SOLVING PUNCH HEAD BREAKAGE PROBLEMS

Punch head breakage can be a serious problem, especially in heavy punching and high-speed work Punch compression occurs during cutting operations. Rapid strain rates that occur in high speed stamping may increase the punch-cutting load from the normal shear strength to a value approaching the ultimate tensile strength.

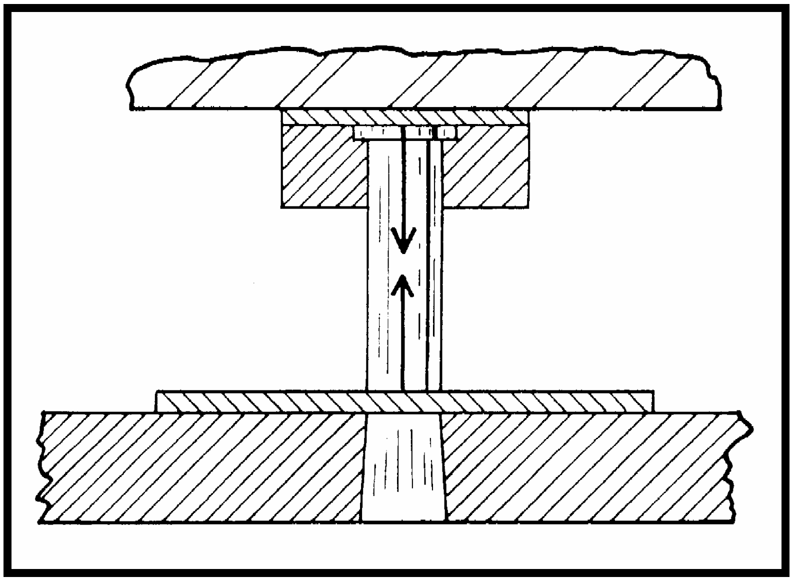

Figure 1. Punch compression occurs during cutting operations. *Smith & Associates*

Factors That Contribute to Punch Head Breakage

High stripping loads often contribute to head breakage. However, extremely high stripping loads alone cannot pull the head off the punch. The amount of stripping force depends on several factors. These include:

1. Type and thickness of stock.
2. Lubrication used.
3. Any galling or metal pickup on the punch.
4. Sharpness of punch and die.

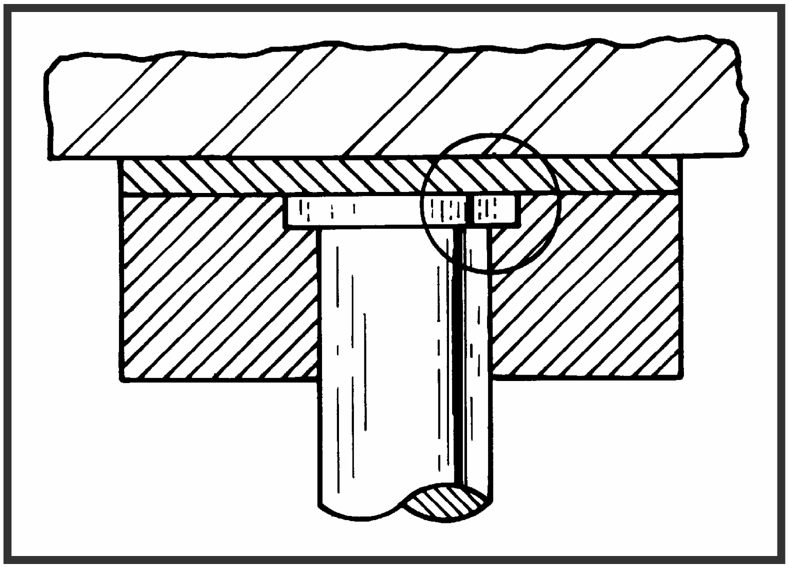

Figure 2. Head breakage problems usually start at the step where the head and punch body join. *Smith & Associates*

Depending on the speed and severity of the work, another head failure mode, is breakage due to extreme compressive forces and load reversal. This is especially a problem in high-speed operations and when cutting heavy stock. Please note that it is not possible to pull on a sound punch with enough stripping force to cause a tensile failure. Cyclical loading and crack propagation is the usual failure mode. Figure 2 illustrates the part of the punch where the failure starts.

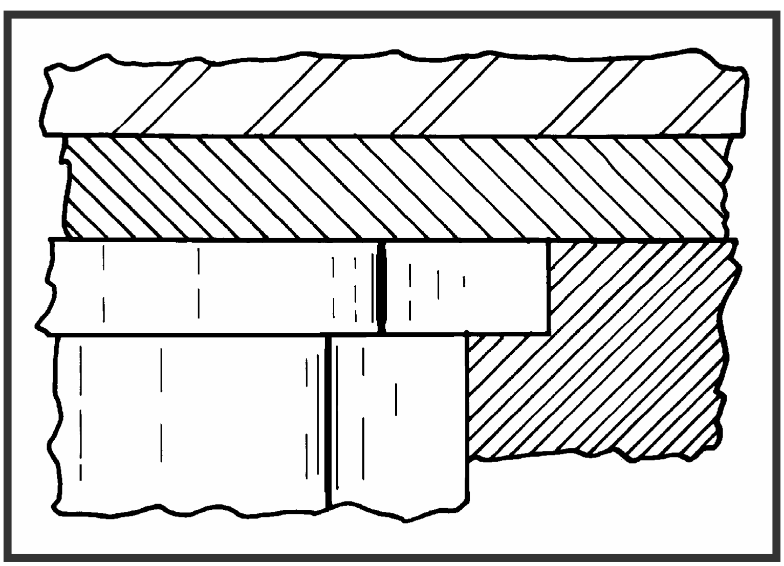

Figure 3. Close up view where the head and punch body join. *Smith & Associates*

Figure 2 illustrates a view of a punch head in a retainer having a hardened tool-steel backing plate. Typically, the backing plate is heat-treated for toughness to 38 to 45 RC. See Figure 3 for a close-up view. In good designs, the punch and retainer should have a small radius or relief to accommodate an unavoidable radius in the corner where the punch head joins the shank body.

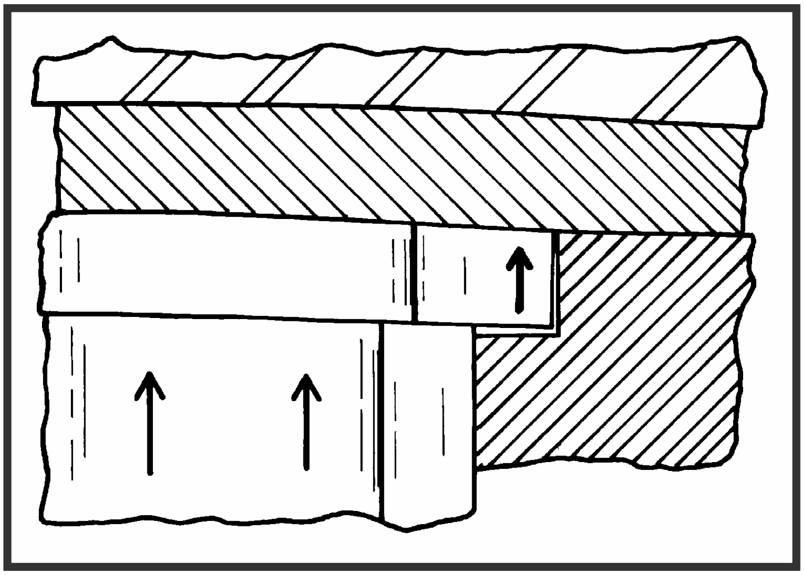

Figure 4. Deflected Punch head is deformed and compressed into compressed into the backing plate. *Smith & Associates*

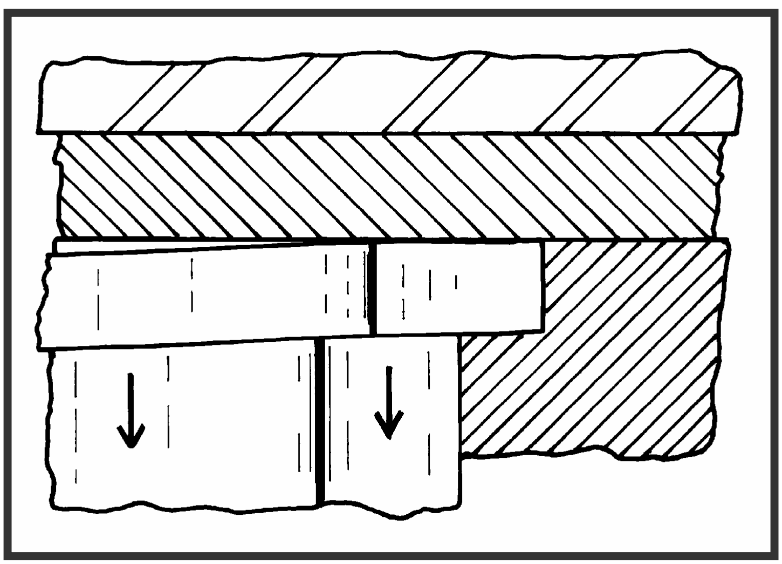

Figure 5. Compressive strains release as the punch cuts through the stock and stripping occurs. This results in a tensile strain on the punch head. *Smith & Associates*

Punch Head Flexure and Crack Formation

As the punch cuts through heavy metal, compressive strain occur in the punch body, backing plate and die shoe. This results in deflection or bending of the punch head shown in Figure 4.

At break through, there is a recoil action resulting in a tensile strain concentrating on the punch head shown in Figure 5. Repeated flexure of the punch head can result in crack formation at the juncture of the punch head and body.

Crack Growth or Propagation

Once a crack forms, continued operation under high cyclical loading is almost certain to cause the crack to grow larger. The ultimate result often is complete separation of the punch head from the body.

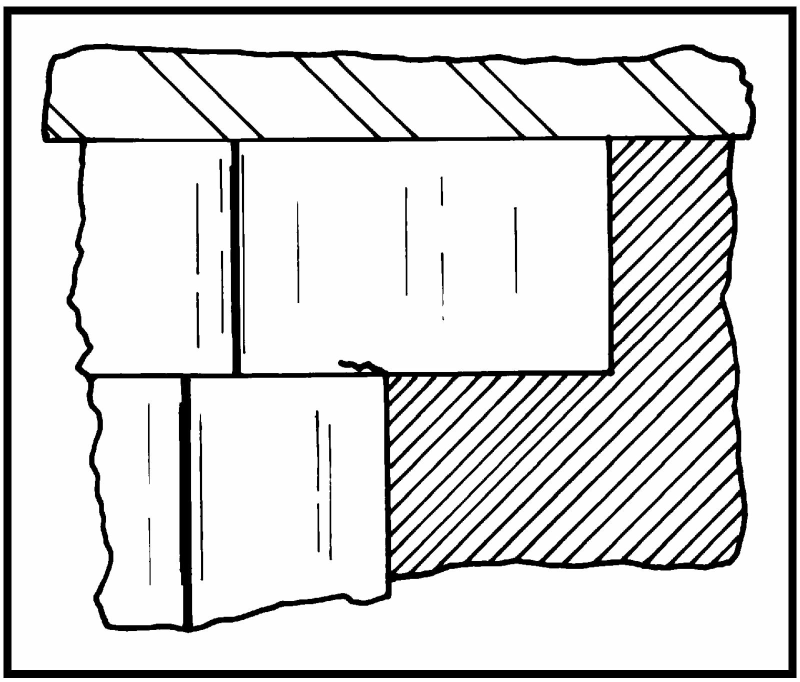

Figure 6. Stress concentration at the juncture of the punch head and body under heavy cyclical loading can result in crack formation. *Smith & Associates*

If the head separates from the punch body, it can fall out of the retainer while the press is being cycled. If this occurs, severe die damage can result. In addition to the pressworking equipment, damage there is a great possibility of serious injury to pressroom personnel. The punch and other tool steel die components may shatter, causing sharp fragments to become airborne at high velocity. Serious or fatal injury to pressroom personnel has occurred in this way.

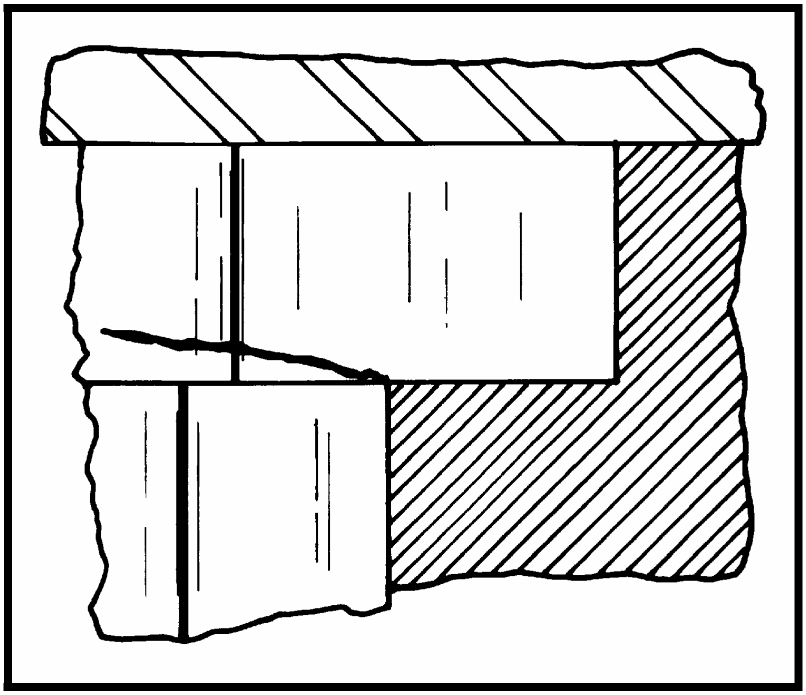

Figure 7. Stress concentration at the juncture of the punch head and body has caused crack formation. Continued operation results in crack propagation. *Smith & Associates*

Safety of Personnel Requirements

The main emphasis of pressworking safety regulations involves keeping body parts out of the point of operation during pressworking operations. Safety distance, guard opening sizes and other safeguarding measures address this aspect of safety of personnel.

All pressroom injuries are avoidable by proper process planning, process control, employee training and following good pressworking practices. Good safety practice in the case of dies that can shatter and eject objects requires a physical barrier guard. This needs clearly stated in all government and insurance safety regulations.

If there is any danger that this can occur in a pressworking operation, a physical barrier guard is necessary. Clear plastic of sufficient thickness and strength to arrest any airborne shattered die components is a solution that may work in some cases. If this is insufficient, solid steel guards of adequate strength may be required. Figure 8 illustrates complete seperation of the punch body from the head.

Addressing the Root Cause of Punch Head Breakage

Designs are available that resist head breakage. These measures are usually effective in eliminating the head breakage problem. The punch head should be a slight interference fit in both the retainer hole and counterbore. The head thickness should also be slightly thicker than the counterbore depth. Keeping these parts tight will prevent breathing and movement.

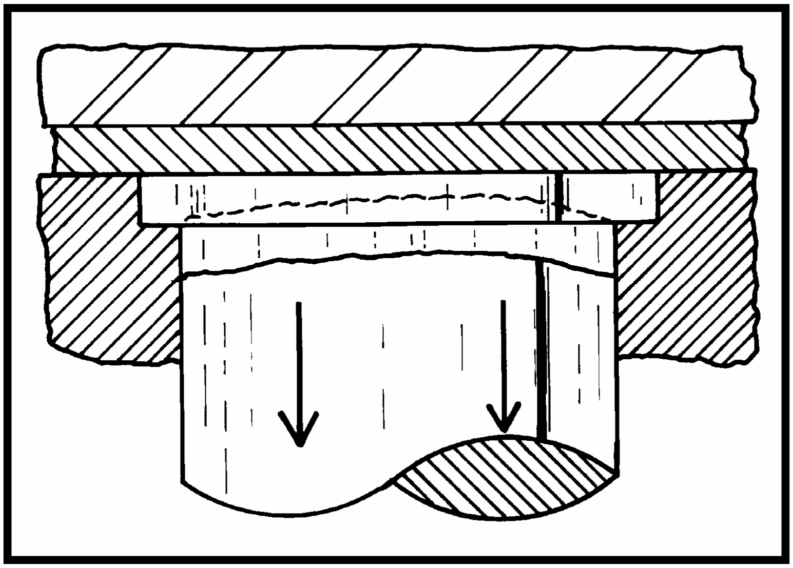

Figure 8. Complete separation of the punch head can result in the punch falling out of the holder. This can result in die damage and injury to personnel. *Smith & Associates*

Function of Punch Backing Plate

The purpose of the backing plate is to provide a hard surface to back-up the punch. A frequently used backing plate material is oil hardening gage stock. The usual practice is to heat treat the backing plate approximately 38 to 45 Rockwell "C" to provide for toughness and wear resistance. This hardness is in the spring temper range giving long flexure life.

Some experts consider this hardness range to provide the best vibration damping capacity. The damping capacity of steel is low in both the hard and soft state. In any case, the backing plate, properly heat-treated, serves to spread the load over the underlying plate without cracking.

As shown in Figure 4, the punch head will compress into the backing plate. The backing plate in turn will compress into the die shoe. This Compression occurs each time that the punch penetrates the stock. Recoil as shown in Figure 5 occurs as the punch breaks through the stock.

Solutions to Head Breakage Problems

Figure 9 illustrates two simple solutions that will eliminate all but the most serious head breakage problems. The first modification is to grind a slight back angle on the head to permit the punch to compress into the backing plate without flexing the punch head.

The second improvement is to provide a generous radius at the head to body juncture. This will reduce the stress concentration in this area when punch recoil occurs at breakthrough.

Implementing Head Modifications

If head separation as shown in Figures 6, 7 and 8 is not a frequent occurrence, grinding an angular taper around the head as illustrated in Figure 9 is simple to accomplish for round shank punches. The angular relief recommended is approximately 3º to 6º and leaves a flat surface in the middle the same size as the shank diameter.

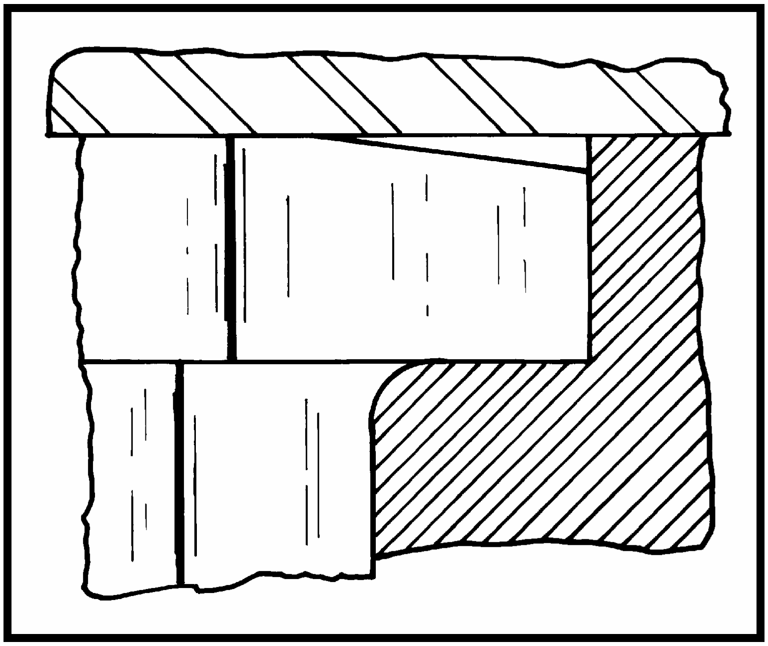

Figure 9. A back angle on the punch head and a large radius at the juncture of the punch head and body reduce stresses. This solution will solve most head breakage problems. *Smith & Associates*

Grinding the angle is a simple procedure. These methods include:

1. The use of a cylindrical grinder.
2. Using a lathe with a tool post grinding attachment.
3. Grinding the tapered land with a simple “whirligig” hand actuated spinning fixture using a surface grinder.
4. Many universal cutter grinders can hold punch shanks and grind the taper easily and quickly.

The Application of a Stress Reducing Head Radius

If the radius shown in Figure 9 is required, a new punch must be made. The retainer must have clearance for the radius. If the punch retainer is heat-treated to no more than 48 Rockwell "C", it should be possible to machine the radius in the retainer with a high-speed steel or counterbore.

These are easy for a skilled cutter grinder or toolmaker to make from drills, milling cutters and existing counterbores. Carbide counterbores are excellent for this work. However, a jig grinder, inside diamater (ID) grinder or conventional electrical discharge machining is another option.

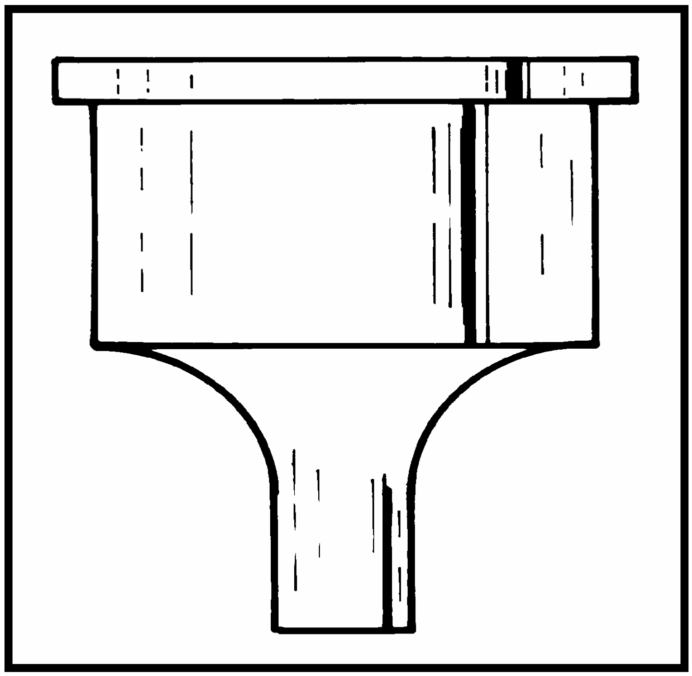

Figure 10. A large body to point diameter ratio is an effective but expensive solution. It also limits how closely punches can be spaced together. *Smith & Associates*

Increasing the Ratio of the Head to the Point

Another solution is to make the body and head diameter much larger than the point. This effective solution usually will work if other methods fail. There are two drawbacks to this solution. A large diameter, expensive tool-steel blank is required. The large head diameter limits how closely together punches can be spaced.

Ironworker and Bulldozer Punching Style Punches

The ironworker style punch has been in use for many years in portable equipment used to punch rivet and bolt holes in heavy plate and structural members. A modern ironworker is a special type of steel fabricating machine capable of cutting steel bars, punching holes cutting off steel angle and bending operations. Mechanical bulldozers have also made use of this type of punch.

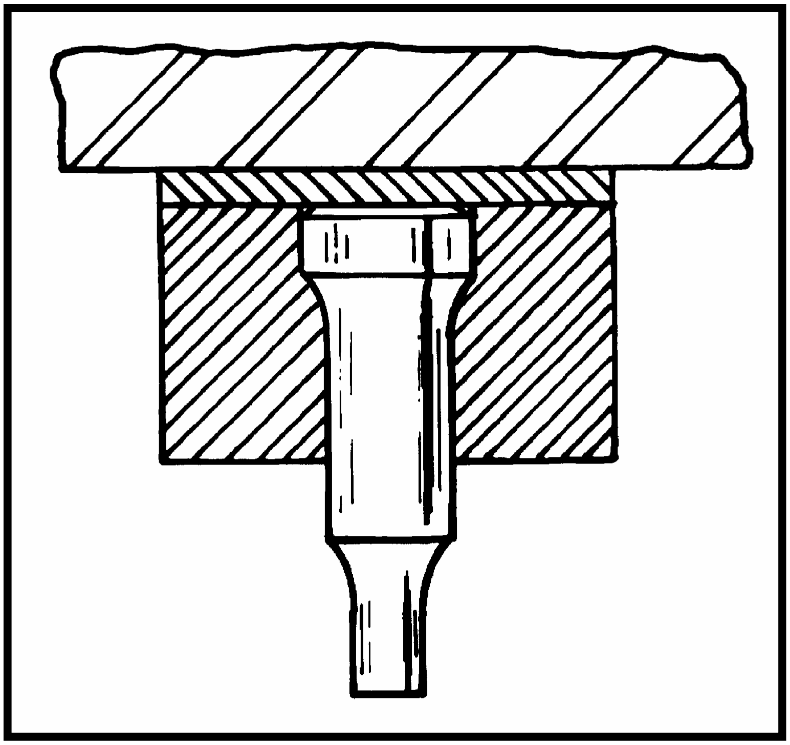

Figure 11. An "Ironworker" style punch is a very old design. This design avoids stress concentrations in any area of the head. *Smith & Associates*

Mechanical bulldozers originated in the middle of the nineteenth century as essentially a powerful C-frame press placed on its back. The early mechanically driven machines were typically double or triple back-geared and, hence capable of exerting great forces. The design found widespread application in all sorts of heavy plate fabrication such as punching rivet holes and bending operations. Metal working bulldozers were in use before the development of the familiar earth-moving bulldozer.

The derivation of this design date to punch head types used for boiler shell and other fabricated wrought ironwork in the nineteenth century. The design probably evolved at the hands of clever blacksmiths who produced simple tooling for this type work. The advantage of this style punch is the reduction of stress concentration as much as possible in the head configuration.

The design is both economical to produce and seldom fails under heavy punching loads. A disadvantage, when applying the design to pressworking tooling, is the need to use a punch retainer that may not be readily available.

Many good punch designs for modern ironworker simply use a generous angle rather than a sweeping radius. These have proven to avoid the punch head breakage problem in heavy steel fabrication work.

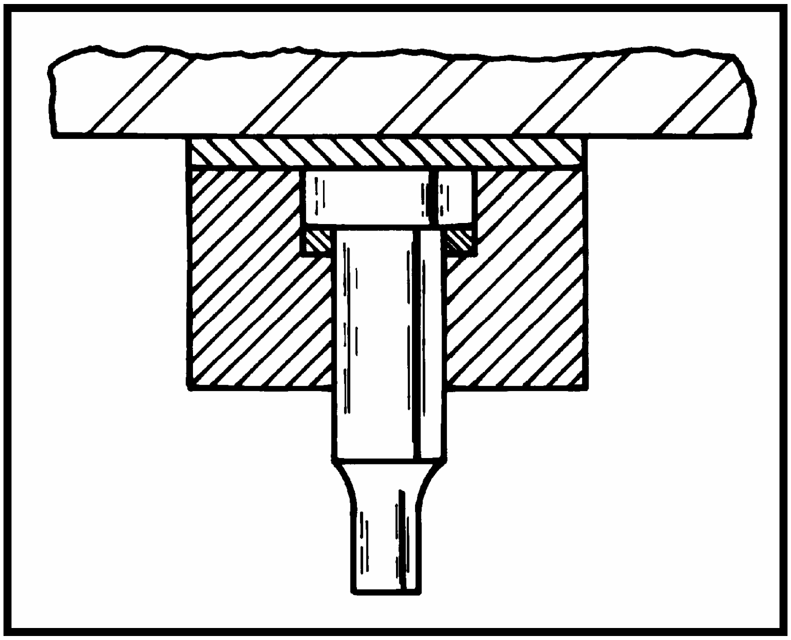

Figure 12. An elastomer washer placed under the punch head as a means to reduce shock. This method has been tried a number of times with very limited success. The elastomer material tends to break down and extrude out around the punch shank.
Smith & Associates

Elastomer Washers

Attempts to place elastomer washers under or around the punch head as a means to reduce shock have limited success. This method has been tried a number of times with very limited success. The elastomer material tends to break down and extrude out around the punch shank.

NOTES: ____