



The ABC's of Diemaking & Diecutting

Article Title "The ABC's of using an alternative Score-Fold rather than a Crease-Fold?"

Introduction: How to Fold without Creasing?

The goal of diecutting-converting is *Speed, Simplicity, Performance & Cost*. All of these objectives revolve around streamlining every key activity, by paring techniques and procedures down to bare essentials, and by minimizing complexity. "To make it as simple as possible, but no simpler." In practice this usually means finding the fastest ways to do things, without compromising quality, and hopefully, through innovation and ingenuity, finding better ways to do things. Certainly, without pushing benchmarks standards and experimenting aggressively, it is unlikely we will stumble across technical innovation and breakthrough methods and practices.

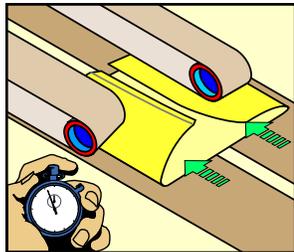


Speed and Cost dominate manufacturing, and while quality is a requirement, it is vital to find ways to reduce make-ready and set-up time; and to develop methods to increase press speed and yield. There is no escaping this relentless push for lower cost, and it is vital we develop methods, which are more consistent, which are simpler to execute, which cause less wear and tear on the tooling, and which lower expense in every facet of manufacturing.



Therefore, it is useful to examine even the most fundamental of techniques, to make sure it is as simple as possible, to make sure is as effective as possible, and to make sure we have not missed any opportunity to streamline and/or to reduce operating costs. It should be obvious, that the more complex a task or procedure the more chances there are for error and for resource waste.

What do our immediate customers demand? Faster gluing, more productive cartoning, see right, greater fulfillment consistency, end user satisfaction, and of course, the lowest cost possible. We need to look aggressively at how we organize and implement the most basic techniques in the diecutting process.



What is Converting?

What is the discipline of Converting, and why is it so important in structural design, in toolmaking and in diecutting?

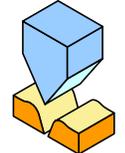
Converting is a machining process, which transforms a substrate into a component, a part, or a finished product, which is of higher value than the original material. Converting is the physical action of diecutting and is a combination of six tooling disciplines.

For example, when we examine a folding carton or a fluted container, *see right*, the manufacturing techniques, which were used to diecut each product, are a combination of six converting disciplines. These are:

- * Cutting
- * Creasing
- * Scoring
- * Perforating
- * Embossing
- * Debossing



CUTTING



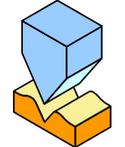
See below. (The Dictionary defines Converting as: "To change (something) from one use, function, or purpose to another; adapt to a new or different purpose: To change the form, state or function of one thing into another.")

CREASING



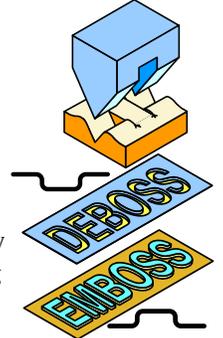
These disciplines form the basis of diemaking and diecutting, or the skill of toolmaking and tool usage in the converting process.

SCORING



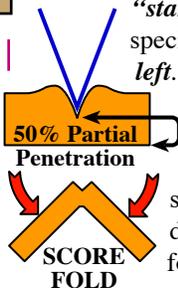
In practical terms the converting process is generally dominated by Cutting & Creasing, with Scoring and Perforating, and Embossing and Debossing, relegated to supporting roles. As a result, we are very familiar with the first two disciplines, and we often lack practical experience in effectively integrating the other four disciplines.

PERFORATING



What is the Role of Scoring in Converting?

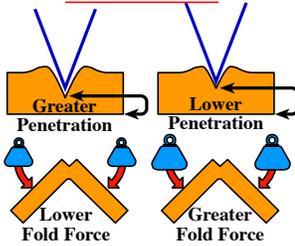
What is a Score? Although the term Score and Crease are both used to describe a fold in paperboard, a score is a fold generated by the partial penetration of a knife into a substrate. The industry "standard," which is always a dangerous term, usually specifies 50% penetration as the initial set-up. *See left.* However, as it is not practical to change all of the scoring knives on-press this is a default standard, which severely limits and constrains scoring performance. Although this is considered a standard setting, it should be obvious that by increasing the degree of knife edge penetration, the resistance to folding is lowered, and by reducing the degree of





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"Many ideas grow better when transplanted into another mind than in the one where they sprung up." Oliver Wendell Holmes



knife penetration, the resistance to folding is increased. *See left.*

The first obvious benefit of using a scoring knife in folding, is the resistance to folding is much lower than the alternative crease, which provides two key advantages. The first is the score lowers

the resistance to folding, and the score generates a very precise and square folded profile, *see right*, as an alternative to a crease, which in some instances can cause panel bowing as the crease is folded. *See left.*

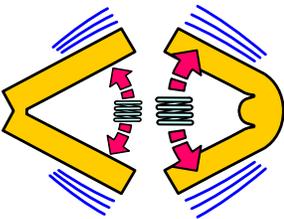
The most common application of scoring is to integrate creasing and scoring, as this combines the strength of the crease and the folding squareness of the score. *See right.* Many designers specify "Cut-Crease" when in practice "Score-Crease" is far more effective and generally produces more reliable and consistent results.

So why is creasing seen as a more effective folding design alternative?

Why is Creasing the Preferred Method of Folding?

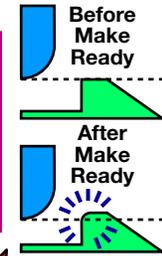
The primary reason creasing is and will always dominate folding is the aesthetic impact of a smooth spine and fold, the graphic impact and the appearance of the finished carton, and the strength of the erected and glued container.

What are some of the other reasons creasing is preferred over scoring? One of the obvious reasons is we have experience using creasing, and we lack experience using scoring. When this is combined with a perception that scoring is more difficult to control and the results are unpredictable, there is a tendency to play safe.



When the important folding force equation is factored in, it is obvious the precise control of this force is simpler with scoring, the logic of using creasing is there is greater resilient opening force or "Fluff" when using a crease. *See above left.*

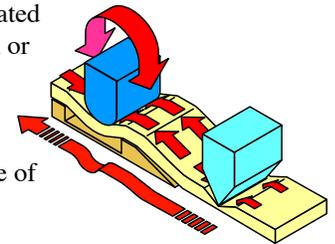
One of the reasons we struggle with scoring is we simply have not had time to develop essential skills, knowledge and expertise in scoring techniques, and there is minimal time to experiment and to test new methods and practices in a process continuously racing against the clock.



In reality, the main reason creasing is preferred over scoring, is ignorance of how scoring parameters can be manipulated to replicate almost any important feature of the paperboard creases. If we examine the range of adjustments, and the ability to mix and match tool features, it is extraordinary what we can achieve using scoring. Clearly there is room for both creasing and scoring in carton design and fabrication, and there is often a necessity for both techniques to be integrated to produce the most effective carton or container.

Before we examine the power of scoring, it is useful to examine some of the disadvantages of creasing.

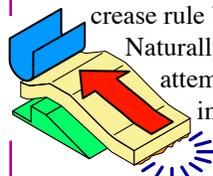
Before we examine the power of scoring, it is useful to examine some of the disadvantages of creasing.



What are the Disadvantages of a Crease-Fold?

Although creasing is the dominant folding method, it does suffer from some key disadvantages.

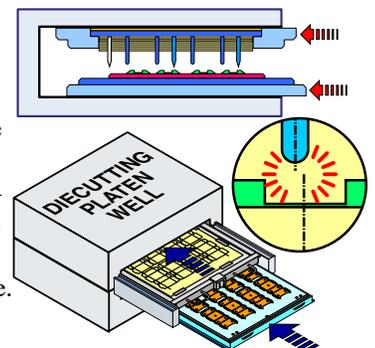
One of the key problems we face in most forms of creasing is rapid and constant erosion of the critical distance, so crease performance varies from the first impression to the last. *See above left.* This wear of the supper corner of each channel is primarily caused during press make-ready, where patching of the knives drives the crease rule below the surface of the female crease tool.



Naturally, this creates a temporary pressure spike when attempting to set a kiss-cut impression, which causes instability in the cutting make-ready.

Over-penetration of the tip of the crease rule into the channel is appropriate to mention at this point, because one of the severe problems with a protruding crease tool, one which sits on top of the anvil, is the creasing process generates high levels of draw and lateral tensile stress during each diecutting stroke. *See above right.* Excess draw generates three critical problems in diecutting. The first is flaking and edge chipping, *see left*; the second is the need to add more and larger nicks to compensate for this uneven pull from the crease; and third, excess tensile stress causes sheet break-up, it lowers press speed, and it reduces productive yield!

Added to these technical problems is the cost of design and fabrication of crease tooling, inventory management, the time required for installation and adjustment, time required to eliminate marking and smoothing the crease tool profile, and the time required for removal and storage. These issues add cost, they add





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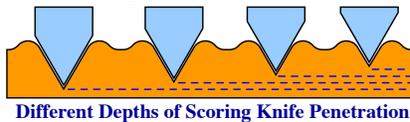
"A person who can create ideas worthy of note is a person who has learned much from others." Konosuke Matsushita

time and they add complexity to every press make-ready. In addition, because of the critical nature of optimal alignment between the male and female tool, *see bottom of right column on previous page*, inconsistent crease performance slows gluing and cartoning. All of these issues can be minimized or prevented by more effective tool design and selecting the right tool parameters, but creasing is not as simple, nor is it as consistent as it appears to be.

How to Optimize Score-Fold Performance?

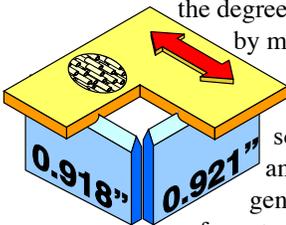
To take full advantage of the use of scoring techniques in converting, it would be useful to start with basic principles, which lead to practical applications.

The most important factor to address is the degree of penetration into a substrate. Although the "standard" set-up specifies 50% penetration, this is only a guideline, and a crude one at that. It is obvious the degree of penetration can be increased and



Different Depths of Scoring Knife Penetration

the degree of penetration can be reduced, simply by modifying the height of the scoring knife used. *See above*. Obviously, greater knife edge penetration will generate a score which requires less force to fold, and lower knife edge penetration will generate a score which requires more force to fold.



Where would this be useful? The most obvious example is when scoring parallel to and at right angles to the paperboard grain. It requires more pressure to cut across the fibers, than parallel to them or between them, therefore, the scoring rule at right angles to the paperboard grain must be higher than the

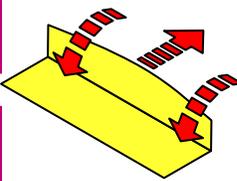
scoring knife parallel to the paperboard grain. *See above*. If we fail to make this adjustment, the score depth at right angles to the grain would be too shallow, and the score depth parallel to the grain would be too deep. *See above right*.

We know the degree of pressure in diecutting, or more accurately the measurement of resistance in penetrating each material is a function of the length of the knife penetrating that material. *See left*. **How would we use this information?** If we were using scoring knife in a simple shape, and to

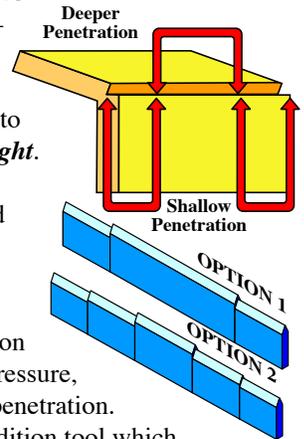
make it easier, we are only scoring in one grain direction, then as the scoring knife length increased in the design, the height of the score knife would have to increase, to counter the increased resistance to penetration. *See left*.



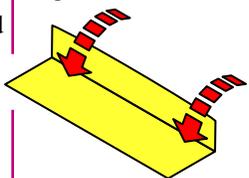
How else could we use this information?



It is a common phenomena, that when creasing or scoring long narrow panels, the panels have a tendency to bow outward in the center of the fold, where the resistance to folding is greatest. *See left*. Clearly we need greater resistance at the ends of the panel, and we need less resistance at the center of the fold. If we are using scoring we would simply increase the height of the scoring knife in the middle portion of the fold, to increase score penetration depth, and to lower the resistance to folding. *See right*.

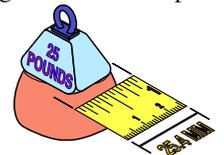


This will cause the narrow flap to fold squarely and evenly along its entire length, without bowing. *See left*.



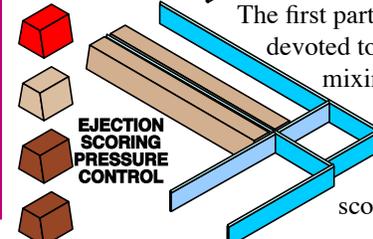
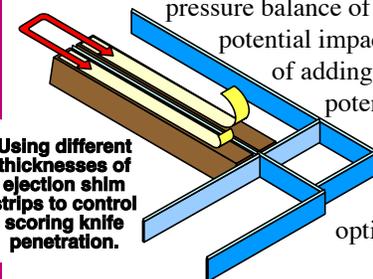
One final point on the subject of pressure, resistance and penetration. There is one addition tool which can be used to control the depth of score on

press, and that is the ejection material. In the standard pressure formula, every square inch of rubber generates 25 pounds of resistance for every square inch of ejection material added to the steel rule die. *See right*. As the rubber is usually positioned next to the scoring knife; by simply changing the height of the rubber; adding shims to the top of or under the ejection strips, by increasing or decreasing the durometer of the rubber; or the proportion of the rubber; next to all or individual or portions of a scoring blade, enables us to regulate the degree of penetration on press. *See left*.



Naturally, it is important to consider the implications to the overall pressure balance of the steel rule die, and the potential impact on surrounding components of adding ejection material, which has a potential to create other problems when solving the scoring issue. However, when used with care this is an effective adjustment option.

Using different thicknesses of ejection shim strips to control scoring knife penetration.



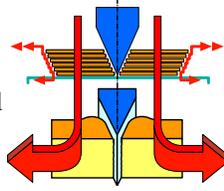
The first part of this section has been devoted to the effect of changing, and mixing and matching the height of the scoring knife in individual folds, but what are the other options available to control scoring-folding performance?



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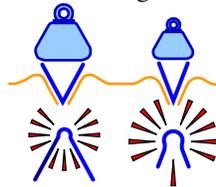
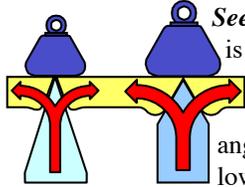
"What lies behind us and what lies before us are tiny matters compared to what lies within us." Ralph Waldo Emerson

Diecutting is a displacement process. This simply means that separation of a material is achieved by the bevel surfaces of the blade as they convert a vertical stroke into a horizontal splitting action. *See right.*

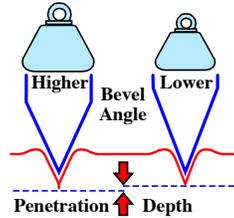


Why is this important? This is not just important, but it is critical in diecutting, because as we increase the knife bevel angle, the pressure to diecut increases, and when we decrease the knife bevel angle, the pressure to diecut decreases.

See left. As controlling pressure in diecutting is crucial to success, the most obvious choice for a cutting knife is the lowest bevel angle. In fact why not 30-degree bevel angle knife? The problem is that although the lower bevel angle knife generates less pressure, there is far greater probability of knife tip damage than a knife with a higher bevel angle. *See right.*



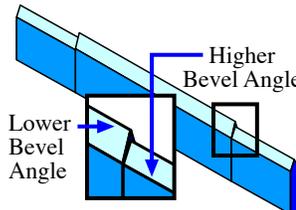
But we are not cutting onto a hard plate or into a soft plate when scoring, we are simply penetrating partially through the material. Therefore, a simple rule in choosing scoring knife, select the knife with the lowest bevel angle! It is far easier to control pressure on a low bevel angle knife, and of course the knife is less impacted by changes in caliper, in density and in the moisture content of the paperboard.



To reiterate, the higher the bevel angle of the knife used in scoring, the lower the degree of control!

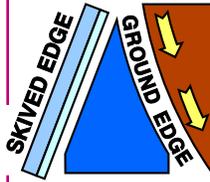
How does this help us in scoring? When comparing the displacement shape and ridges of a high bevel angle knife, with the displacement shape and ridges of a lower bevel angle knife, the difference is significant. Because the narrower bevel angle knife penetrates with less force and less lateral stress, the penetration depth is quite accurate. However, because the wider bevel angle knife penetrates with greater force and greater lateral stress, the penetration depth will be rather deeper than the actual penetration of the cutting edge. *See above.*

Obviously, the more precisely we can control penetration, the greater our chance of adjusting the important parameters of score-folding. In an earlier example, we suggested a three height score-fold for long narrow panels to eliminate panel bowing. It is an advantage to use a higher bevel knife at the ends of the fold, and a higher, narrow bevel knife in the center of the fold. *See above right.*



There is one other key factor, which should impact our choice of cutting blade. Is the knife a Skived Edge or a Ground Edge? *See*

right. As you can see from the illustration the machining striations in the Skived Knife run parallel to the cutting edge, while the machining striations of the Ground Knife run at right angles to the cutting edge. Another critical difference is the shape formed by each machining system. The skived knife face is flat, while the ground knife face is concave. *See left.*



When you consider the vertical striations of the Ground Knife, combined with the slight serrated edge caused by the grinding process, it is obvious this knife is sharper, and will penetrate a material with far less force. This does not mean in general diecutting applications that the Ground Knife is necessarily a better choice, because the sensitivity of the ground edge knife profile would be rapidly damaged when using a hard steel anvil! But in scoring, as the cutting edge will not be making contact with the cutting plate, this is not an issue.

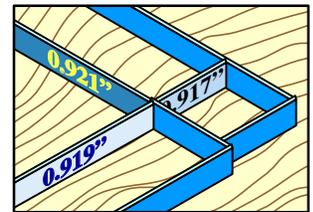
Therefore, when choosing scoring knife the best selection is a Low Bevel Angle Ground Blade.

To summarize some of the key the technical options this provides they are as follows:

- * Option 01: Integrate Different Heights of Knife
- * Option 02: Integrate Lower Bevel Angles of Knife
- * Option 03: Implement a Multiple Property Fold: Heights
- * Option 04: Implement a Multiple Property Fold: Bevel Angles
- * Option 05: Implement a Multiple Property Fold: Edge Types

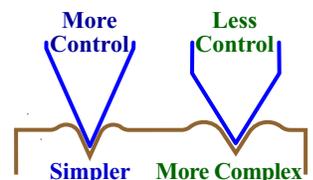
Option 01: Integrate Different Heights of Knife

In *Option One* we determined it is important to consider different heights of scoring knife based on the length of each knife in the design, and when the knife is cutting a right angles or parallel to the paperboard grain. *See right.*



Option 02: Integrate Lower Bevel Angles of Knife

In *Option Two* we determined the use of the lowest bevel angle for scoring was a distinct advantage, because of lower resistance to penetration, because of greater control of penetration depth, and for greater diecut part quality and consistency. *See right.*





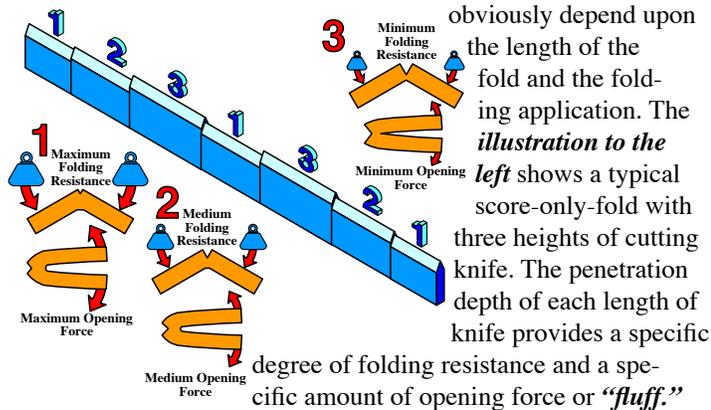
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"No man can be satisfied with his attainment, although he may be satisfied with his circumstances." Frank Swinnerton

Option 03: Implement a Multiple Property Fold: Heights

In Option Three we determined that by manipulating the different heights of scoring knife, we could eliminate creasing, and yet produce a fold with control of folding and opening force.

To provide a fold with multiple attributes and with precise control of folding force and opening force requires integrating several heights of scoring knife. The number of different heights will



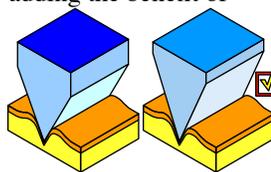
By mixing and matching different lengths of different heights of knife, we can create a Score-Fold with a range of folding and opening force attributes, which can be precisely adjusted and regulated. Instead of a *Crease-Fold*, or a *Cut-Crease-Fold*, we have created a *Score-Fold*, which requires no female tooling.

Option 04: Implement a Multiple Property Fold: Bevel Angles

In Option Four we are basically mimicking the solution we just defined in Option Three, however, we are adding the benefit of now introducing different bevels to the different heights of scoring knife.

What is the advantage of this?

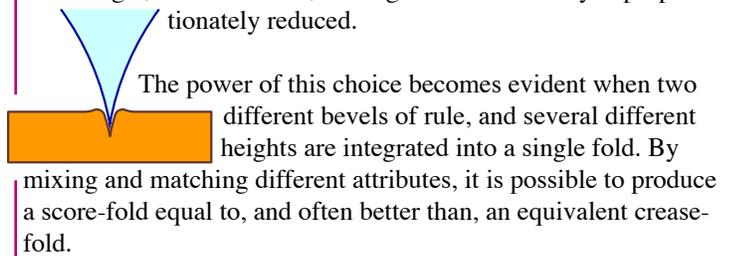
The advantage of a lower bevel knife is it penetrates a material with lower displacement force, which means it meets with lower resistance from the material being penetrated. As materials get denser or harder, or a material has a tougher upper surface, or a laminated material has to be scored, the lower the bevel angle, the easier it is to set, and stabilize consistent scoring-folding performance. *See above.*



But it is also useful for long panels, where we need greater penetration in the middle of the fold, to lower the force required to fold the panels. *See above.* In practice, the primary advantage of this technique is far less pressure is needed to diecut, and the precision of the result fold is a key advantage. This is particularly important as the length of the panel increases and the width narrows.

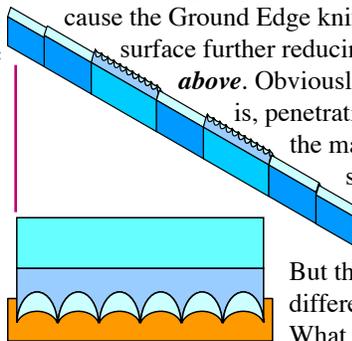


The significant advantage of using the lowest bevel knife in scoring, is the degree of control it gives in terms of material penetration, and therefore, in terms of controlling the precision of folding. The results are far more predictable than when using a higher bevel angle, and as a result, the degree of make-ready is proportionately reduced.



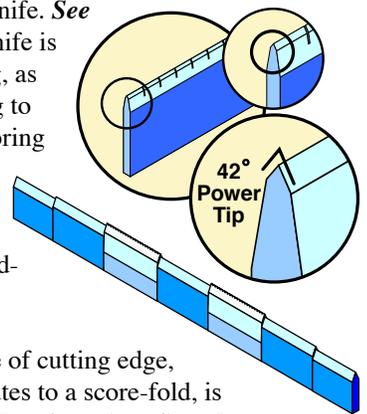
Option 05: Implement a Multiple Property Fold: Edge Types

In Option Five the recommendation was to use a *Ground Edge* knife for scoring, in preference to a *Skived Edge* knife. This is because the Ground Edge knife is sharper, and the concave bevel surface further reducing the displacement force. *See above.* Obviously, the theme of effective scoring is, penetration with minimum resistance from the material being diecut. That means as sharp as possible and as low a bevel angle as possible.



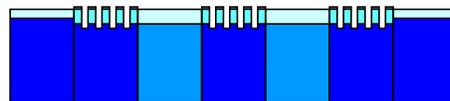
But this section is also about integrating different knife edge types or treatments. What may come as a surprising choice

is the integration of a Serrated Knife. *See above.* Even though a serrated knife is designed for soft anvil diecutting, as the tips of the knife are not going to reach the cutting anvil in the scoring application, *see above*, the variety of shapes of serrated knife edge profile, provide some very interesting attributes in score-folding.



In a similar fashion, another type of cutting edge, which can provide unique attributes to a score-fold, is MicroPerf Knife from Zimmer Manufacturing. *See above right.*

Finally, one of the more obvious cutting edges to integrate into the fold is perforating-knife. There are many variations of tooth spacing, of tooth and gullet shape, and bevel angle, which makes the choice somewhat overwhelming. However, suffice to say, the range of folding attributes, which can be built into a Multiple Property Fold using Skived Edge Knife, Serrated Knife, and Perforating Knife, and of course, different heights of knife and different bevel angles, provide a range of attributes far outweighing crease-fold options.





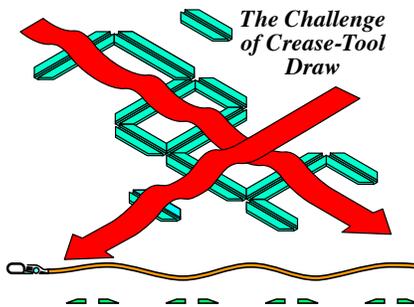
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"If you want to make enemies, try to change something." Woodrow Wilson

The Advantage of a Score-Fold over a Crease-Fold?

There is little doubt that the creasing method of creating a converting hinge will continue to dominate the folding carton and fluted container market. However, there are many occasions where a score-fold is required to play a important role in carton and container design, and it is crucial to design a score-fold, which is has a positive impact on container performance and not a negative impact. But there are many applications where score-folds would have a greater advantage than crease-folds, particularly because there are some key advantages of scoring over creasing: These Score-Fold advantages would include:

- * The elimination of female tooling
- * The reduction in protruding tool tensile stress
- * The reduction in nicks and better sheet integrity
- * Faster press speed and greater yield
- * The reduction in draw and flaking or edge chipping
- * The elimination of pressure spikes & simpler make-ready
- * Faster gluing, cartoning, and packaging
- * A simpler process with lower manufacturing costs

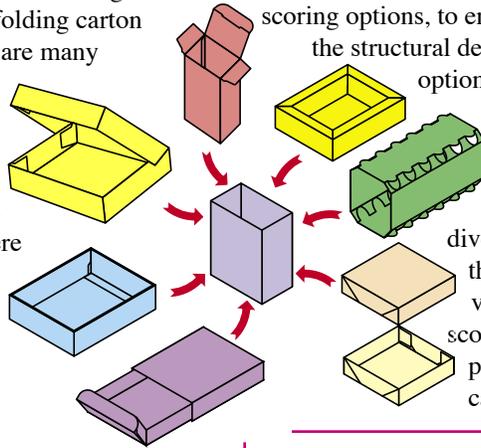


The goal of this article is to demonstrate the under utilized power and innovative potential of Score-Folding, and not to denigrate the Crease-Folding Technique, but it is critical to make scoring a more effective and a more important part of your folding toolbox.

Summary?

The methods and practices of Crease-Folding will always dominate carton and container converting, however, there are many situations, where poor execution of a score-fold technique undermines an otherwise effective folding product, and many more situations where crease-folding is incorrectly selected, where score-folding would be the more effective choice. As a result, score-folding is rarely developed as a viable practical alternative, and because we do not practice score-folding techniques, it inevi-

tably generates an on-press and a customer problem.



The goal of this article is to define the potential diversity of scoring options, to ensure score-folding is a important option in the structural design portfolio, and to make sure when this options is selected, the score-fold performs flawlessly.

Scoring is a great alternative to creasing. Particularly when the range and the diversity of scoring options is understood, and the skills and techniques of this powerful converting discipline are fully developed. When scoring-folding techniques are mastered, they provide powerful addition to the designer and carton makers toolbox.

DieInfo Products & Services

I would certainly be remiss in not recommending the latest DieInfo Publication:

"The ABC's of Fast Press Changeover."

"This technical training program represents the cornerstone for an effective organization strategy, as it provides a detailed guide to 25 key disciplines or building blocks, which provide a foundation for fast press changeover success. It is an essential reference tool for every professional diecutting operation."

I would also strongly recommend visiting the DieInfo Web Site, www.dieinfo.com, and reviewing our other publications, technical articles, and our training programs for diemakers and for diecutters.

