

High Speed Stamping



High Speed Stamping



Program Objectives

- Define High Speed Stamping
- Effects of Die Clearance
- Methods of Slug Control
- Tool Steel & Surface Treatment Selection
- Stripper Design Recommendations
- Application Problems & Recommendations

What is High Speed Stamping?

Strokes/Minute	Strokes/Second	Material Feed/Minute (.375 Progression)
250	= 4.2 S/sec.	93.9 in./min.
400	= 6.7 S/sec.	150 in./min.
600	= 10 S/sec.	225 in./min.
1200	= 20 S/sec.	450 in./min.
1500	= 25 S/sec.	562.5 in./min.
2000	= 33.3 S/sec.	750 in./min.

High speed stamping is:
• Fast enough to require special attention

Effect of Clearance

- Define Die Clearance
- Illustrate the effects that clearance has on the Hole and Slug size
- Explain the Advantages of using Engineered Die Clearance in High Speed Applications

Introduction

The Dayton Mission...

It is the mission of Dayton Progress Corporation to continue furnishing our customers with the highest quality information, metal stamping tools and precision components. Our over half century of surpassing delivery performance of the competition is our commitment to the future.

This report addresses the special concerns of high-speed stamping. We define high-speed stamping and discuss operating factors - such as the effects of die clearance and methods of slug control - that will help improve your stamping operation. We explore tool steel and selecting the proper surface treatment for your application. We further describe how stripper design affects your high-speed stamping operation. Finally, we discuss application problems and possible solutions.

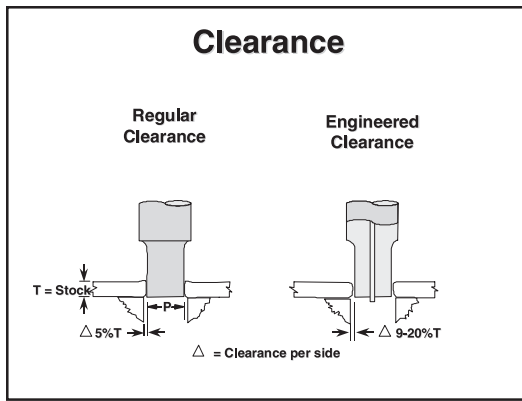
Understanding High-Speed Stamping

How fast is fast? We define high-speed stamping as an operation that generates special needs due to fast operating speeds. These special requirements generally relate to stock control, slug control and excessive wear problems.

Speed-related problems typically start when press speeds exceed 100 strokes per minute. The following chart shows how strokes-per-minute and strokes-per-second compare to how much material you must feed into the stamping tool based on a 3/8-inch progression.

Effects of Clearance on High-Speed Stamping

Punch-to-matrix clearance directly affects wear and slug control. High-speed stamping applications magnify these effects. In this section we define die clearance and discuss the effects clearance has on hole and slug size. We also explain how engineered die clearance benefits your high-speed applications.



Die Clearance

For many years toolmakers used 5% of stock thickness per side as a standard punch-to-die clearance. This clearance provided an acceptable burr height and slug control.

The high production volumes of high-speed stamping too often resulted in maintenance downtime due to wear and galling. High-speed stampers looked for new tooling materials to remedy the wear problems, but found them more expensive with longer lead times. These materials were also limited in their range of use.

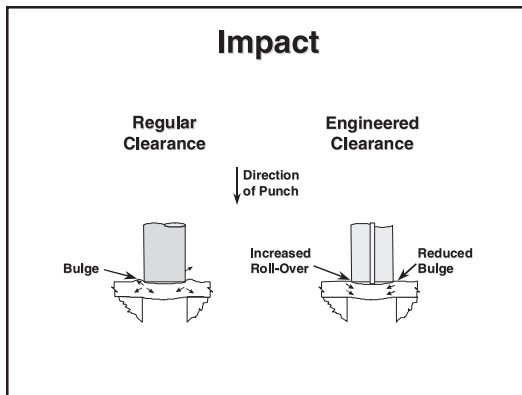
Research and testing has revealed that a radical increase in punch-to-die clearance reduces burr height to the lowest point while increasing tool life by several times.

A side effect to this approach is slug pulling. A spring-loaded ejector pin extending from the center of the punch face solves slug pulling in most cases.

We describe punch-to-die (matrix) clearance two ways: Total and Per Side. Both descriptions are correct. To minimize confusion, this report uses Clearance Per Side as the standard. The Delta symbol denotes Clearance Per Side.

Per Side clearance is the distance between the cutting edges of the punch and matrix. This distance between punch and matrix is maintained around the entire perimeter.

Example: Engineered Clearance of 10% Per Side for .060" thick material
10% Per Side Clearance x 2
 .012" (.006" x 2)
 + .500" Punch Point Size
 .512" Matrix Hole Size



The Perforating Process

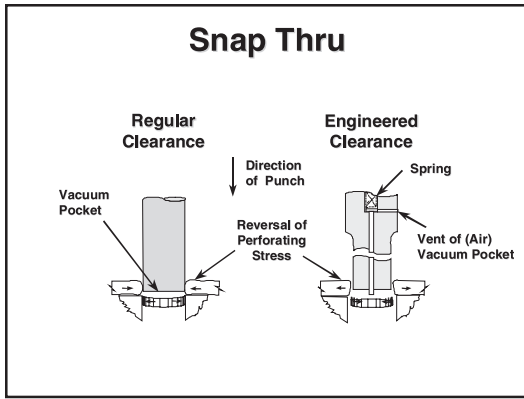
There are several critical steps in the perforating process, which significantly affect tool life and hole characteristics. The first of these steps is impact.

Impact

Impact is when the punch first makes contact with the part material. For a brief moment, the punch stops as backlash and flex of the ram and press are absorbed. The graphic at left shows impact response of regular versus engineered clearance.

A compressive load rapidly builds - sending a shock wave up through the punch - and the part material begins to deform. With regular clearance, the part material bulges from under the punch point and compresses into the matrix. Using greater clearances (engineered clearance) produces the opposite effect. The part material stretches as the punch enters, placing the part material under tensile load.

Part materials thinner than .020" (0.5mm) thickness have greater tendency to bulge around the punch and compress into the matrix. Thin materials typically require greater punch-to-matrix clearance to offset this effect.



Snap-Thru

When tensile load exceeds limits of the part material, the slug suddenly separates from the part. This sudden unloading of pressure on the punch generates a reverse shock that often leads to punch head breakage.

Snap-Thru shock directly relates to part material hardness. Harder, stronger part material generates greater shock.

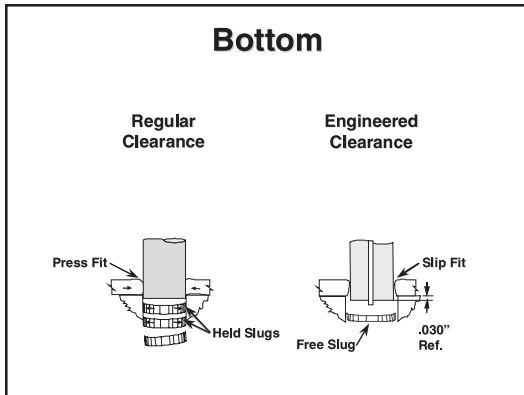
Compare the direction of part material springback once the slug breaks free. With Regular Clearance, the part material springs back. The hole in the part closes up and grabs the end of the punch. The slug - which was compressed - springs back and is now tightly held in the matrix.

Engineered Clearance creates the opposite reaction and minimizes potential slug jamming problems. The hole becomes larger than the punch point diameter, and the slug is now loose in the matrix. A hole in the side of the punch vents the vacuum pocket, allowing the ejector pin to push the slug away without resistance.



Tight Clearance

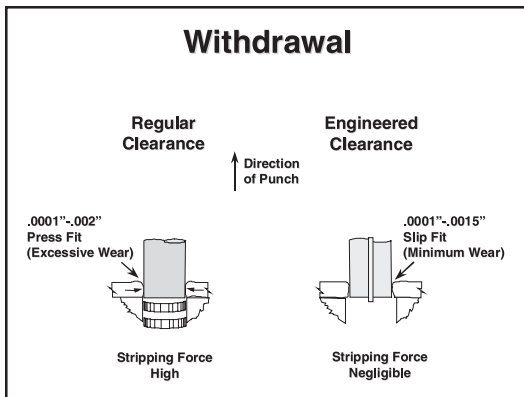
The photo at left also illustrates the effects of tight clearance. The rings around the point indicate that the part material has sprung back on the point at Snap Thru, grabbing the end of the punch. This tight fit on the point has generated heat, discoloring the area just behind the tip and potentially damaging its heat-treated properties. Heat damage dramatically reduces tool life.



Bottom

When the press ram reaches the bottom of its stroke, the punch should enter the matrix no more than .020" (0.5mm) in high-speed applications.

Punch over-entry creates excessive wear, particularly when using Regular Clearance. An over-entered punch also causes slug pulling. The farther a punch enters, the greater the suction it creates at withdrawal. This suction likely results in slug pulling.



Withdrawal

Withdrawal of the punch from the part material can generate as much as two-thirds the punch wear and be responsible for slug pulling.

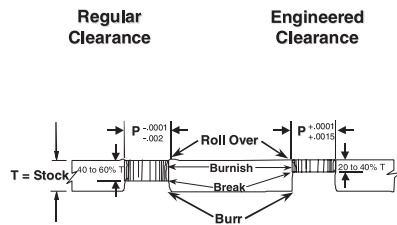
Because Regular Clearance can produce a hole that is as much as .002" smaller than the punch point, it creates a press-fit condition on the punch point with every hit. Abrasive wear on both punch and matrix will be excessive.

Engineered Clearance produces a hole that is larger than the punch point. This leaves a slip-fit condition and eliminates as much as two-thirds of the wear incurred while using Regular Clearance.

Increasing punch-to-matrix clearance reduces slug size, leaving the slug loose and free to pull up at Withdrawal. The ejector punch solves that problem by pushing the free slug away from the end of the punch.

You can use Engineered Clearance as long as you have a means of slug control. It can apply this clearance to all shapes.

Hole Characteristics



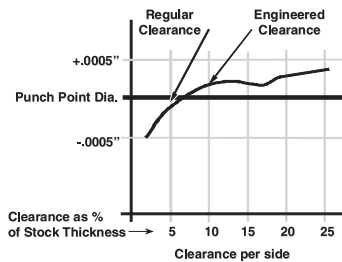
Hole Characteristics

Hole characteristics vary with different clearances. Regular Clearance typically results in a high percentage of shear or burnish with minimal rollover and break. The hole tends to be smaller than the punch point.

Engineered Clearance achieves a low percentage of shear or burnish, with greater rollover and break. Hole size with Engineered Clearance is larger than the punch point.

Refer to the graphic at left for differences in hole characteristics for Regular and Engineered Clearance.

Hole Size Comparison



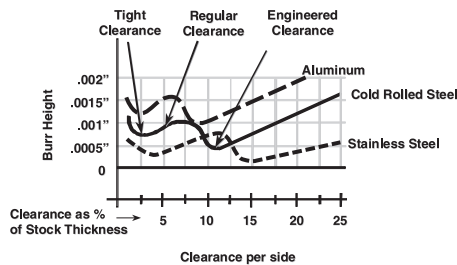
Hole Size Comparison

A comparison of holes perforated with Regular Clearance versus holes perforated using Engineered Clearance reveals the advantage of increasing clearance between punch and matrix.

As punch-to-matrix clearance increases, the hole-to-punch point size relation increases, which reduces stripping friction and wear. The result is longer punch life.

Part materials thinner than .020" (0.5mm) commonly require substantially higher punch-to-matrix clearance before the perforated hole becomes larger than the punch point and for the slug to free up in the matrix. The actual amount varies depending on part material type and hardness.

Burr Generation



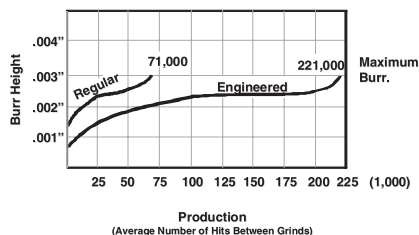
Burr Generation

Punch-to-matrix clearance also affects burr height. Regular Clearance offers acceptable burrs in many cases. As clearance increases, burr height initially increases.

Substantial increases in punch-to-matrix clearance reduce burr height below that of Regular Clearance in most applications. This phenomenon is exaggerated and requires even higher clearance when perforating thin and hard material.

Because burr height initially increases before dropping to its lowest point when using Engineered Clearance, a compromise between Regular and Engineered Clearance is not recommended.

Productivity



Improving Productivity

The graph at left shows a case study based on .036" thick cold-rolled steel. The lessened burr height with Engineered Clearance reveals a threefold increase in punch life over that for Regular Clearance.

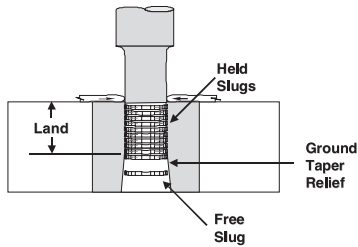
Slug Control Problems

- Slug Stacking
- Slug Pulling
- Slug Tumbling

Slug Control

A discussion on punch-to-matrix clearance would be incomplete without addressing slug control. This section explores three common slug related problems: stacking, pulling and tumbling.

Slug Stacking



Solution:

- Increase clearance
- Reduce land in matrix

Slug Stacking

Slug stacking or jamming most commonly occurs when perforating thin and/or soft material. This jamming can lead to punch breakage or matrix splitting.

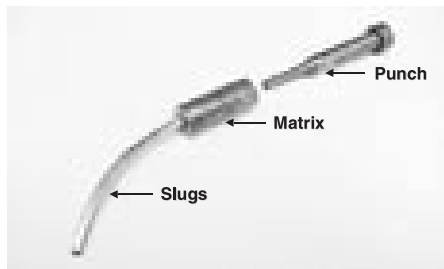
The two primary causes for slug jamming are tight punch-to-matrix clearance and excessive land length in the matrix.

One solution is to increase punch-to-matrix clearance. This reduces slug size, allowing them to freely fall through the matrix. Increasing clearance also reduces wear on punch and matrix, resulting in improved tool life.

Another solution for reducing slug jamming is to reduce the land length in the matrix. Fewer slugs held in the land require less force to drive them out. Recommended land length should not exceed four times material thickness.

Tight punch-to-matrix clearance and excessive land in the matrix can lead to slug stacking. The slugs can stick together forming a continuous piece as shown in the photo at left. This is common when working with thin material.

Slug Stacking



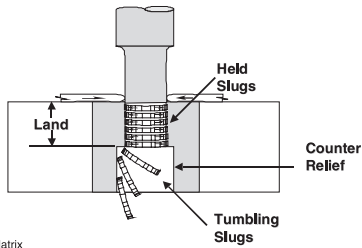
Deformation



Slug stacking and jamming can lead to punch point deformation, which can occur at the point - or as seen in this photo - behind the guide in the stripper.

The punch pictured is M2 with nitride and has a Rockwell C hardness of 62. Properly tempered tool steels will bend or deform before they break.

Slug Tumbling



Solution:

- Use Taper Relief Matrix
- Check for Misalignment

Slug Tumbling

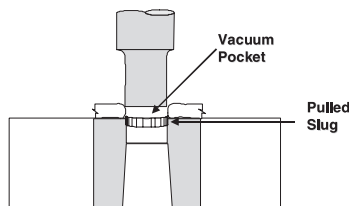
Slug tumbling occurs when slugs tip to one side of the matrix as they are released from the bottom of the die land. Slug tumbling can lead to slug stacking, which damages the tooling.

Counterbore relief matrixes have a higher chance of misalignment due to their broad tolerance. Uneven cutting caused by this misalignment plus rapid release of the slug at the counterbore leads to slug tumbling. Rough-drilled finish in the counterbore compounds this problem, which tends to catch and hold slugs.

Thick or heavily applied lubricants can also cause slug tumbling.

Using a taper relief matrix - with higher precision and smooth relief finish - commonly solves this problem. Apply lubricants relatively thinly and in moderate amounts.

Slug Pulling



Solution:

- Reduce punch entry
- Change lubricants
- Use Jektole punch with side vent hole

Slug Pulling

Slug pulling has many causes. Some of the common causes are sticky lubricants, punch over-entry and loose punch-to-matrix clearance that has no means of slug control.

During hole perforation the slug bows away from the center of the punch, creating a vacuum pocket. This vacuum pocket can cause the slug to stick to the end of the punch, resulting in slug pulling. Lubricants create a seal around the vacuum pocket, which increases the chance of slug pulling.

Punch over-entry generates a similar problem. The farther a punch over-enters, the greater the vacuum it creates at withdrawal.

Minimize slug pulling by using Jektole punches with a side vent hole. The side vent hole breaks the vacuum seal, allowing the Jektole pin to push the slug away. A thin-viscosity, lightly applied lubricant allows the side vent hole and Jektole pin to operate at maximum efficiency.

If the slug is allowed to pull up at withdrawal, feeding the stock strip can be a problem.

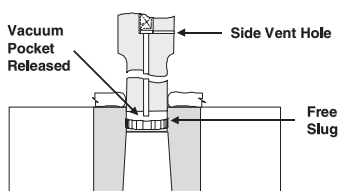
Slug Pulling Solutions

- Jektole Punches
- Air Blow-Off
- Change punch point configuration (Shear)
- Demagnetize punches and matrixes
- Change Matrix Design
- Roughen land in matrix
- Use patented slug control grooves in matrix
- Vacuum slug sucker
- Change lubricants
- Tighten clearance

Slug Pulling Solutions

Slug pulling has many possible solutions, as listed at left. This section discusses some of these more common methods.

Jektole Punches



• Side vent hole breaks vacuum pocket seal

• Jektole pin pushes slug free

Jektole Punches

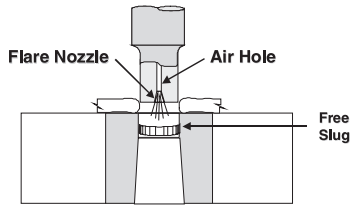
Slug pulling can result from the vacuum pocket between the tip of the punch and the slug. This problem worsens when stamping lubricants seal the vacuum pocket.

The side vent hole helps break the seal, allowing the Jektole pin to work more effectively.

Effectiveness of the Jektole punch in high-speed stamping applications can be hindered by thick or heavily applied lubricant, light-weight slugs and press speed.

Extreme high speeds may exceed the slug control capabilities of Jektole punches. Such conditions may require additional measures.

Air Blow-Off



- Flare nozzle to disperse air evenly
- Time air whenever possible (Under 200 SPM)

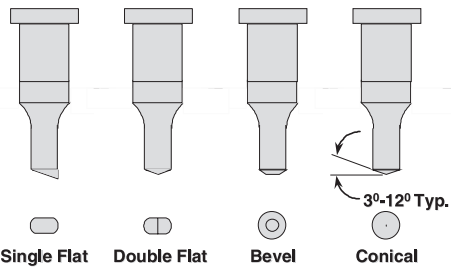
Air Blow-Off

Air ejection through the center of the punch is an effective means of slug control for high-speed applications.

For best results, flare the nozzle to disperse the air evenly. Time the air to eject just after impact and continue blowing until the punch has completely withdrawn from the hole. Unfortunately, such timing is nearly impossible when press speeds exceed 200 strokes per minute. Run air continuously for these high speeds.

Be aware that air does come with some drawbacks. Compressed air systems cost money to operate and maintain. Air is also noisy and can blow lubricants away from where they are needed.

Shear Angles



- Punch load reduction
- Minimize slug pulling

Punch Point Configuration

You can also reduce slug pulling by utilizing shear angles on the punch face.

Shear angles come in many configurations. The most applicable styles for metal stamping operations are pictured at left.

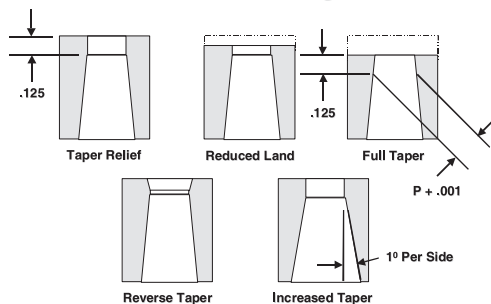
Single flat shear reduces the load but tends to deflect the punch laterally to cause uneven and excessive wear, punch and matrix chipping, and punch point breakage. Typically use the single flat shear on shaped punch points to perforate holes through uneven surfaces.

The double flat shear has two flats on the face and is often referred to as a roof-top shear. It works best on oblong and rectangular punch point shapes. Avoid concave roof-top shear since it tends to cause punch point chipping and splitting.

A bevel shear reduces punch load and minimizes punch point chipping. But it tends to induce wear.

Conical shear is the best configuration when perforating with a round punch. Load reduction is greater than with the bevel shear, wear is evenly distributed around the point, and the slug deforms enough to minimize slug pulling.

Matrix Design



Matrix Design

The matrix offers some of the best methods of slug control for high-speed stamping applications. Minimal land length allows slugs to fall away. Methods of holding a few slugs in the matrix can prevent both slug jamming and pulling.

1/8 inch (.125") land is the industry standard. This works well in most applications. Because high-speed applications tend to deal with thin material, you can usually reduce the land. Land length should not exceed four times the material thickness.

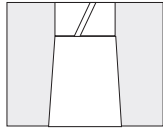
Full or reverse taper effectively minimize slug pulling in high-speed applications. Note that when full taper is sharpened 1/8 inch, the P dimension increases by only .001 inch.

Reverse taper takes advantage of Engineered Clearance, increasing tool life. It also reduces slug pulling by tapering down to a dimension less than the slug diameter for a short distance before tapering back out at a quarter degree per side or more. A drawback of reverse taper is it's more difficult to maintain.

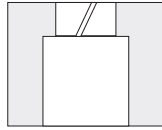
Increased taper is designed to prevent soft part material from sticking in the relief area, which minimizes slug stacking.

Patented Slug Control Grooves

(US Patent Number 4,543,865)



Taper Relief



C'Bore Relief

- Opposing grooves hold slug down
- Guaranteed to prevent slug pulling
- Clearance must be 10% per side or less
- Punch entry should be kept to a minimum

Tool Steel Considerations

- Tool Steel Analyses & Characteristics
- Surface Treatments for added Wear Resistance
- Carbide Considerations
- Tips for Maintaining Tool Steel Components

Typical Analysis

Steel Type	C	Mn	Si	Cr	W	Mo	V
A2	1.0	0.9	0.3	5.25	0	1.15	0.3
D2	1.5	0.5	0.3	12	0	0.9	0.9
M2	0.85	0.3	0.3	4.15	6.4	5.0	1.9
M4	1.4	0.3	0.3	4.0	5.75	4.5	4.0
CPM 10V	2.45	0.5	0.9	5.25	0	1.3	9.75

Patented Slug Control Grooves

The solution of precision grooves ground in the matrix land (US Patent No. 4,543,865) was designed specifically for high-speed stamping applications.

The opposing grooves create small ears on the slug. The grooves spiral in opposite directions, holding the slugs to one side of the matrix and preventing them from pulling up when the punch withdraws. These grooves vary in size based on material thickness and punch-to-matrix clearance.

These grooves can be applied to both taper and counterbored relief matrices, as well as to shapes. They are guaranteed to work in applications where punch-to-matrix clearance does not exceed 10 percent per side.

Keep punch entry to a minimum (less than .060") to prevent removal of the small tabs created by the grooves. These tabs are essential for retaining the slugs in the matrix.

Tool Steel Considerations

Selecting the proper tool steels, heat treat, and surface treatments for a given stamping application can be complex and confusing.

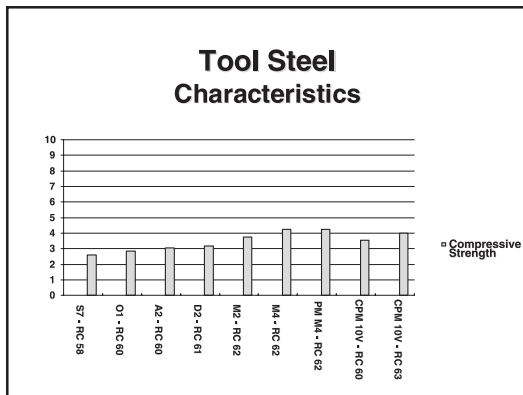
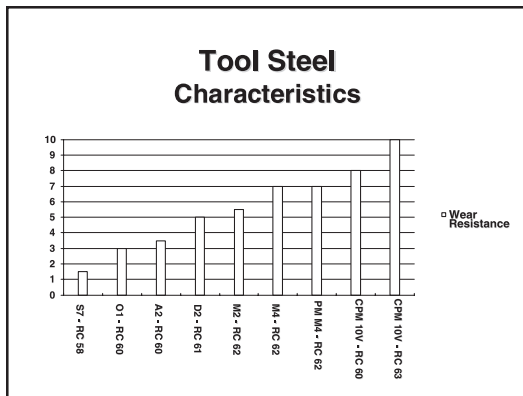
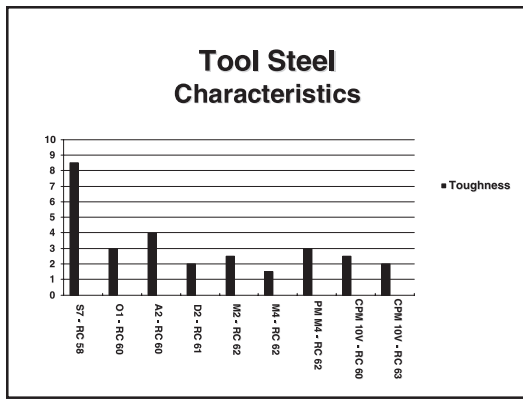
Tooling for high-speed stamping applications requires a high degree of wear and temper resistance. Tool steel selection and the appropriate heat treat are crucial in achieving acceptable tool life.

To simplify the tool steel selection process, we must first understand a few basic facts about the potential candidates. This section examines those facts using terms familiar to the non-metallurgist.

Tool Steel Analysis

The high-speed stamping environment requires tool steels to have good temper and wear resistance. You can often identify these features by a tool steel's alloy content. While chrome offers some temper and wear resistance, molybdenum, tungsten and vanadium are more effective when used in sufficient amounts.

The chart at left lists some of the commonly used tool steels and their alloy content. Each alloy element listed in the table contributes to a specific characteristic in the finished steel. But these alloys can also create undesirable side effects, particularly when used in excess. Alloy elements can also react with each other, which can either enhance or sometimes degrade the final result.



Tool Steel Characteristics

Toughness

If toughness was the only factor in choosing a tool steel, S7 would be the obvious choice. Unfortunately, this toughness is achieved at the expense of other characteristics necessary in most stamping applications.

This bar graph compares toughness for tool steels commonly used in stamping applications. These steels are listed in order of increasing alloy content from left to right. Tool steel toughness tends to drop as alloy content increases. Higher alloy content also demands a higher price.

The steel manufacturing process also affects toughness. The PM (Particle Metallurgy) process can greatly enhance toughness of a given tool steel grade over its conventional counterpart. Note the difference in toughness between M4 and CPM M4 in the chart.

Hardness also effects toughness. CPM 10V appears twice in our chart. Any given grade of tool steel has greater toughness at lower hardness. Be aware that the lower hardness may have a negative effect on other characteristics necessary in achieving sufficient tool life.

Wear Resistance

Optimum wear resistance is crucial for high-speed applications. Increased alloy content typically means increased wear resistance as shown in this bar graph.

Increased hardness also adds wear resistance. Note the additional wear resistance when the hardness of CPM 10V is increased from RC 60 to RC 63. This relation between hardness and wear resistance holds true within any given grade of tool steel.

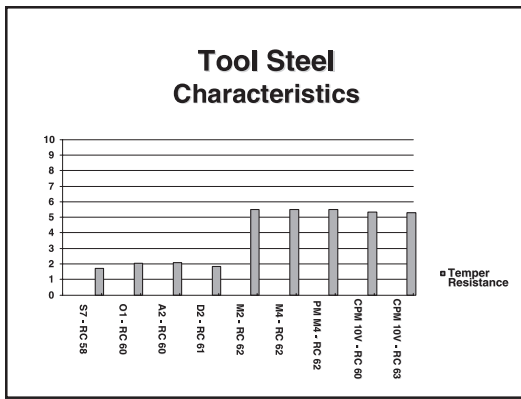
Compressive Strength

At first glance, high-speed stamping applications do not appear to require a great deal of force to perforate or blank out parts. Parts are generally small and manufactured from thin, relatively soft material. Because the part material is thin and typically soft, it tends to stack up and jam in the matrix or die plate. If the punch lacks the necessary compressive strength, it fails.

Two factors affect compressive strength: alloy content and punch material hardness.

Alloy elements such as molybdenum and tungsten contribute a great deal to the compressive strength. Also higher hardness of a given grade of steel increases that steel's compressive strength.

Alloys such as molybdenum, tungsten and cobalt that contribute to compressive strength also tend to improve temper resistance and red hardness. This is important in high-speed applications where heat buildup in the tool is a concern.



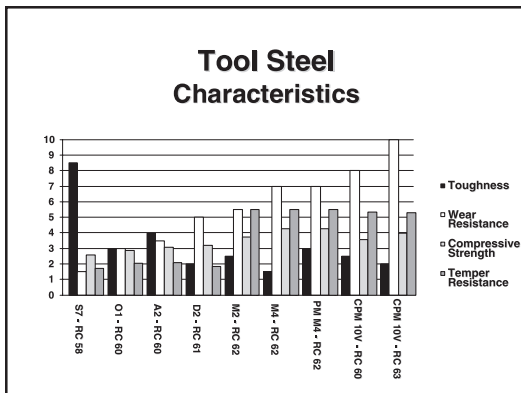
Temper Resistance

Temper resistance is the tool steel's ability to maintain hardness after exposure to heat. Compromising hardness of a given tool steel reduces wear resistance and strength.

Several factors influence temper resistance. Alloy content is the primary contributor. The level of refractory alloy elements - such as molybdenum, tungsten and cobalt - significantly affects a tool steel's resistance to being tempered to a lower hardness. Other alloy elements, such as vanadium and chrome, also provide some temper resistance.

The temperature where a tool steel's temper resistance is affected is directly affected by the tempering temperature used during initial heat treatment. A service temper within 28°C (50°F) of the tempering temperature directly affects a tool steel's temper.

The bar graph illustrates the temper-resistant advantage of high-speed and high-alloy steels such as M2, M4 and CPM-10V over common cold work tool steels like A2 and D2.



The Right Combination of Properties

This bar graph compares toughness, wear resistance, compressive strength and temper resistance. While some steels possess exceptional values with one characteristic, they tend to have low values in one or more of the other characteristics.

High load applications such as stainless steel, spring steel and high-strength low alloy call for tool steels with a combination of shock resistance and high compressive strength. M2 or PM-M4 perform best in these applications.

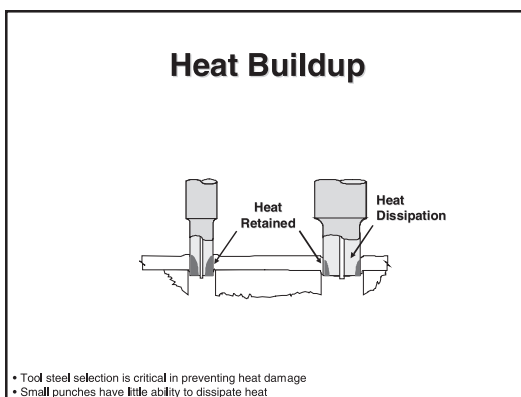


Managing the Effects of Friction and Heat Galling

Relatively tight punch-to-matrix clearance is often used as a means of slug control. The resulting tight fit of the part material around the punch point causes friction and generates heat.

At high speeds the punch does not have enough time between strokes to cool. Therefore heat builds up in the punch, causing galling and heat damage as shown in this photo.

Tool steels with high temper resistance minimize this type of failure.



Heat Buildup

Punching small holes in high-speed applications requires special attention to tool steel selection.

High-speed stamping generates tremendous amounts of heat. Because small punches have less ability to dissipate heat, they are prone to overheating. This leads to loss of hardness, reduced wear resistance and dimensional instability.

High-speed or high-alloy steels - such as M2 or CPM-10V, which are tempered above 1000 °F - have temper resistance superior to A2, D2 and other cold-working tool steels. This property makes them ideal candidates for high-speed conditions.

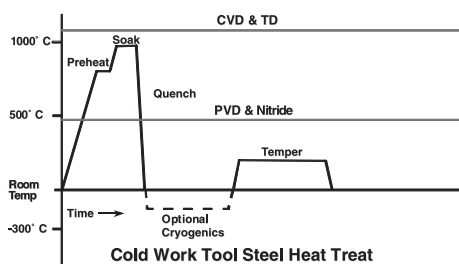
Surface Treatment Considerations

- Commonly used Coatings
- Process Temperature
- Substrate Material
- Coating Thickness
- Coating Hardness

Common Surface Treatments

- | | |
|------------------------------|------------------------------------|
| ■ Fluidized Bed Nitride | ■ TiN (Titanium Nitride) CVD |
| ■ Salt Bath Nitride | ■ TiCN (Titanium Carbonitride) PVD |
| ■ Gas Nitride | ■ CrN (Chromium Nitride) PVD |
| ■ Ion Nitride | ■ TiC (Titanium Carbide) CVD |
| ■ Amorphous Boron Carbide | ■ TD (Thermal Diffusion) |
| ■ AlN (Aluminum Nitride) PVD | ■ XND (DayKote) |
| ■ TiN (Titanium Nitride) PVD | |

Surface Treatment Process Temperatures



Surface Treatments

Surface treatments are often used as a means of improving tool life. These treatments increase surface hardness and wear resistance while reducing the coefficient of friction.

Important considerations when selecting a surface treatment include substrate material, coating process temperature, coating thickness and coating hardness.

Common Surface Treatments

There are many surface treatments and coating processes to choose from, as listed at left.

Nitride case-hardens the surface of the substrate material. This treatment is applied by numerous processes. Fluidized bed, salt bath and gas are the most common and economical processes for nitride application. Ion nitride is also an effective process, but it tends to be a little more expensive. Nitride surface treatments work in a broad range of applications. Salt bath nitride is perhaps the most effective means of application, but has lost favor due to environmental concerns.

Titanium nitride, titanium carbonitride and chromium nitride applied by Physical Vapor Deposition (PVD) work well on precision tooling used in specific applications. Titanium nitride offers better wear resistance than nitride, but it experiences some difficulty with copper and stainless steel applications. Titanium carbonitride provides even greater wear resistance in a narrower range of applications.

Titanium nitride, titanium carbide applied by Chemical Vapor Deposition (CVD) and thermal diffusion do well in forming applications. These coatings work best during forming that does not require high precision. The high processing temperatures involved cause distortion and size change, which limit precision.

Surface Treatment Process Temperatures

Surface treatments can be applied to a wide variety of tool steel substrates with varying results.

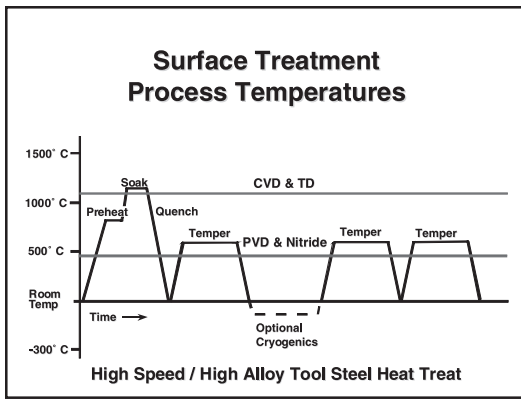
Cold-Work Tool Steels

Note the relatively low tempering temperature for cold-work tool steels such as A2 and D2. These temperatures are below the PVD and nitride processing temperatures. Exposure to these temperatures draws the hardness of cold-work tool steels below HRC 58. Hardness below this level leaves the substrate steel vulnerable to deformation beneath the coating, creating adhesion problems for coatings.

Part growth and distortion also become factors, which affect tooling assembly and finished product precision.

CVD process coatings are applied at the high end of the austenitizing range of cold-work tool steels. Expect coarse grain structure and size change in this circumstance. Precision and toughness are also questionable.

Thermal diffusion is a unique process that utilizes the carbon content within the substrate material to form the coating and quenches the tool as part of its coating cycle. You can apply this process to D2 steel. But substrate hardness typically falls below HRC 58, potentially reduces part strength.

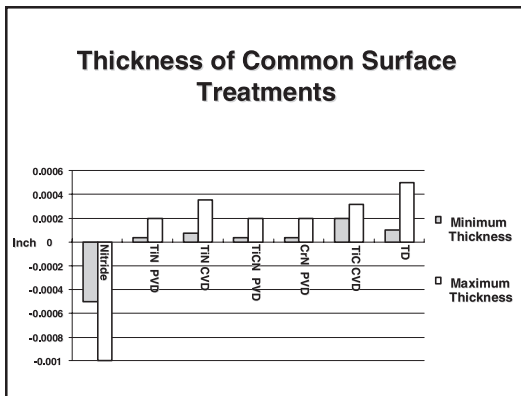


High-Speed/High-Alloy Tool Steels

PVD process coatings and nitride work well with high-speed and high-alloy tool steels such as M2, M4 and CPM-10V. PVD process temperatures fall more than 30°C (50°F) below the tempering temperature for high-speed and high-alloy tool steels, nearly eliminating distortion and part growth.

Due to the high processing temperature of CVD coatings and thermal diffusion, post-heat treat is commonly require to achieve acceptable substrate material hardness. Expect distortion and growth.

Because of its utilization of carbon within the substrate material, thermal diffusion works well on steels with high carbon content - such as M4 and CPM-10V - in low to moderate precision applications. Thermal diffusion is not recommended on M2 due to its relatively low carbon content.



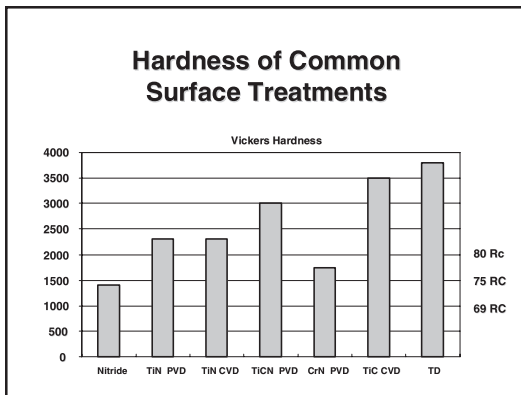
Thickness of Common Surface Treatments

Coating thickness becomes an issue in high precision applications.

Nitride is a process of case-hardening the existing part surface. Although nitride does not build up on the surface, the heat involved may cause slight part growth as a result of the matrix accommodating diffusion of the nitrogen.

PVD coatings are relatively thin and only cover areas within line of sight of the coating source. Precision of the coated area is generally maintained. Fit at tool assembly is typically unaffected by this process.

CVD and TD coating processes are thicker and cover the entire part, which affects precision of the working end and fit in a retainer. Stripping and reworking portions of punches may be necessary to assemble the tooling.

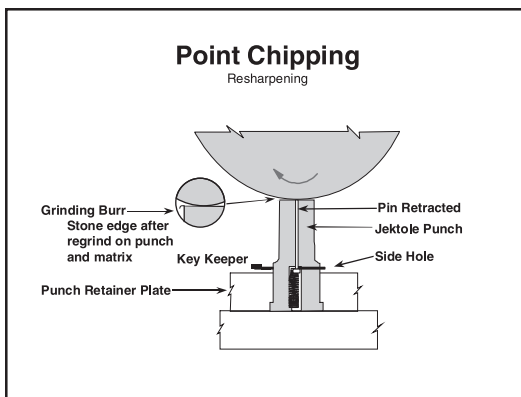


Hardness of Common Surface Treatments

Just as for tool steels, hardness indicates wear resistance and lubricity for a given coating. PVD process coatings and nitride enhance the life of precision high-speed and high-alloy tool steels. But these treatments do not cure wear caused by tight die clearance or punch bending due to high load.

Higher hardness coatings - such as titanium carbide and thermal diffusion - tend to be thicker and require a great deal of heat, which eliminates them from many applications.

The hardness values in this chart represent the coatings themselves. Because these coatings are extremely thin, their hardness values are virtually undetectable on the Rockwell "C" scale.



Point Chipping

The side vent hole in Jektole punches serve two functions. One minimizes the suction at withdrawal that can cause slug pulling.

The other function provides a keeper key for locking the Jektole in the retracted position. This lets you sharpen the punch without disassembly.

Removing the grinding burr is also critical. The best way to remove this burr is to use a sharpening stone. Failure to remove this burr leads to chipping and wear on the punch and a burr on the part.

EDM Considerations

- **Reduce or Remove Recast (White layer)**
 - White layer is the the recasting and rehardened area on the newly cut surface. Multiple skim cuts, bead blasting and tempering will reduce problems associated with recast.
- **Stress Reduction**
 - Cutting thick sections or removing large areas of a tool steel block unleash pent up stress allowing the block to warp. Removing as much material prior to heat treat, cryogenic treatment during heat treat and tempering after the EDM process will minimize the stress.

What About Carbide?

Pro's	Con's
<ul style="list-style-type: none"> ■ Better wear resistance ■ Higher compressive strength ■ Increased thermal stability 	<ul style="list-style-type: none"> ■ Lower toughness ■ Special grinding wheels to sharpen and maintain ■ Special application considerations (Press Condition, Coolants, etc.) ■ Higher price and longer lead times

Carbide Special Considerations

- **Select the right grade. 10% to 15% cobalt is recommended. Higher levels of cobalt are required in forming applications.**
- **Avoid sulfur and chlorine. They will leach out the cobalt binder severely damaging the tool.**
- **Alignment and precision are critical. Avoid the use of Ball Lock as a means of retaining punches.**

Electrical Discharge Machine Considerations

The Electrical Discharge Machine (EDM) is popular for cutting intricate shapes in hardened tool steels. It uses a repeated process of electric erosion to remove material.

The EDM requires high voltage to heat and cut the part to the desired shape. This process leaves a deposit of recast material on the newly cut surface, resulting in premature tool failure. Take special precautions to minimize or remove the recast.

One way to minimize recast is to increase spark frequency. However, this slows cutting speed. Another way to minimize damage is to take light finishing passes using a high-frequency spark. Several light passes are recommended to achieve optimum results.

Mechanically removing the white layer is also recommended. Do this by grinding, polishing or bead blasting the surface. Because these procedures can impart surface stress, use a tempering process when the detail is complete.

Carbide Considerations

Carbide offers exceptional resistance to wear, withstands high compressive loads and maintains its hardness when exposed to temperatures that would damage most tool steels. Carbide can also be ground to very high precision tolerances.

All these properties are highly desirable in high-speed stamping applications. However, they do have limitations and special considerations you must be address to reap their benefits.

The greatest limitation with carbide is its lack of toughness. Chipping and breakage are the common failures of carbide.

Its high wear resistance also hinders grinding, fabrication and sharpening. You must use specialized grinding wheels and coolants. Even when done properly, material removal rates are low. For this reason and its expense, carbide is usually sold as a preform at near net shape. This significantly reduces material and grinding cost.

Selecting the Right Grade

Selecting the right grade of carbide is important. The amounts of cobalt binder and grain size are two factors you can adjust based on application.

These considerations directly affect toughness and wear resistance. Reducing the amount of cobalt and grain size increases wear resistance. Eight percent cobalt with a micro-grain structure provides high wear resistance, but offers minimal toughness and strength. Carbide stamping tools featuring 10 to 15 percent cobalt and a medium to coarse grain structure tend to perform best. Carbide forming punches require additional cobalt.

Avoiding Sulfur and Chlorine

Stamping, grinding and cleaning fluid selection is particularly important. Any amounts of sulfur or chlorine will damage carbide. These elements leach out the cobalt binder, weakening the tool structure. Once the tool is exposed to these elements, damage begins and continues even after the tool is put on the shelf. Avoid common tap water unless it is purified. Use de-ionized water when mixing stamping, grinding and cleaning fluids.

Application-Related Problems & Considerations

- Stripper Related Considerations
- Ball Lock Ball Bounce Concerns
- Punch Stagger Recommendations

Punch-Matrix Alignment

Punch-matrix alignment is critical in all stamping applications. It is extremely critical when using carbide. Misalignment causes lateral loading on the punch point. Because carbide does not flex well, it will fail. Ball Lock tooling has natural misalignment inherent in its design, eliminating it as means for retaining carbide punches.

Application-Related Considerations

You must address many potential problems when stamping at high speeds. Some of the application-related considerations include stripper, ball lock ball bounce and punch stagger.

Die Construction Considerations

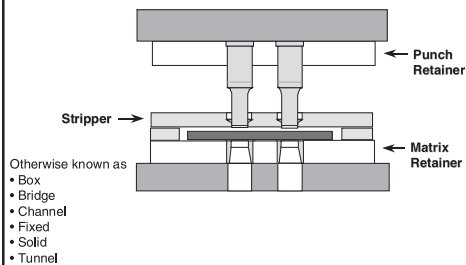
Strippers

- Fixed
- Spring

Stripper Considerations

Stamping dies require some means of stripping the part from the end of the punch at withdrawal. You can accomplish this by incorporating one of several types of strippers. The common types for high-speed stamping applications are Fixed and Spring.

Fixed Stripper Open



Fixed Stripper

Fixed strippers are generally not recommended for high-volume or high-precision applications. But they have a niche in high-speed applications. Because they have no moving parts, fixed strippers keep up with unique demands associated with high-speed stamping.

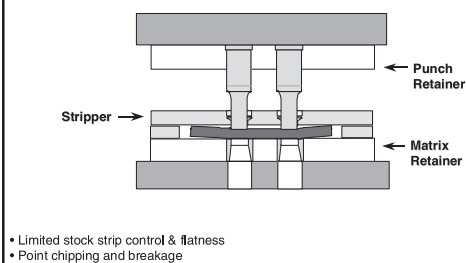
Fixed strippers go by many names including:

- Box
- Channel
- Solid
- Bridge
- Positive
- Tunnel

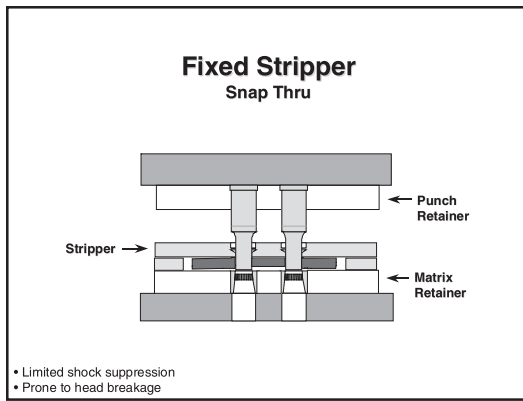
A fixed stripper is a steel plate with a clearance slot that allows the part material to pass under it. This plate mounts to the die retainer in a fixed position. Clearance holes cut through the stripper plate let the punches extend through without interference. At withdrawal, the part material hits the bottom of the stripper to prevent the material from lifting as the punch retracts. The part material strips from the end of the punch or punches.

Although fixed strippers are inexpensive and easy to maintain, they have several drawbacks. They do not hold the stock strip flat, and are unable to absorb impact and snap-thru shock. The result is poor part flatness and premature punch failure.

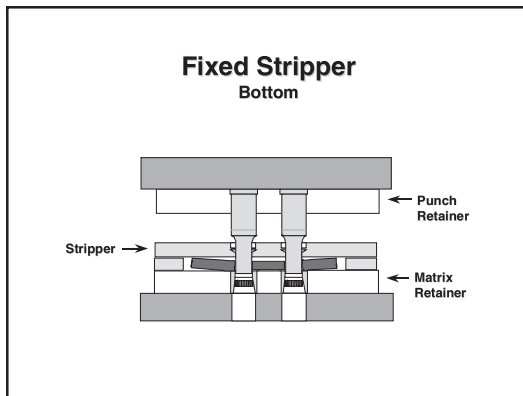
Fixed Stripper Impact



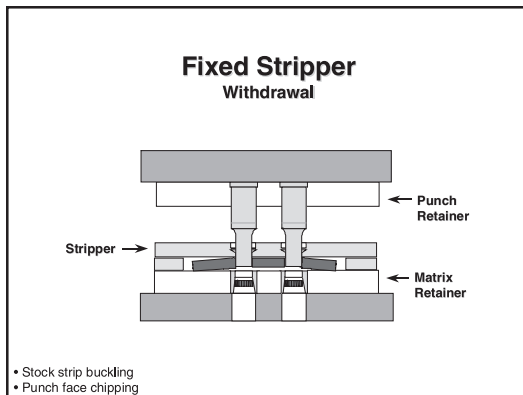
The clearance under a fixed stripper is commonly set at 1 1/2 times the part material. This clearance allows considerable part material deformation under the punch points resulting in punch point chipping. That deformation can also cause lateral movement of part and punches, resulting in punch point breakage and poor part quality.



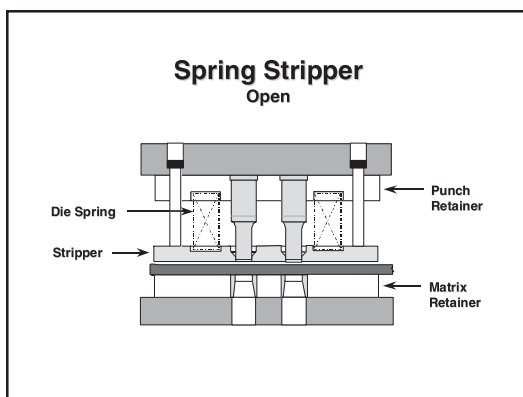
The sudden unloading of pressure on the punches and part material at snap-thru generates shock. This shock can lead to punch head breakage.



Despite the disadvantages of a fixed stripper, there is no limit to how fast the press can run before they become ineffective.



At withdrawal, the part material tends to buckle. This buckling binds the part on the ends of the punches, increasing stripping pressure and potentially chipping the punch face.

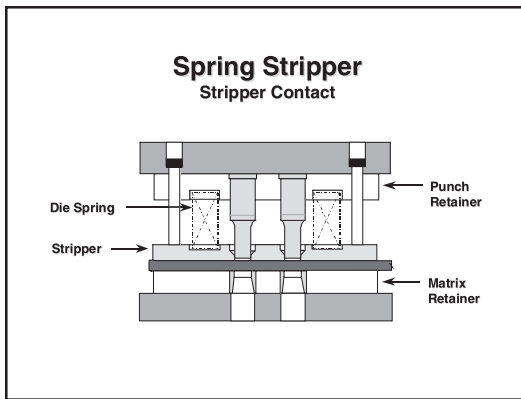


Spring Stripper

Spring strippers offer superior performance.

Their main advantage is that as the die closes, the stripper holds the stock strip, or part, flat in place during perforation and stripping. The stripper prevents the part material from lifting or hanging up on the punches.

Use spring strippers in applications up to 1000 strokes a minute.

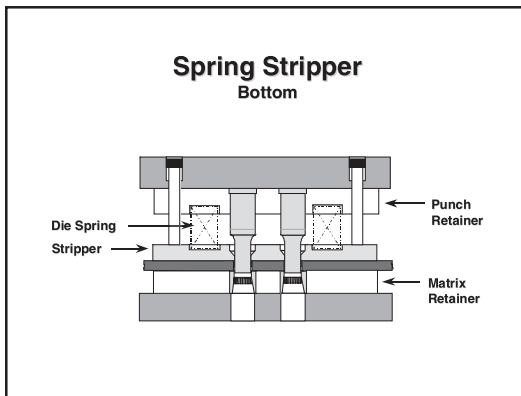


When a spring stripper hits the part material it bounces. At high speeds it may not settle on the part before withdrawal, preventing it from holding the part flat and in proper location.

Reducing stripper weight reduces bounce and greatly improves its ability to respond.

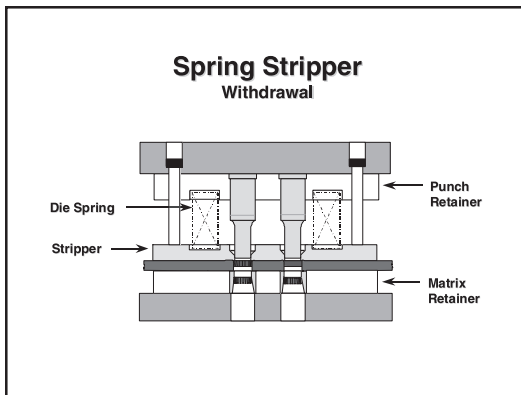
There are two ways to reduce weight. One is to use lightweight materials such as aluminum, inconnel, or titanium. Because inconnel and titanium have great strength, you can reduce stripper size, further reducing weight.

Removing material from the stripper is another way to remove weight. Drilling holes through the stripper is one of the most effective ways to remove material. Round holes are easy to drill while having minimal effect on stripper strength. Chamfer these holes on the bottom side to prevent the stripper from marking the part. Strategically placed holes can also provide venting of the air from between the stripper and the part to further improve the stripper's ability to respond.



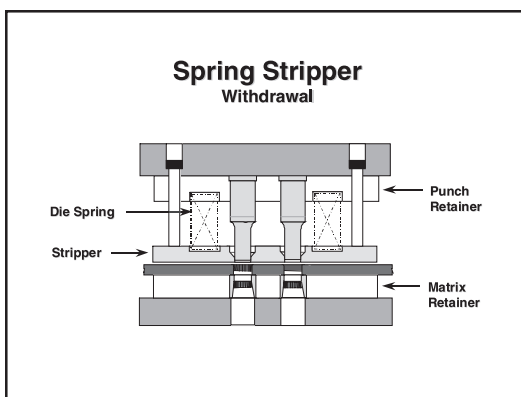
A spring stripper absorbs shock at snap-thru and eliminates shock at withdrawal that would otherwise damage the tooling and possibly the press.

In high-speed applications, keep stripper travel to a minimum. This improves the stripper's ability to respond.

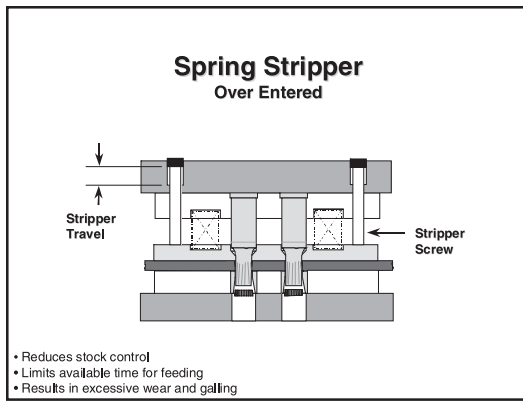


The main purpose of a stripper is to pull material from the ends of the punches. This function occurs at the withdrawal phase of the perforating process.

Stripping force varies based on part material type and thickness as well as punch-to-matrix clearance. This force can range from nearly zero to as much as 25% of the force required to perforate the initial hole. Most applications do not exceed 10% of the perforating force.



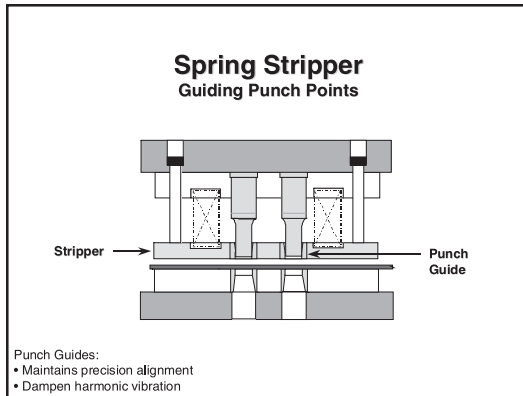
Because the stripper lifts away from the part material after each stroke, visual monitoring of the die performance is made easy. At high speed, a strobe light can be used to monitor the die.



Over entry or closing a die below its recommended shut height can have catastrophic consequences.

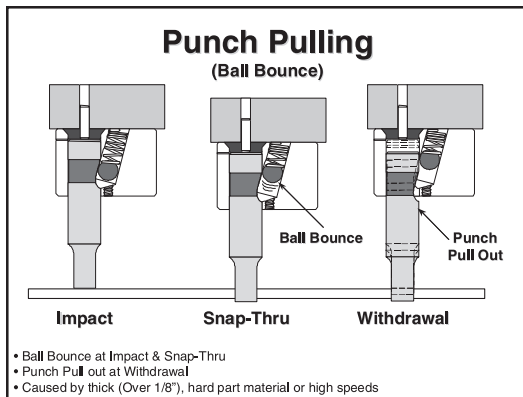
Excessive stripper travel at high speeds:

- 1) Causes it to bounce and limits its ability to respond.
- 2) Reduces the amount of time available for feeding the stock strip.
- 3) Results in excessive punch wear and galling.



High-speed stamping applications typically deal with thin part material. Clearances are small and must be accurate. Punch guides commonly mounted in a guided spring stripper maintain this accuracy.

Guides also dampen harmonic vibrations, which can build up at high speeds.

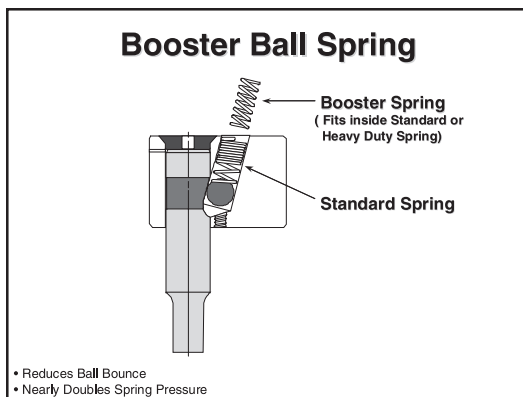


Punch Pulling and Ball Control

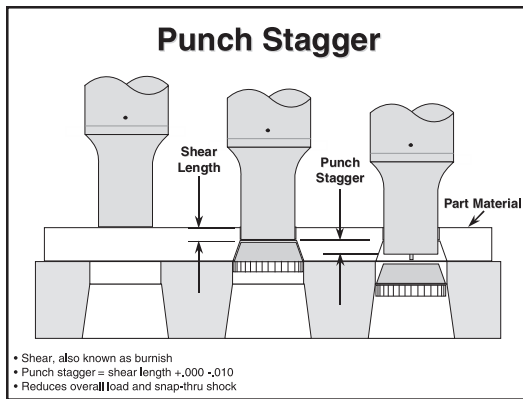
Ball Lock can also be troublesome when punching hard materials. The shock generated at impact and snap-thru can cause the ball to bounce. Ball bounce can also occur in high-speed stamping applications where press speeds are above 250 strokes a minute.

Ball bounce creates two problems. One is the bouncing action eventually causes the ball to fatigue and break. The other problem is punch retention. If the ball is broken or the ball spring pressure does not seat the ball against the punch before withdrawal, the punch falls or is pulled from the retainer.

Avoid Ball Lock carbide tooling in high-speed stamping at all cost. Carbide tooling requires accurate alignment, which is limited when using Ball Lock components.



You can reduce ball bounce by using a heavy-duty and/or a booster spring in the retainer. Heavy duty and booster springs are only available for heavy-duty retainers only.



Punch Stagger

Punches can be staggered in length to minimize impact and snap-thru shock. You can split punch lengths into two or three groups, reducing impact and snap-thru shock by half or third.

Common practice is to stagger the different groups of punches by an amount equaling stock thickness. Although this reduces the initial shock, it does not reduce the total shock. Each punch or group of punches is exposed to both impact and snap-thru shock.

Making stagger equal to or slightly less than burnish length in the hole being perforated greatly reduces impact and snap-thru shock. This amount of stagger allows the next group of punches to contact the material prior to the first group snapping thru. The snap-thru energy from the first group of punches is absorbed and used to drive the next group of punches through the part material.

Using burnish length instead of material thickness as the amount of stagger is extremely important in high-speed stamping applications. It reduces punch entry to minimize punch wear and slug pulling. Because the punches withdraw from the stock strip sooner, you also gain more feed time.

For More Information...

For additional assistance or other technical support, feel free to contact any of our offices listed on the back of this report. Or check out our website at www.daytonprogress.com

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