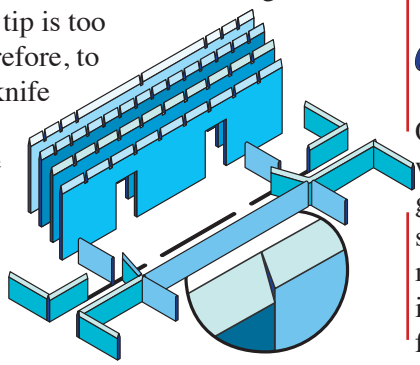


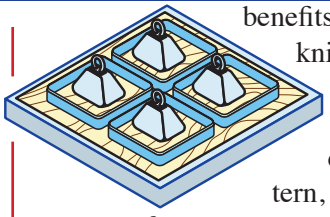
The primary source of nick failure is the displacement action generated by the sharpened/knife wedge as it penetrates and pushes the material simultaneously away from the center of effort of the knife. ***See right***. In other words it is the bevel action and the bevel angle of the cutting knife which puts the greatest stress on the nick/tag.



Simply stated the greater the bevel angle of the knife, the higher the tensile stress on the nick/tag, and the weaker that tag is in diecutting. Therefore, the most effective method of strengthening the holding power of the nick/tag or making the tag as small as possible is to use the lowest knife bevel angle possible. ***See above***.

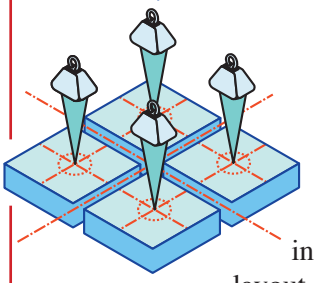
The reason this narrow knife bevel angle is not used throughout the dieboard is the lower the bevel angle the more susceptible the knife tip is too compressive damage. Therefore, to integrate low bevel angle knife at the specific point of the profile of the design where nicks will be positioned, the inset knife technique is again used. ***See right***. This is simple, it is effective, and it combines the



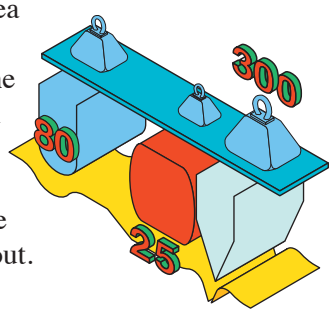


benefits of the standard bevel angle of knife, for cutting support and stability, with the low bevel angle knife at the nick locations, with different variants of nicking pattern, and different knife edge types.

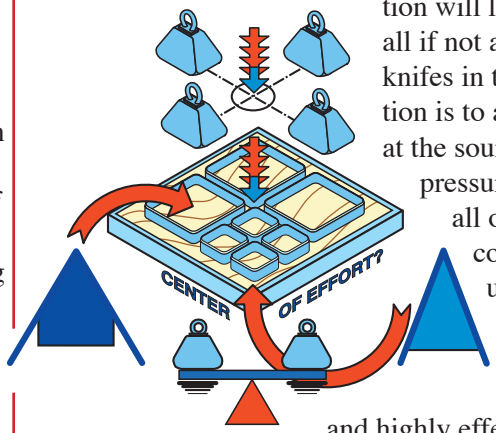
05 Knife Concentration Compensation



The perfect layout in terms of pressure distribution and balance in diecutting would be a four square layout, ***see left***, in which each quadrant of the die has the same linear inches of knife. However, it is not uncommon to have one area of the layout with a concentration of knife.. Which based on the formulae of 300 pounds per inch of knife, ***see right***, results in one part of the layout requiring a much higher degree of pressure then other areas of the same layout.

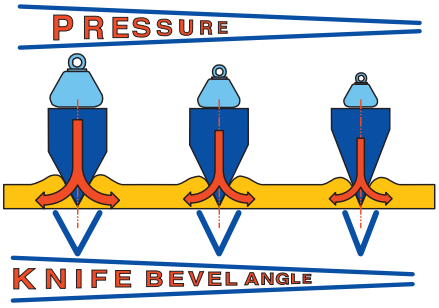


It is obviously impossible for the diecutter to segment the cutting anvil, and adding patch-up compensation will lead to damage to all if not a majority of the knifes in the die. The solution is to attack the problem at the source by lowering the pressure needed where all of the knives are concentrated, by using a lower bevel angle of knife. ***See left***. Simple, straightforward, and highly effective.

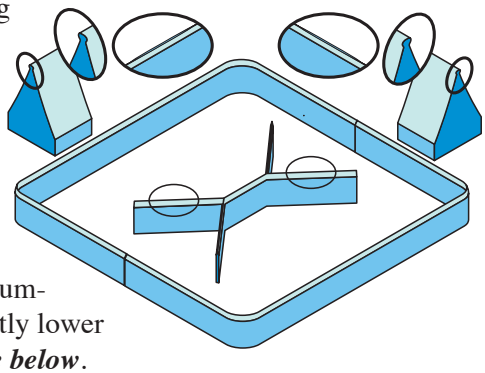


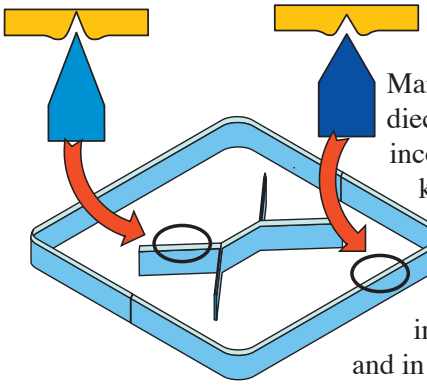
06 Kiss Cut Control

One of the primary goals of platen diecutting is to kiss cut with minimal pressure. This principle behind this practical goal is simple. If the knife penetrates with minimal pressure, the amount of lateral draw and displacement will be minimized, the degree of material bevel penetration ridging will be eliminated, and the knife-edge will be protected from compression damage. ***See first column, next page***.



This is particularly important where there is an internal cut in a design, which can only be verified as the consumer uses the carton or container. As a result these internal cuts are over-pressurized to ***"make-sure"*** they are fully cutting, unfortunately this action results in the very knife edge damage which leads to poor cutting performance. ***See right***. As before, the most effective solution is to use a lower bevel knife for internal cuts, and even experiment in special circumstances with a slightly lower height of knife! ***See below***.





Summary

Many diemakers and diecutter have been taught incorrectly, that mixing knife 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 as 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. Now go and mix those bevels in the next die!

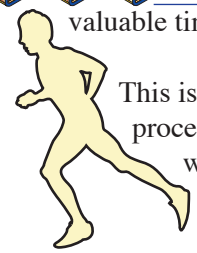
In Manufacturing: Seconds Count!

"We must remember that one determined person can make a significant difference, and that a small group of determined people can change the course of history." *Sonia Johnson*

Time is at once the most valuable and the most perishable of all of our possessions, and in manufacturing, this means every second counts! The secret of effective manufacturing is contained in the mission directive Safety, Speed, Quality, and Cost. ***See above***. Using this focus it is clear speed of processing is the dominant discipline, with cost being an equal partner. However, in the production environment talking about cost has little relevance to day-to-day activity, therefore, cost in manufacturing is converted to time management or time competition.

This is further refined and turned into a pragmatic and understandable improvement tool by using a basic and a consistently applied measurement of a specific time block. In numerous time and motion studies it has been demonstrated that even the simplest action takes one tenth of a minute or six seconds. This means that every step, every reach for a tool, and every basic movement will consume six seconds of

valuable time.



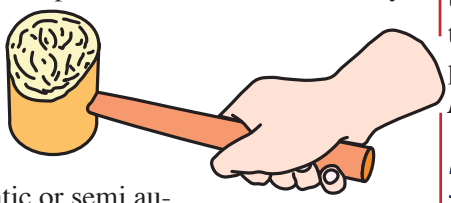
This is a valuable measurement tool as each process is standardized or stabilized because without a universally accepted method of time measurement and time analysis performance becomes highly subjective. As Horace Mann wryly pointed out: ***"Lost, yesterday, somewhere between sunrise and sunset, two golden hours, each set with sixty diamond minutes. No reward is offered for they are gone forever."***

Every Step is Six Seconds!

The Diemaker's Toolbox: The Bar Plate Rule Setter

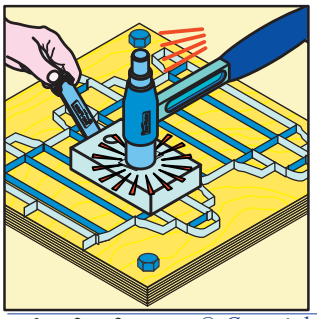
"In great matters men show themselves as they wish to be seen; in small matters, as they are." *Gamaliel Bradford*

In the rush of technology into the ruling discipline it is easy to forget that every steel rule bent or processed must be inserted into a dieboard and the ultimate customer assessment of tool performance is often predicated on how effectively this task is performed.



In most operations steel rule shaped in the traditional manner or fabricated by an automatic or semi automatic rule processor is inserted by hand using a traditional hide or plastic mallet. The disadvantage of this approach depends upon if the diemaker is right or is left handed. Whichever hand is used the head of the hammer will rapidly degrade on one side, ***see above***, and the rule insertion action is compromised. Not only is this bad for the rule and for the die application it puts severe stress on the hand, wrist, and forearm of the diemaker.

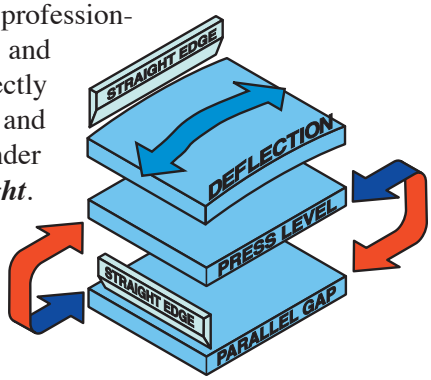
Fortunately, the Bar Plate Company developed a simple but highly effective tool which inserts the rule evenly, it minimizes plywood/kerf damage, it seats the rule squarely, it is far less stressful on the user, and it produces a higher quality finished steel rule die. The planer is made from a block of non-mar composite plastic which is attached to a simple handle. After the rule is started in the normal manner the planer is used to drive the rule into the dieboard. ***See left***. This is a highly effective tool which is particularly important to be used as the last task of the diemaker to go across the entire steel rule die and plane every knife level. ***For more information call Bar-Plate at 1-800-356-9940***



The Importance of Bend Relief

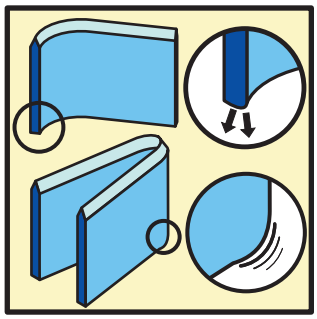
"A little neglect may breed great mischief ... For want of a nail, the shoe was lost; for want of a shoe, the horse was lost; for want of a horse, the battle was lost; for want of the battle, the war was lost." *Benjamin Franklin*

The entire focus of a press make-ready is to generate a perfect kiss cut impression with minimal pressure and the elimination of any knife edge damage. The goal of the diemaker and the diecutter is to gradually refine the tool-making and the make-ready process to eliminate any factor, which could undermine a fast, a simple, and a stable set-up. The assumption of both professionals is the platen surfaces and the steel rule die is perfectly level, precisely parallel, and resistant to deflection under cutting pressure. ***See right***.



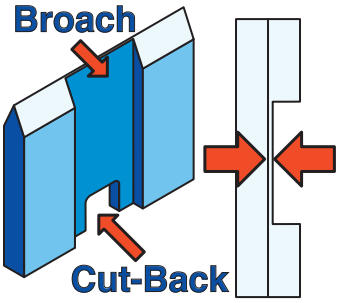
However, there are many factors in both the steel rule die and the diecutting press,

which can undermine kiss cut perfection. One key factor, which often remains hidden is the deviation caused by the distortion of steel rule as it is shaped.

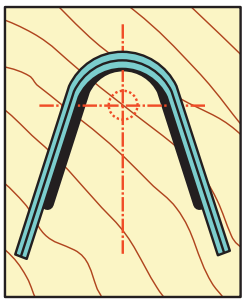


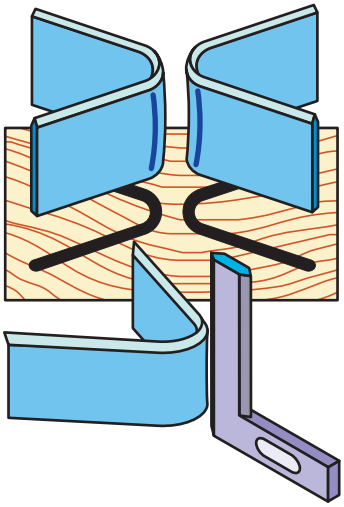
Steel Rule Distortion

As steel rule is shaped the material on the inside of the bend is compressed, while that material around the outside is obviously stretched. In practice this results in a swaging at the base of the rule, which causes the bend point to be lifted and the height of the knife increased. ***See above***. This can be eliminated by either broaching, by a lower rule cut back, or by a combination of both techniques. ***See left.***



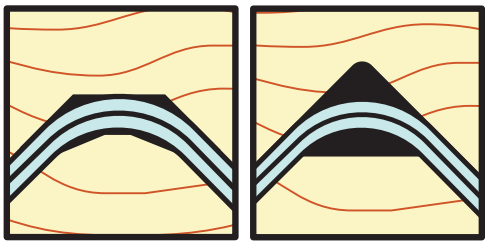
In addition, as the rule is shaped, depending upon arbor condition and hardness of the metal strip, the radius generated in the knife rarely matches the curvature of the kerf profile cut into the plywood diebase. ***See right.*** When this is combined with the lateral distortion of the bent shape, ***see below***, caused by knife dish, by arbor wear, or by an inconsistent hardness between the bottom and the top of the steel strip.





This mismatch between the finished shape and the lasercut profile will generate many diecutting problems. These can include knife-edge damage at the bend point; dieboard warping caused by tension between the knife and the kerf, stacking, and poor seating of the cutting blade.

All of these problems can be eliminated, by simply cutting a bend relief shape around every bend point in the dieboard. ***See right***. This is a highly effective and universally recommended practice as it solves so many problems and it has no disadvantages. Any professionally made dieboard should contain bend relief for all of the bent knife shapes. Failure to do so provides the diecutter with a tool, which is already doomed to fail.



Diecutting Paperboard Moisture Problems?

"Put your heart, mind, intellect, and soul even to your smallest acts. This is the secret of success." *Sivananda*

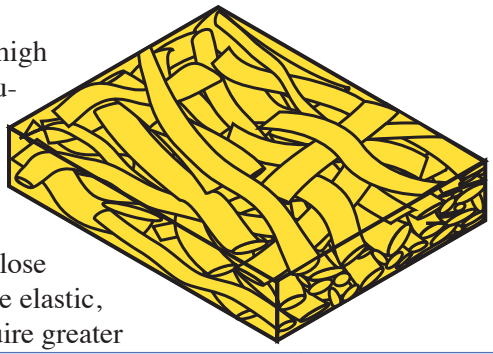
There are always unknowns in every converting production cycle. The product, the process or the material, can generate these unpredictable variables. One of the primary goals in manufacturing is to use every production cycle as a test and as an opportunity to gain a more complete understanding of gray areas of the process. Every production cycle yields new information and reveals important secrets to the careful observer.

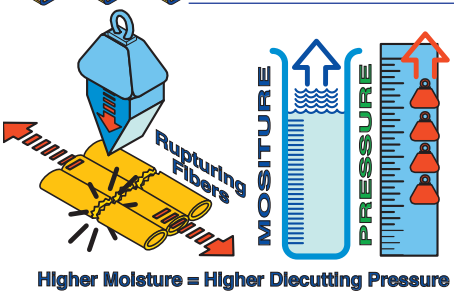
One of the most common frustrations for the paper, the paperboard, or the fluted diecutting technician is the unpredictability of converting performance from one pallet of material to the next, or from one web of paperboard to another. It is even more frustrating when the operator knows he or she has minimal control over the potential variation and little is being done to solve this perennial problem.

Although there are a number of paperboard attributes, which could be responsible, the primary culprit is generally moisture content, or more accurately a moisture content outside of the range the press was made ready to accept.

The Impact of Moisture Variation

When moisture is high the individual cellulose fiber which are the building blocks of all paper products, ***see right***, the cellulose fiber becomes more elastic, and therefore, require greater

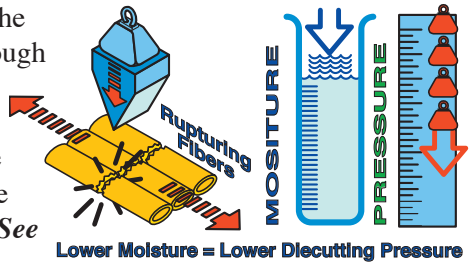




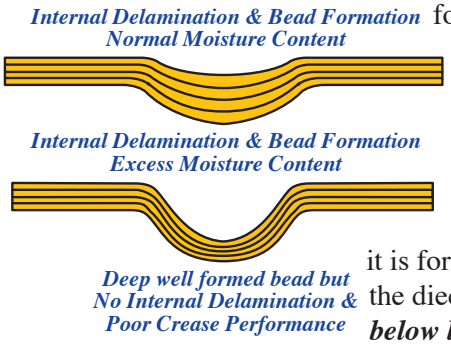
pressure to diecut. ***See left***.

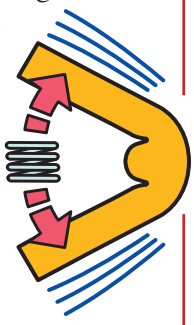
Obviously, if the moisture content is reduced and the cellulose fibers become more brittle, it requires less pressure to diecut. ***See below***.

The strange part of the problem is that although increased moisture makes cutting more difficult it makes the formation of a crease bead much simpler. ***See below***.

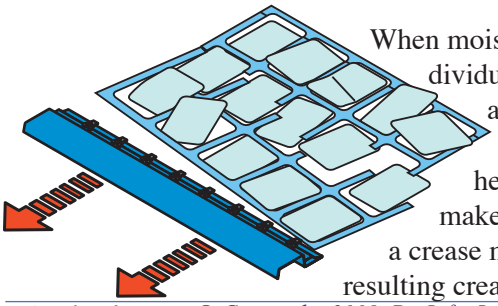


However, because the crease is formed in this way it can be folded with minimal force but it is very difficult to open later during cartoning. ***See below right***. By contrast the more moist the sheet, the harder it is for the nick tags to hold the diecut parts together, ***see below left***, and a drop in stiffness increases the complexity of stripping and blanking.

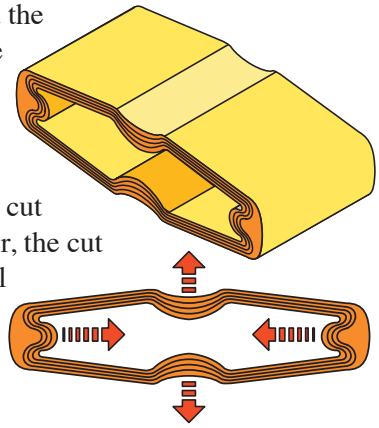




If moisture is increased from one load to the next, the cutting impression needs more pressure to penetrate the material. However, in making the necessary adjustment, if the next load is back to the original moisture content, the pressure is too high, and the knife-edges in the die are severely damaged.



When moisture is low the individual cellulose fibers are brittle and easily snapped, which helps in cutting but makes the formation of a crease more difficult. The resulting crease will require higher levels of force to fold the panels and the opening force in the container will be excessive. ***See right***.



The bottom line is if there is more moisture it is harder to cut and easier to crease, however, the cut is clean. If the moisture level is too low, it is easier to cut, but more difficult to generate a good crease and the cut will be ragged.

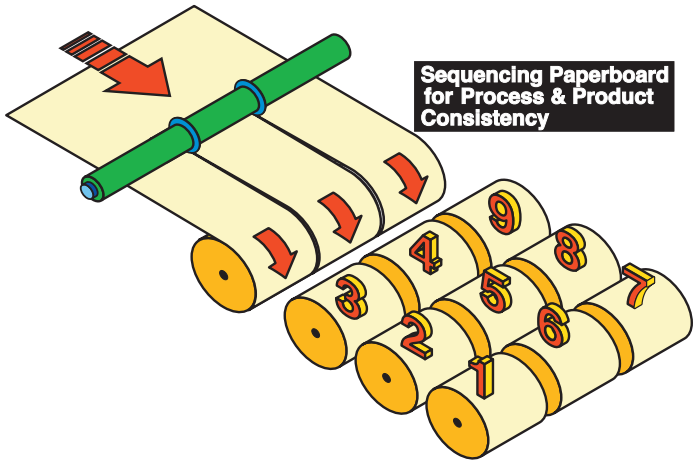
It is clearly impossible for the diecutter to change the moisture content of the material supplied from the mill; however, there are two key actions, which could be taken to reduce the impact of variability.

Paperboard Sequencing

Water is not only a primary ingredient of the papermaking process, it is also essential in forming the bonds between each fiber, therefore, moisture is important to the finished product. The problem for the diecutter is the variation from one load to the next.

The first step is to ensure during make-ready the sheets being used to set the cutting impression are representative of the entire production run. This means taking several sheets from as many of the loads waiting to be diecut as possible, and integrating them into evaluating the cutting impression to ensure the make-ready is an accurate representation of the entire batch of material. This may be arduous but it is effective.

The second action is to follow the recommendation of the paper manufacturing association and sequence the paperboard. ***See below***.



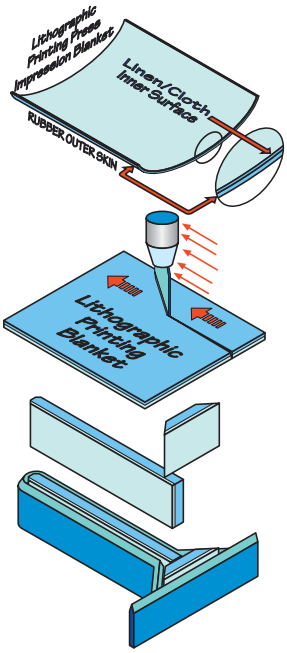
This simply means as the wide log of paper is reeled and cut at the end of the paperboard machine, the cut reels are marked and used in a specific sequence. This is intended to ensure whatever moisture, caliper, or density variation there is, is even distributed through the entire production lot.

Summary

Moisture variation generate very real problems for the diecutter, however, it is a function of every production cycle. As a result it is often a primary cause of low productive output and high material waste, but it can also be used as a crutch to explain bad performance. Moisture variation is an important factor of working with paper materials and to minimize on-press variation the paperboard should be sequenced consistently, and the make-ready should integrate a wider selection of representative material.

Splitting Litho Blanket Ejection

"I claimed to have controlled events, but confess plainly that events have controlled me." *Abraham Lincoln*

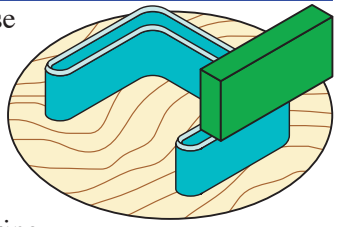


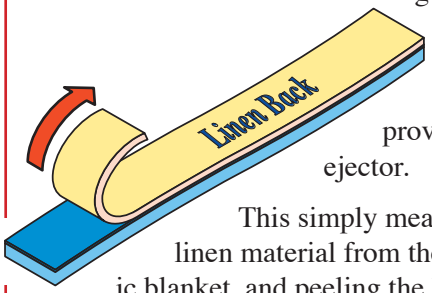
There are more than fifty types of ejector and associated materials used in toolmaking for the diecutting process. One of the most effective toolmaking materials is obtained by cutting lithographic printing blanket into strips, and using these strips on edge in the die, to provide one of the most effective ejectors for narrow slots. ***See left***.

Lithographic Printing Blanket Ejectors

The advantage of this material is it is a very precise combination of a layer of very consistent rubber supported by layers of linen support materials. Another advantage is the blanket is a disposable item in the printing process and is generally discarded after it begins to wear and degrade. However, the degree of wear, which renders the blanket unsuitable to the printing process, is undetectable when applied to the ejection process, and it is free!

Litho blanket ejectors are amongst the most effective, they are simple to prepare and to use, and they perform flawlessly on-press. However, there are applications where this material, or the standard alternatives, as thin as it is, is to wide to fit into applications where the steel knives are very close together. ***See right***. In these circumstances, where most ejectors are either difficult to machine consistently, or they are difficult to insert in between the knives, or they are too weak to withstand the stress of diecutting, a simple modification to the standard thickness Litho blanket can provide a remarkable stable ejector.

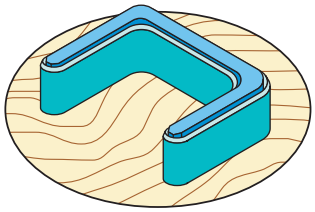




This simply means splitting a layer of linen material from the back of the lithographic blanket, and peeling the layer from the balance of the material, leaving the rubber layer. ***See above***. This is simply cut to length and inserted into the die to provide an effective and very powerful ejection system. ***See below.***

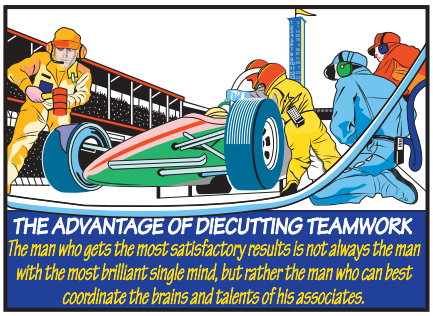
Summary

Although it is not recognized as a potential ejection material, the use of discarded lithographic printing blanket for the diemaking process provides a powerful, a versatile, a flexible, and a very effective on-press ejection device.



Diecutting Slack Time Projects

"The successful organization has one major attribute that sets it apart from unsuccessful organizations: dynamic and effective leadership." *Paul Hersey*



Diecutting is like the Indianapolis 500 Motor-Race. ***See left***. A hectic time trial, a race against the clock, driving as fast as possible, and desperately avoiding any potential crash and break-up. The difference between diecutting and the auto race example is the next race begins as soon as the previous one ends. And there are no awards, no champagne, no victory podium, no applause, and no rest! However, there are occasionally periods where the volume of work is moderate and even short times when there is no work at all.

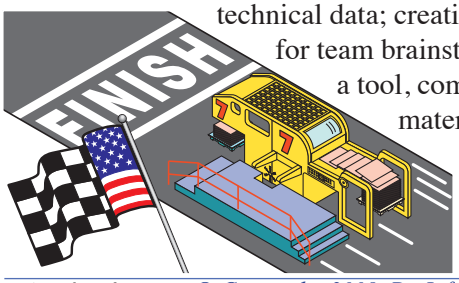
Although you may be forgiven for thinking this is a time to rest, in fact it is a time to work twice as hard! This precious time should be used to make the next production race simpler, faster, less stressful and more efficient. The problem is few companies plan for these periods and as a result this valuable time is squandered on non-critical activity.

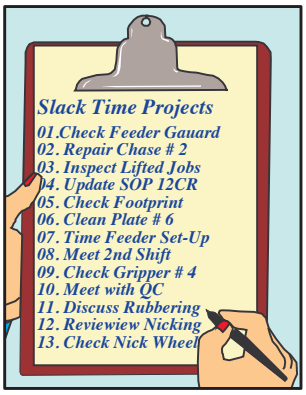
Professional companies have contingency plans for slack times and immediately implement a prioritized list of activities and scheduled projects, already allocated to individuals and teams.

What can we Do?

The usual response to unplanned downtime is to do housekeeping, clean everything and anything, and even perhaps oiling the diecutting press. However, this is to causal, it is poorly organized, and it is generally non-productive. Therefore, it is important to plan for these times by creating groups of activities for both individuals and for teams.

For example, process administrative functions could include; consolidating records and purging logbooks for key technical data; creating a list of questions for team brainstorming; conduct a tool, component, parts and material inventory; and reviewing the previous periods quality issues. Process improvement initiatives could include; reviewing and updating standard operating procedures; researching steel rule die and paperboard tonnage; updating the press footprint and calibrating the underlay; re-organizing the press work station; timing, testing and updating benchmark time standards; testing crease and paperboard parameters: and auditing other diecutting areas which are still producing.





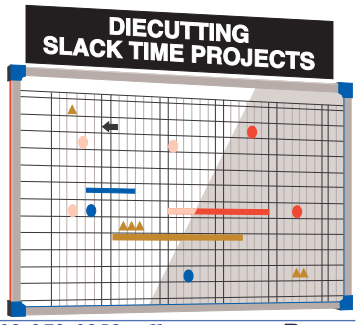
Training initiatives could include; training & cross training; brainstorming problems and seeking solutions; organize inter-shift meetings and evaluate ideas and suggestions. System Maintenance could include; testing guards and safety equipment; reviewing crisis and emergency procedures; inspecting and repairing or reporting on damaged press components; and maintaining and re-painting the equipment. Naturally, production tools such as steel rule dies, counters, patch-up sheets, strippers, guillotines and blankers could be inspected, repaired, reworked and re-stored.

The bottom line is there is an immense amount of preparatory work to do but it must be pre-planned in advance of any opportunity.

Summary

Anyone who has been involved in press make-ready or production understands there is never enough time. As a result, things get put off or put to one side to be dealt with, ***"when there is time?"*** It is essential all of these projects and opportunities are prioritized and organized with the same urgency and attention to detail applied to a customer order.

Waiting until the often-unexpected slack time arrives and trying to get everyone organized into a productive activity is too late. There should be a scheduled board of activities, actions, and projects displayed in the press area, just waiting for the opportunity to be executed. This saves more time, eliminates unnecessary dialog, and clearly defines duties and responsibility, in readiness to maximize slack time productivity.

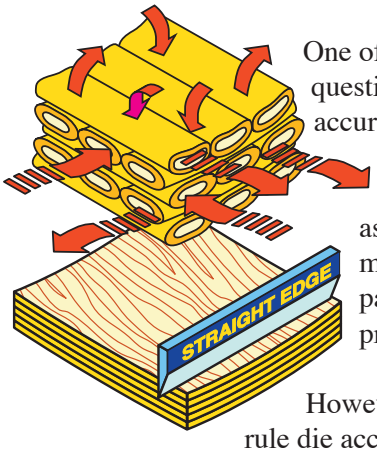


"The more we do, the more we can do; the more busy we are the more leisure we have." *William Hazlitt*

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

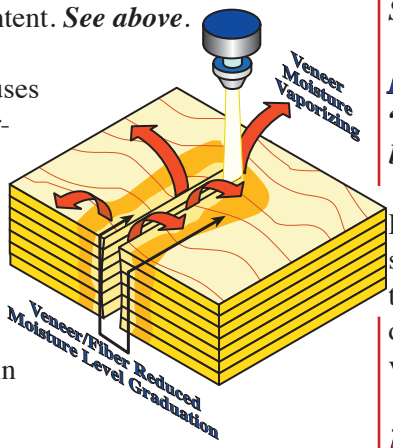
Dieboard Shrinkage

"Once we accept our limits, we go beyond them." *Einstein*



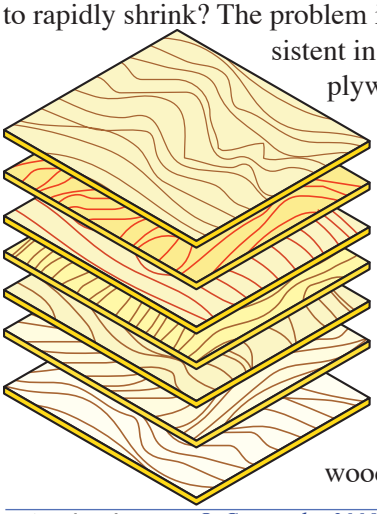
One of the most frequently asked questions in diemaking is how accurate the dimensions of the finished die will be. This is a somewhat vague question as the only precise measurement of a die is of the diecut part after it has been cut on-press.

However, when evaluating steel rule die accuracy it is important to recognize the precision of the rule is a function of a material made from highly dimensionally volatile natural wood product. Plywood is made from veneer layers of cellulose fiber sheets which when magnified are shown to be hollow tubes of vegetable matter which are highly susceptible to changes in their moisture content. ***See above***.

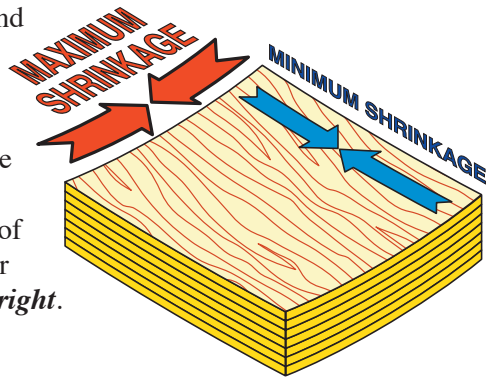


As the laser cutting process uses intense focused heat to vaporize a kerf in the dieboard the material on either side of the slot has all of the moisture evaporated from the cellulose material and the newly cut slot exposes much larger areas of end grain to the atmosphere. ***See right***.

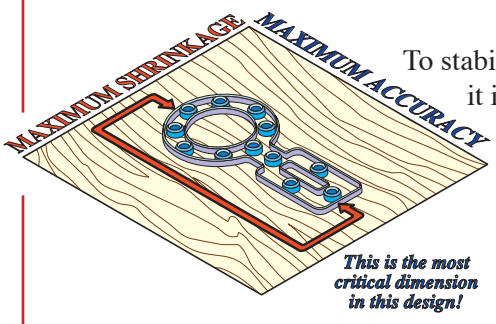
As the atmosphere in most operations is much lower than the moisture content of the wood the plywood panel begins to rapidly shrink? The problem is the shrinkage is not consistent in both directions. Although plywood is made from a odd number of veneer layers, which are alternately rotated through 90 degrees to stabilize the fabricated panel, more than 60 percent of the grain is oriented in a single direction. ***See left***.



In practice this means a plywood panel will shrink in both directions during and immediately after lasercutting, however, the shrinkage will be almost twice as much parallel to the grain direction of the upper and lower outer veneers. ***See right***.



Summary



To stabilize die performance it is important to orientate the die design so the most critical dimension is parallel to the grain direction of the upper veneer.

See above.

Plus or Minus - What?

"The Irish attempt on Mount Everest was a valiant effort, but it failed: They ran out of scaffolding."

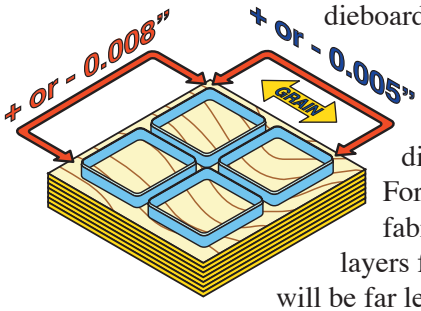
Diemakers often use the words plus or minus 0.005" of a similar tolerance to describe the potential accuracy of the tool which is being fabricated. However, it is important the diecutting user has a clear understanding of the potential variation from this precise description.

Plywood Volatility

A dieboard is only as accurate as the stability of the material the design is machined into. Plywood is highly susceptible to moisture loss and as a result it is likely to shrink as it is machined. This shrinkage is not consistent in both grain directions of the fabricated wooded veneer panel. For example, a machined dieboard will shrink almost twice as much parallel to the grain direction of the upper and the lower veneer as it will at right angles to these veneer layers. ***See top of this column***.

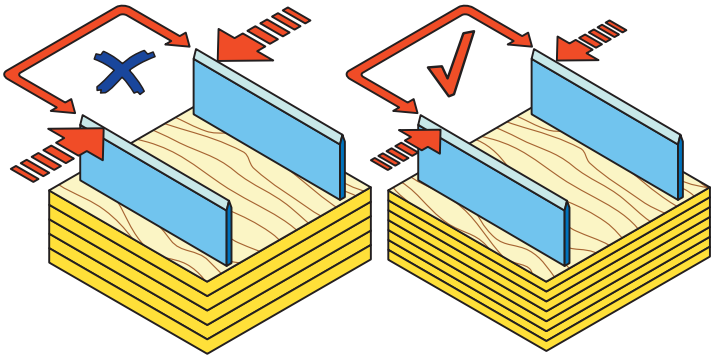
Therefore it would be more accurate and more honest to first state the tolerances for a dieboard may be plus or minus 0.005" at right angles to the grain direction of the top and bottom veneer. And second plus or minus 0.008" parallel to the grain direction of the top and bottom veneer of the

dieboard. ***See left.***



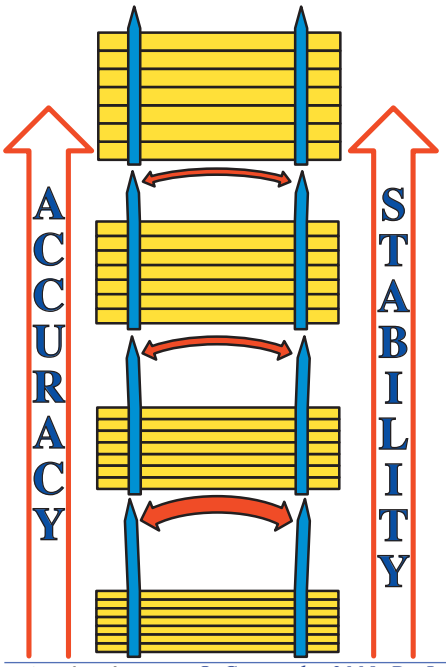
What other factors impact potential dimensional variability? For example, a dieboard fabricated with less veneer layers for a given thickness will be far less dimensionally stable than a dieboard fabricated with a higher number of veneer layers for the same dieboard thickness. ***See below.***

LESS Dimensionally Accurate ***MORE Dimensionally Accurate***



In a similar fashion the dimensional accuracy of a dieboard is a function of the thickness of the dieboard. For example, it is impossible to guarantee plus or minus 0.005" on a 5/8" thick dieboard where a combination of plywood shrinkage and exposed rule flexing will undermine the stated dimensions of the finished part.

Therefore, a 7/8" thick dieboard, will be more accurate and more stable than a 3/4" thick dieboard, which will be more accurate and more stable than an 11/16" thick dieboard, which will be more accurate than the identical design cut into a 5/8" thick dieboard. ***See left.***

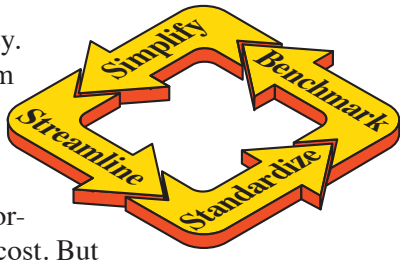


It is clearly important to understand the inherent variability of all of the materials when quoting any specific tolerance in a steel rule die.

The Competitive Edge

"Lost time is never found again." *John Aughey*

In Diemaking and Diecutting manufacturing, a majority regard automation as a key tool in reducing man-time and unpredictable cost. But this investment often only provides a temporary respite. The solution is to build a world class, high-speed, low-cost manufacturing operation where the mission is to rapidly extract the maximum knowledge from every production cycle. Speed in manufacturing is the ability to anticipate failure, to solve problems, and to apply better methods, derived from this learning cycle, as quickly as possible.



Simplicity is indeed the key. Every step we remove from every procedure saves time, reduces complexity, lowers skill, increases throughput, eliminate opportunity to fail, and reduces cost. But everything must be timed! Time measurement and benchmarking are the new disciplines. Organizations who will thrive will do so by managing the most volatile resource at our disposal. Time. Time is the most precious commodity we allow to slip through our fingers. ***How do you manage and compress time in your organization?***

Work Organization

"Have a time and place for everything, and do everything in its time and place, and you will not only accomplish more, but have far more leisure than those who are always hurrying." *Tyron Edwards*

You can tell how little we understand the problem by the typical organization of a diemaking operation or of a diecutting operation. They are based upon outdated ideas, slow inconsistently applied practices, and a layout which undermines efficiency. The universally understood examples of Just-In-Time organization, which are demonstrated daily in the hospital emergency room, or by the Pit-Crew changeover in auto racing, seem to have missed the Converting Industry completely.

Every single step, every action, every move, in manufacturing consumes a minimum of a tenth of a minute or six seconds. Even without defining each action as a value added step or a non-value added step it is difficult to understand why we do not benchmark and constantly attack key procedures.