MACHINING

Level - III

Learning Guide 7

Unit of Competence: Perform Advanced Press Operations

Module Title: Performing Advanced Press Operations

LG Code: <u>IND MAC3 07 0217</u>

Instruction Sheet	Learning Guide #1

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Determine work requirements
- Prepare and perform press machine for operation
- Monitor machine/process

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Drawings, work instructions and specifications are interpreted and task is understood including press machine/process selection and settings due to requirements
- Machine/process is operated in accordance with job instructions or standard operating procedures.
- Machine/work processes are monitored for safe and correct operation

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 55.
3. Read the information written in the information “Sheet.
4. Accomplish the “Self-check test.
5. Do the “LAP test”.

What Is a Press?

One of the most efficient methods for making metal parts is metal forming. Metal-forming processes rapidly shape thin sheets of metal by pressing the metal between two plates. These processes can bend the metal, punch out holes, or even create impressions like the face of a coin.

The press, shown in Figure 1, is the common machine used in metal forming. The top section, or the ram, is forced down toward the base of the machine. Both of these components hold special metal plates that bend, puncture, or shape the metal as they close. The parts in Figure 2 were made on the press.

You may be familiar with how other presses work, such as the printing press or a flower press. Some of the same ideas apply to metalworking, except there are much larger forces. Many things we use daily are the product of metalworking processes. Bicycles, cars, buses, and planes are made of parts that have been formed from sheet metal.

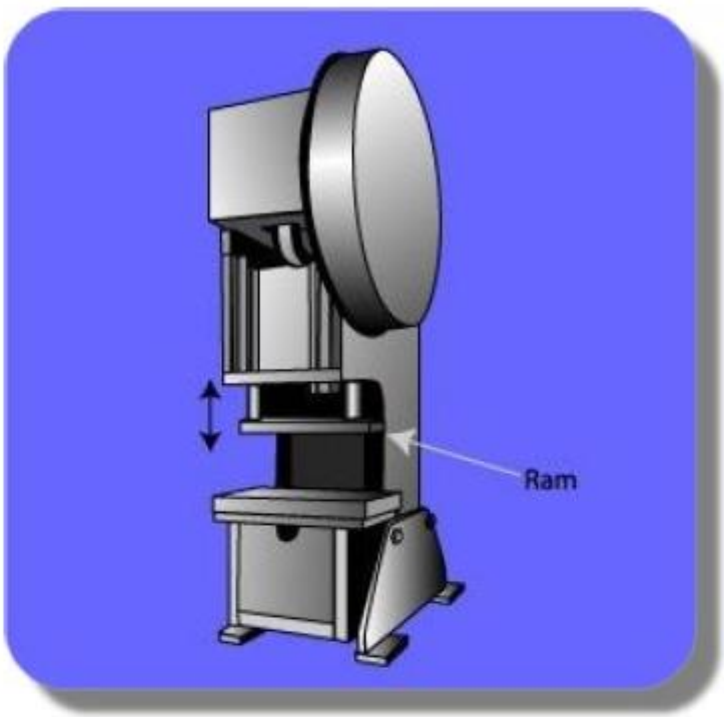


Figure 1. The ram of a press repeatedly moves up and down.

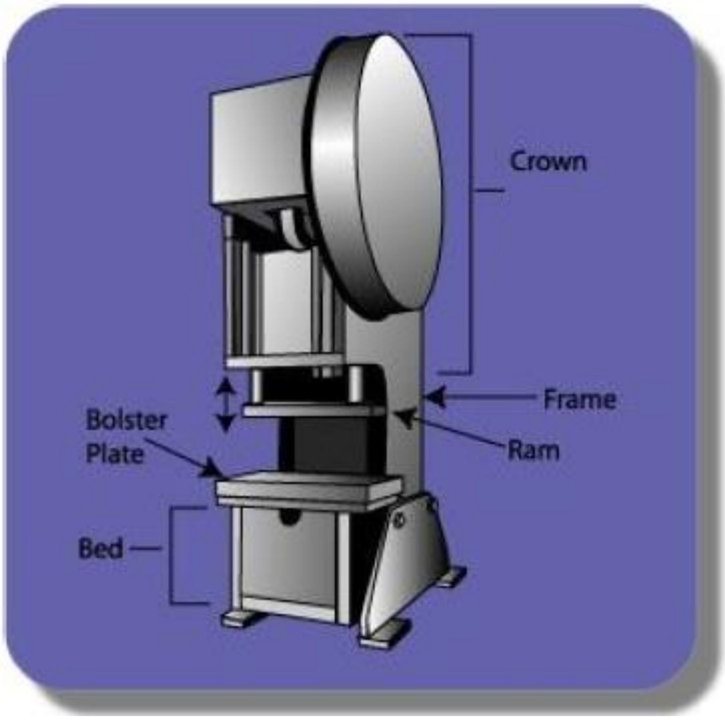
Figure 2. These parts were separated from the copper strip on a press.

The Major Press Components

Figure 1 shows the major components of a basic punch press. The frame is the support structure of the press. This frame is divided into the upper section, called the crown, and the lower section, or **bed.**

The crown contains the power source or motor, which drives the reciprocating up-and-down motion of the ram. When the press is operating, the ram can be observed moving up and down. This motion is called the **stroke.**

Directly underneath the ram are the bed and the **bolster plate.** The bed acts as the foundation for the entire machine. The top of the bed often contains holes to leave room for removed sections of metal. The bolster plate is secured to the top of the bed, and it conceals large portions of these holes. Each operation requires specific tooling components, which are clamped to the ram and bolster plate.



The Die Set

The ram and the bolster plate are essentially
permanent components of the machine. They are rarely changed. However, every type of press operation requires its own unique **die set** that matches the operation. This die set is attached to the ram and bolster plate, as shown in Figure 1.

Figure 2 illustrates the basic die set. The die set consists of the upper **die** shoe and **lower die shoe,** which are both shown in Figure 3. The die shoes are metal plates that open and close as the ram raises and lowers the upper shoe. Strips of sheet metal pass between these two shoes as they open and close.

The actual cutting and shaping of the metal is performed by the punch and **die.** The upper shoe holds the punch, and the lower shoe contains the die. The punch is forced into the sheet to either cut or shape it. The die contains the opening that matches the punch.

Figure 1. The die set is positioned between the ram and t bolster plate.

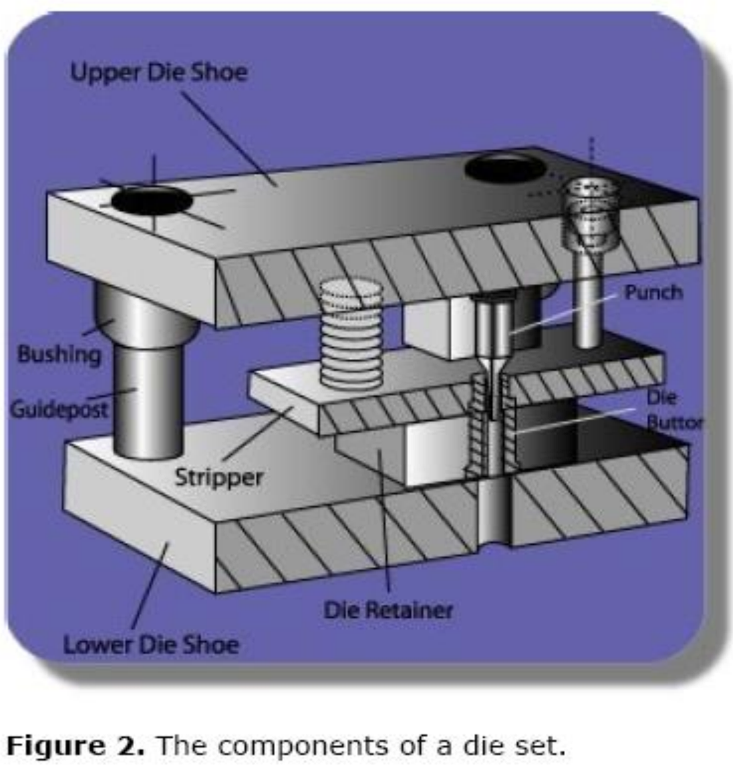


Figure 2. The components of a die set.

Figure 3. Disassembled upper and lower die shoes.

The Operation of a Press

During the operation of a press, drive mechanisms power the up-and-down motion of the ram, as shown in Figure 1. This action opens and closes the upper and lower die shoes. As the press operates, the strip of sheet metal passes between the two die shoes. As you can see in Figure 2, the punch enters the metal sheet and cuts it. The removed section passes through the opening in the die.

Sheet metal-forming processes are similar to cutting out cookies. While cutting cookies, you are the power source. Your arm repeatedly moves up and down, much like the ram. Your hand serves as the end of the ram as it holds the cookie cutter. When you have reached the table and the bottom of your stroke, a cookie that needs baking is formed. The tabletop supports the operation, similar to the bolster plate. Like the cookie cutter, the die determines the shape of the part

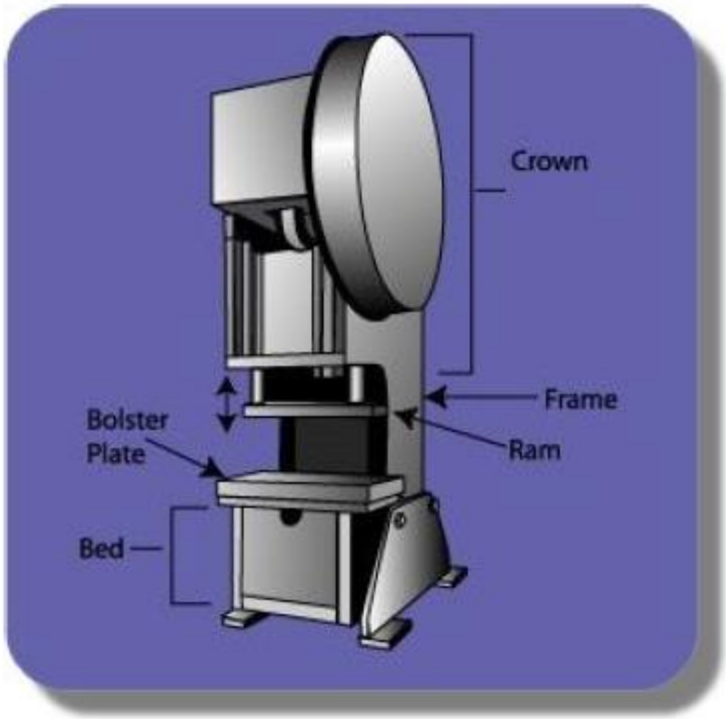


Figure 1. The ram is in constant motion during operation.

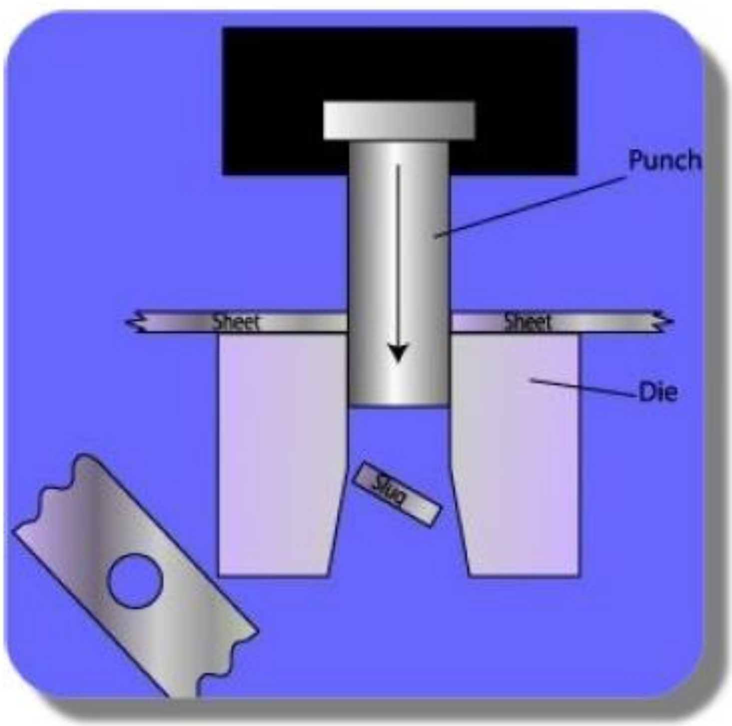


Figure 2. The typical operation is performed by a punch and die.

The Gap-Frame Press

A distinguishing characteristic of the press is the shape of its **frame.** Structurally, the press frame absorbs the shock of the operation. It also determines limitations on the size and type of work, as well as methods for loading and unloading.

One of the more common presses is the gap-frame press, which is shown in Figures 1 and 2. You may also see this machine called a C-fran'ie **press** because its frame is shaped like the letter "C." The gap-frame press is very versatile. The open frame makes the die set easy to access for numerous operations. Certain gap-frame presses are inclinable. In other words, the bed and frame can be tilted backwards to encourage parts to slide off after separation. You will see these presses referred to as **open-back inclinable** (OBI) presses.

Unfortunately, the versatility of the gap-frame press reduces the sturdiness of the frame. Over time, the gap-frame press will likely experience some deflections as the forces start to bend the frame. This eventually reduces the accuracy of the parts

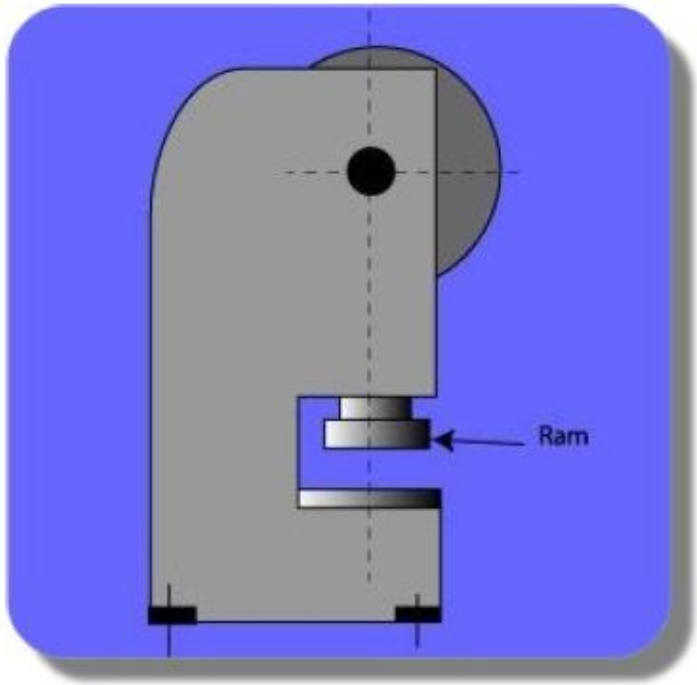


Figure 1. A gap-frame press.

Figure 2. The C-shaped frame is very accessible.

Straight-Side Press

The name of the press frequently describes the shape of the frame. In addition to the gap-frame press, most stamping shops rely on the straight-side **press.** Figure 1 illustrates the shape of this machine.

The straight-side press has much greater rigidity than the gap-frame press. As shown in Figure 2, the straight-side press has supports in four corners. Depending on the machine, the frame is built from one solid piece of metal or is assembled in sections with tie rods.

All straight-side presses effectively keep the punch and die properly aligned during operation. This greater rigidity adds the ability to withstand larger forces. Straight-side presses are chosen for their ability to create more accurate shapes by avoiding the risk of misaligned components. This creates very accurate parts and helps tools last longer.

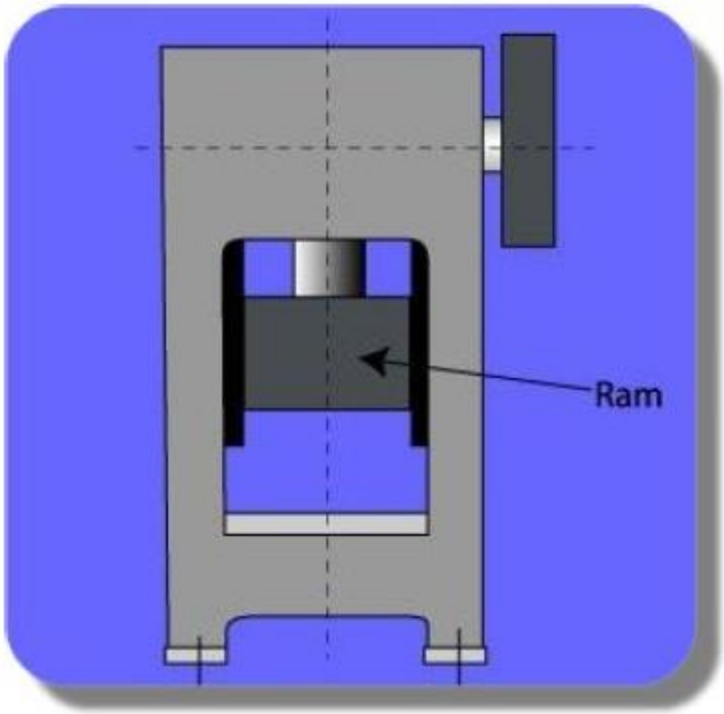


Figure 1. The frame of a straight-side press.

Figure 2. The straight-side press offers excellent rigidity.

The Mechanical Press

Presses are also grouped according to their power source, which is typically either mechanical **power** or **hydraulic power.**

The **mechanical press,** such as the one in Figure 1, uses a motor to send energy to a flywheel. The flywheel is attached to the crankshaft that forces the ram of the press to move up and down. Figure 2 illustrates this crankshaft.

Mechanical drives provide faster motion of the ram. The shape of the crankshaft determines the **stroke** of the press. Once a press is built, the length of the stroke cannot be changed. The most powerful place in the stroke of a mechanical press is at the bottom. This makes the mechanical press most useful for **blanking** and **punching** operations.

Baseball players try to contact the ball at the most powerful point in their swing. Different points of the swing have different available forces, just like the stroke of the mechanical press.

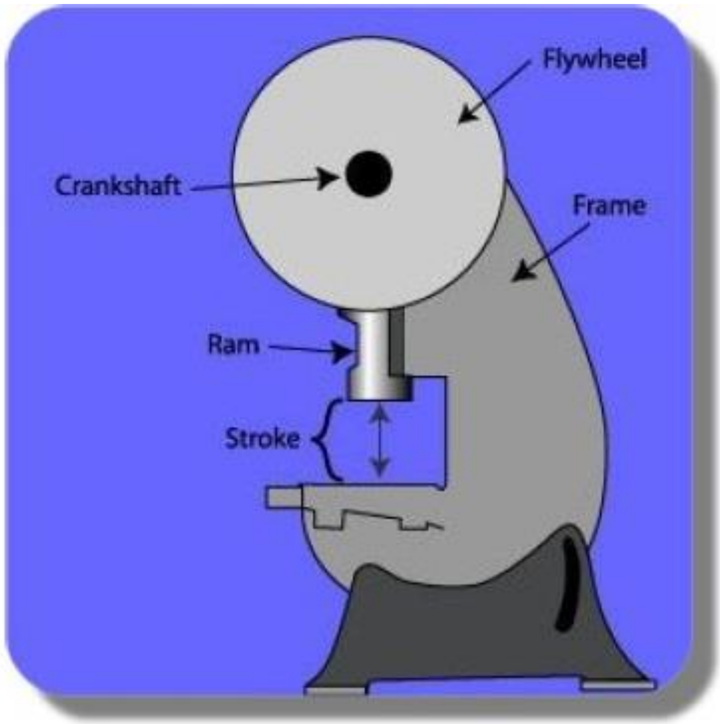


Figure 1. The crankshaft determines the stroke of the press.

Figure 2. The crankshaft powers the motion of the ram.

The Hydraulic Press

The other common type of power source is found in the **hydraulic press.** Hydraulic systems transform electrical energy into hydraulic energy, which in turn is transformed into mechanical energy by the hydraulic **cylinders in** the press. Figure 1 shows a hydraulic cylinder and piston.

The hydraulic press has a longer, slower stroke than the mechanical press. Pressure from hydraulic fluid acts on an area within the cylinder to create a steady force. In addition, forces can be more accurately controlled since the ram produces a steady force throughout the stroke. Hydraulic presses are very useful for **deep** drawing operations because of this slow, uniform application of force.

Unlike a baseball swing, the hydraulic press is more similar to a series of pushups. Your arm muscles exert a more constant force as you raise and lower yourself from the floor.

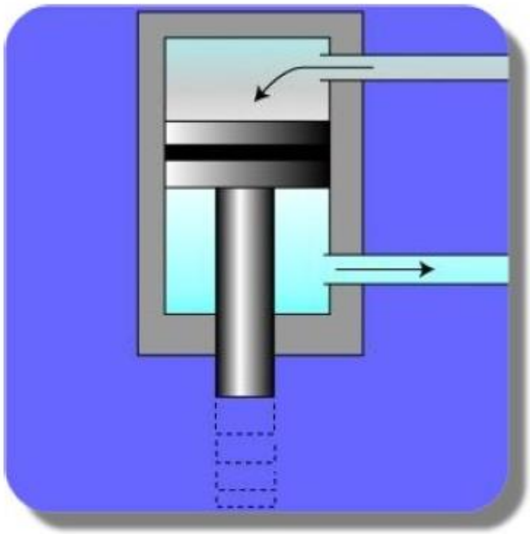


Figure 1. Fluid pressure controls the motion of the ram.

Figure 2. A hydraulic press.

Capacity of a Press

The **capacity** of the press is the ability to deliver enough force necessary to perform the metalworking operation. The capacity is generally expressed in tons, kilo Newton (kN), or meganewtons (MN). For mechanical presses, the press capacity is the force that the ram is able to exert near the bottom of the stroke. Flywheel speed influences the output capacity. Hydraulic presses exert the same force throughout the stroke. The capacity is determined by the pressure generated within the cylinder. Figures 1 and 2 compare these power sources.

The physical size, the strength of the components, and the power system of the press all influence the capacity, just like they would affect the swing of baseball sluggers. All presses should have their rated capacity marked in some way. Figure 3 shows such information from a press.

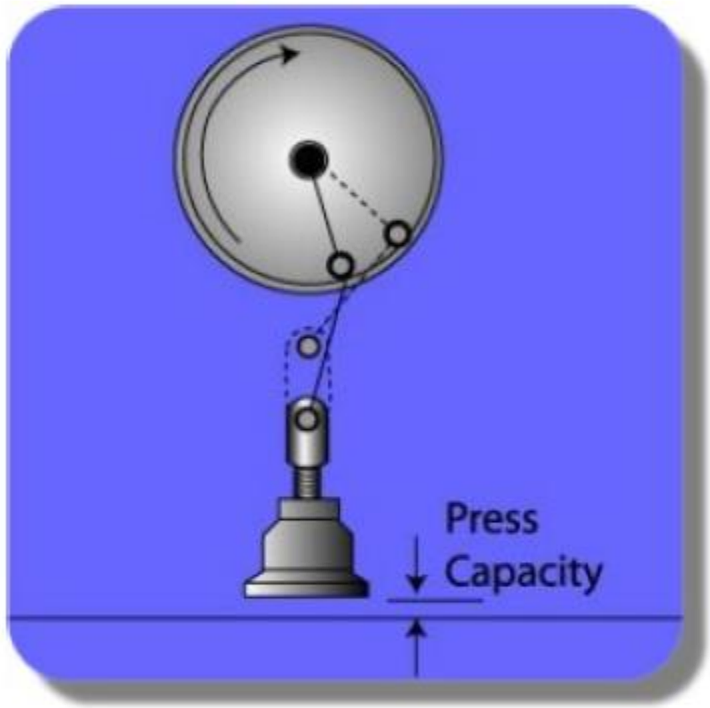


Figure 1. For mechanical presses, the greatest capacity is at the bottom.

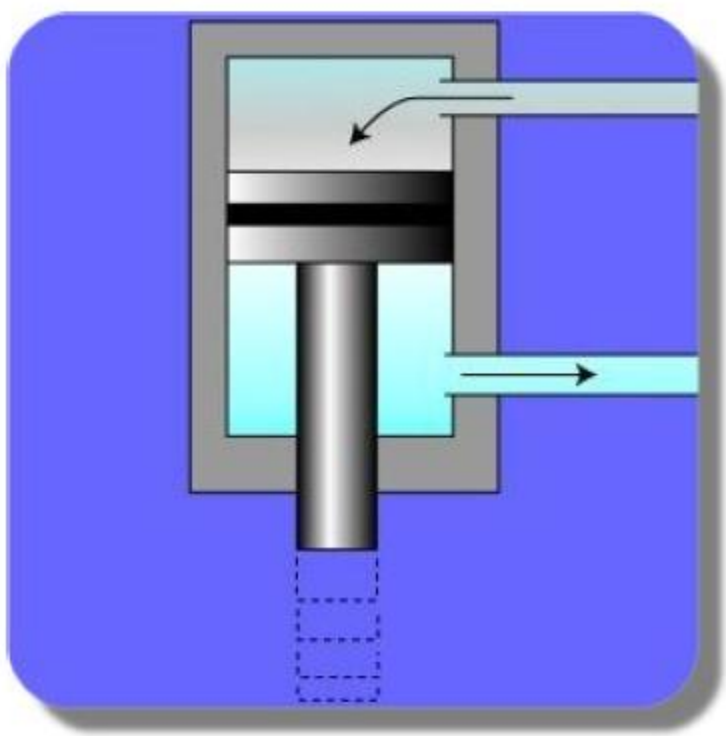


Figure 2. For hydraulic presses, capacity is equal throughout.

Range of Press Capacities

Every operation requires a certain capacity. Depending on the capacity that is needed, certain press styles will be more appropriate than others. Gap-frame presses, like the one in Figure 1, are available from small 1-ton (8.90 kN) machines up to 300 tons (2660 kN) in size. Gap-frame presses are most common up to 100 tons (888 kN). Beyond 100 tons, straight-side presses, like the one in Figure 2, are generally used. They are also available with capacities above 1250 tons (11,100 kN). The structure of the straight-side press allows for this greater capacity. Very few mechanical presses have a capacity above 6000 tons (53.4 MN). However, some hydraulic presses have capacities greater than 50,000 tons (445 MN). Hydraulic presses are capable of greater capacity due to their more compact nature.

Obviously, not all operations require the most powerful press. Parts that fit in your hand may be produced on presses of just a few hundred tons. Most high-production presses creating larger parts operate around several thousand tons


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Figure 2. A 150-ton straight-side mechanical press.

Press Forces

One of the most common operations performed on a press is punching, which is illustrated in Figure 1. During a punching operation, the idea is to apply a force greater than what the material can withstand, just like a paper hole punch applies a force with enough capacity to break through the paper. Similarly, the punch and die apply shear **forces** to the metal part. To actually cut the metal and remove a section, the shear force applied must exceed the shear strength of the metal.

However, presses are capable of performing a wide variety of operations. These operations are combined to form parts, such as the part in Figure 2. Presses are capable of cutting, bending, and compressing sheet metal. Operations such as **bending and** drawing shape the metal without actually removing a section. In this case, the shear stress applied is only sufficient to distort the metal to the desired shape without actually penetrating the sheet.

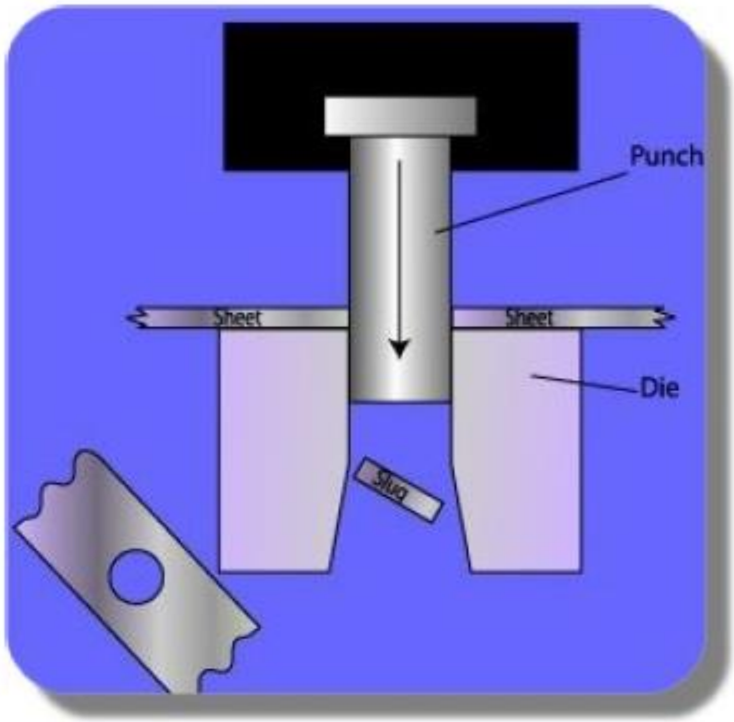


Figure 1. A punching operation.

Figure 2. This part was made by punching and bending operations.

The Press Brake and Turret Press

Many manufacturers use machines similar to the basic punch press. Other machines that are commonly used for press operations include the press brake and **turret press.**

Figure 1 shows a press brake. This machine usually has a short stroke and an eccentric **drive.** They are often used to perform a variety of bending operations in long strips of metal. The press brake is basically a gap-frame press with a very wide, narrow bed. Press brake capacities can range up to several thousand tons of bending capacity.

A turret press, like the one in Figure 2, is an impressive machine that rapidly performs a sequence of punching operations. It is used to form sheet metal that requires many different kinds of repeating slots or holes, such as the pattern shown in Figure 3. The turret press changes punches between different types of holes. Today, these machines are generally controlled by computer programs.

Figure 1. A press brake.

Figure 2. A turret press.

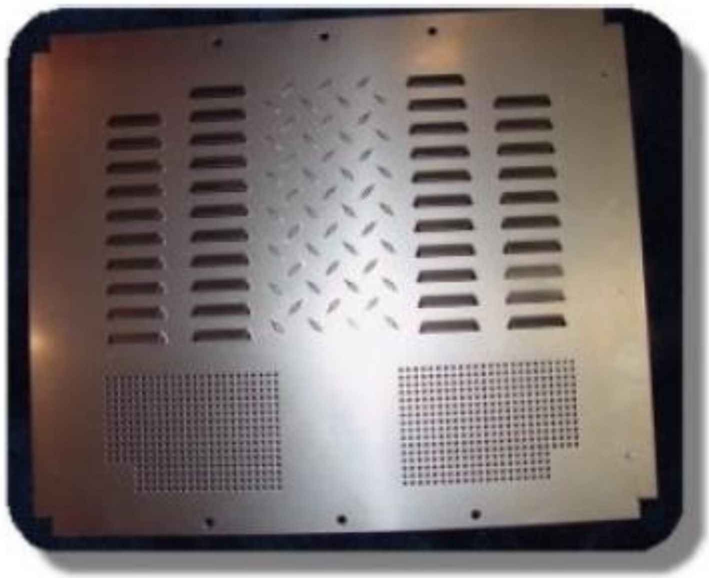


Figure 3. These complex patterns were made on a turret press.

The Arch Press and Horn Press

Other types of presses have been designed to accommodate a variety of part shapes and sizes. The arch **press is** essentially a straight-side press that has been widened at the bed. The frame of this machine is illustrated in Figure 1. This type of press can effectively accommodate larger pieces of metal. Arch presses are often used in light **blanking** and bending operations.

Figure 2 illustrates the **horn press.** This type of press is an upright open-back press that has a projecting shaft, or "horn," that replaces the usual bed and bolster plate of the press. It is generally used for forming cylindrical parts, which fit over the horn. Horn presses are often used with cylindrical objects that require seaming or flanging.

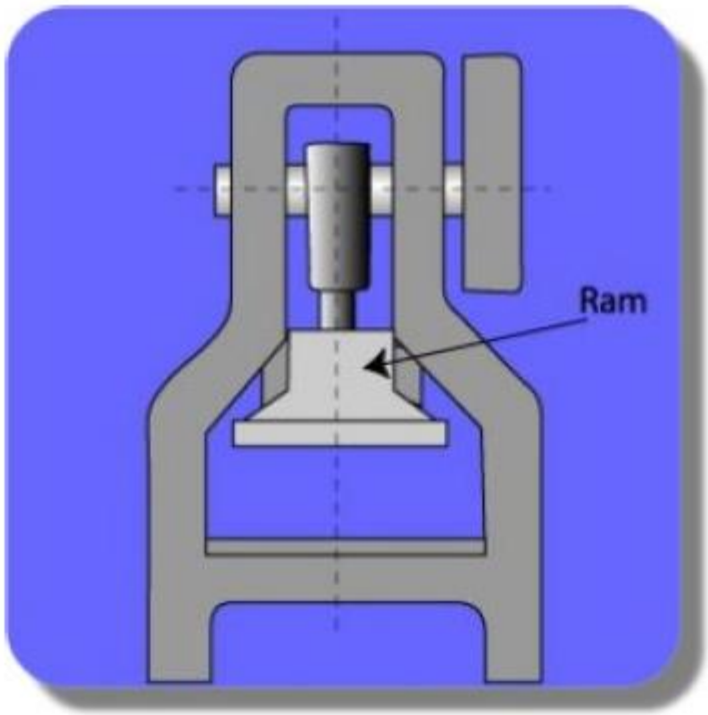


Figure 1. The frame of an arch press accommodates larger sheets.

Figure 2. Parts on the horn press are fitted over a round shaft.

The Role of Press Operations

One of the most impressive properties of metal is its ability to be shaped by forming operations. The use of machinery to shape metal provides us with an incredible variety of products, including car body panels, paper clips, cans, etc.

As a category, metal forming includes numerous operations. These operations can be divided into hot working and **cold working.** Most hot working involves the shaping of metal in bulk sizes. Most cold working involves the shaping of sheet metal or **bar stock** at room temperature. Figure 1 shows large coils of sheet metal.

The cutting and shaping of sheet metal draws considerable attention. The basic press and its cousins are capable of a wide range of operations. This class will teach you some of the most common operations performed on the press. Keep in mind, though, that literally hundreds of operations are possible. Nevertheless, the fundamentals of sheet metalworking stay the same

Figure 1. Sheet metal is sold in large coils.

Cold Work vs. Hot Work

Cold working and hot working each offer their own distinct advantages. In fact, most metal products will experience both as they are transformed throughout their manufacturing processes.

Generally speaking, hot working is used to shape bulk forms of metal, as shown in Figure 1. The temperature of the metal affects how it is shaped. At elevated temperatures, metal is easily shaped. Consequently, hot working is capable of shaping large, thick forms of metal that would otherwise be impossible. Unfortunately, hot working often results in products with

imprecise measurements, and it leaves a scaly exterior.
Because sheet metal is thin, it is easily cut and shaped by cold-working operations. Cold working results in improved accuracy and surface finish. There is no scaly surface after cold working. Cold working also adds **hardness and** strength to the metal. For these reasons, the large majority of sheet metalworking operations are performed at room temperature. Figure 2 shows parts formed by cold working.

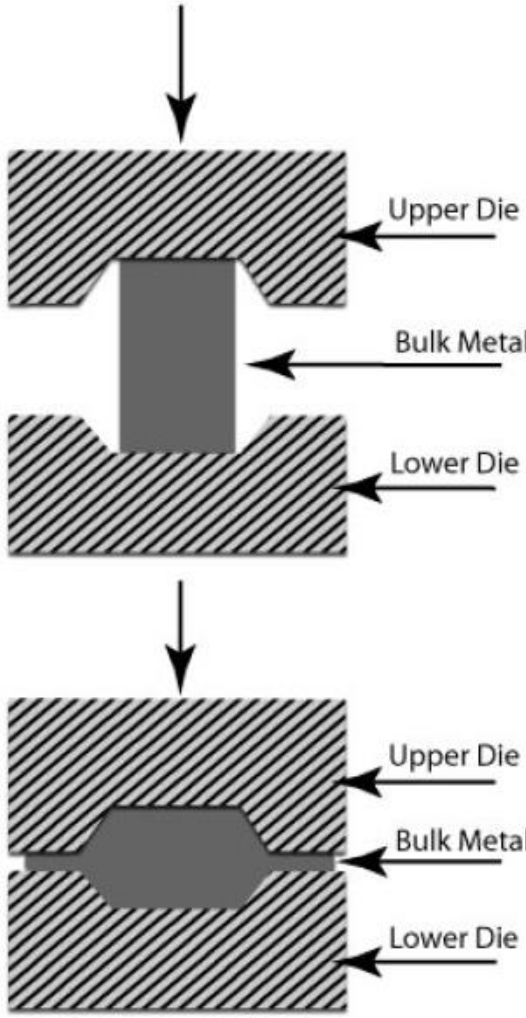


Figure 1. Bulk parts are most often hot worked.

Figure 2. These parts were made by cold-working operations.

Metalworking Categories

Metal can be shaped in multiple ways. Depending on the direction of the applied force, sheet metal can experience shearing, bending, tension, and compression.

Numerous stamping operations involve **shearing.** As you can see in Figure 1, shearing is the mechanical cutting of a material without creating **chips. A** shearing operation forces the material to slide against itself until it separates. However, not all press operations are cutting operations. Sheet metal can also be bent, squeezed, and stretched. These forces alter the shape of the metal without removing any material. As you can see in Figures 2 and 3, non-cutting operations can turn a flat sheet into an angled shape or a thin disc into a hollowed part.

A **punch** and die work together as parts of the complete die set to perform these operations on the press. Often, a work piece will require a number of different operations from start to finish. Manufacturers must carefully control these operations to prevent the unplanned tearing or cracking of the metal.

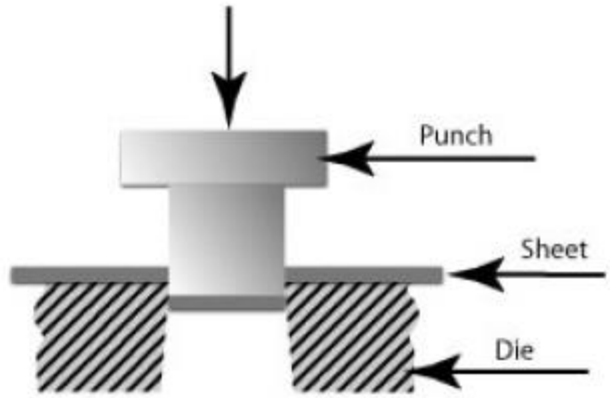


Figure 1. Shearing separates metal from the sheet.

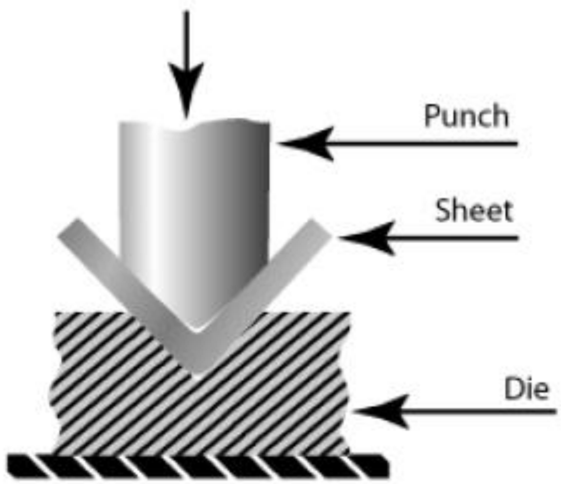


Figure 2. Bending operations create angles in the sheet.

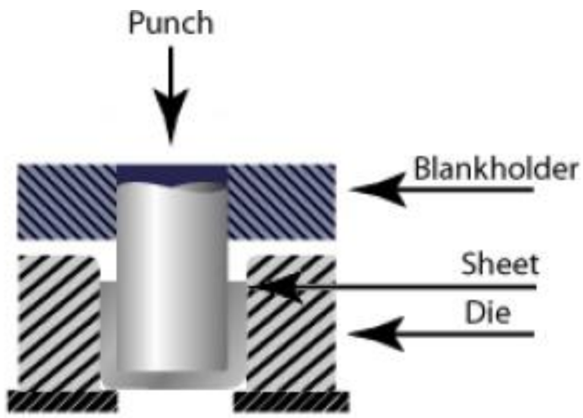


Figure 3. Sheet metal can be stretched into hollow shapes.

Shearing

Many press operations involve shearing. As the punch first contacts the metal, it experiences **plastic deformation,** as shown in Figure 1. The opposite surface bulges slightly. The clearance between the punch and the die is small enough to create a very localized shear. When the punch penetrates the metal somewhere between **15%** and 60% of the way through, an area of instability is created. This first part of the shear deforms the metal. At this point, the applied stress exceeds the **shear** strength of the sheet metal and causes it to tear the rest of the way. This second stage involves complete fracture. Provided the clearance is correct and the punch and die are equally sharp, the deformation and fracture meet in the center of the sheet. This newly formed edge will have two different visible sections, as shown in Figure 2.

Blanking and Punching

The two basic shearing operations are **punching** and **blanking.** In both cases, the punch is forced into the sheet metal, and a section of the sheet separates. The only real difference between punching and blanking is the location of scrap. With punching, the separated section is scrap, and it is called a **slug.** Figure 1 illustrates punching. With blanking, the separated section is the actual part, called the blank. The remaining skeleton strip is the scrap after blanking, as shown in Figure 2.

Each operation emphasizes a particular dimension. For punching, the size of the punch primarily determines the size of the opening. For blanking, the size of the die opening mostly determines the size of the part. This is like the difference between cutting a hole with scissors from the outside or inside edge.

You may also hear punching referred to as **piercing.** These terms are sometimes used interchangeably. However, certain manufacturers define piercing as a punching operation that pokes through the metal but does not create a slug, as shown in Figure **3.**

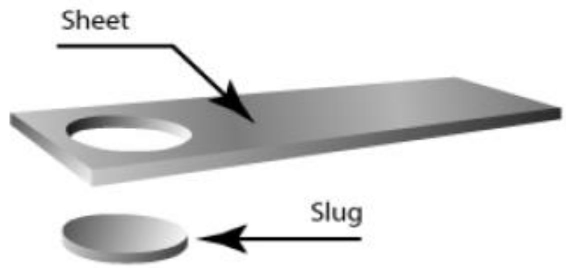


Figure 1. Punching creates a slug.

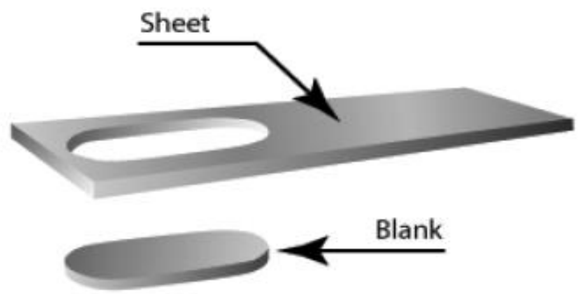


Figure 2. Blanking creates a part, or blank.

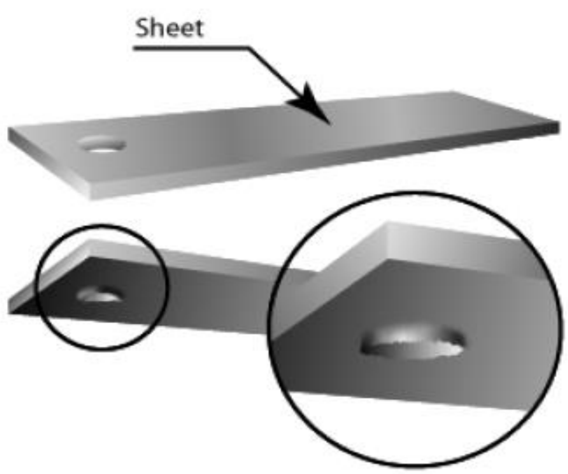


Figure 3. Piercing does not create a removed slug.

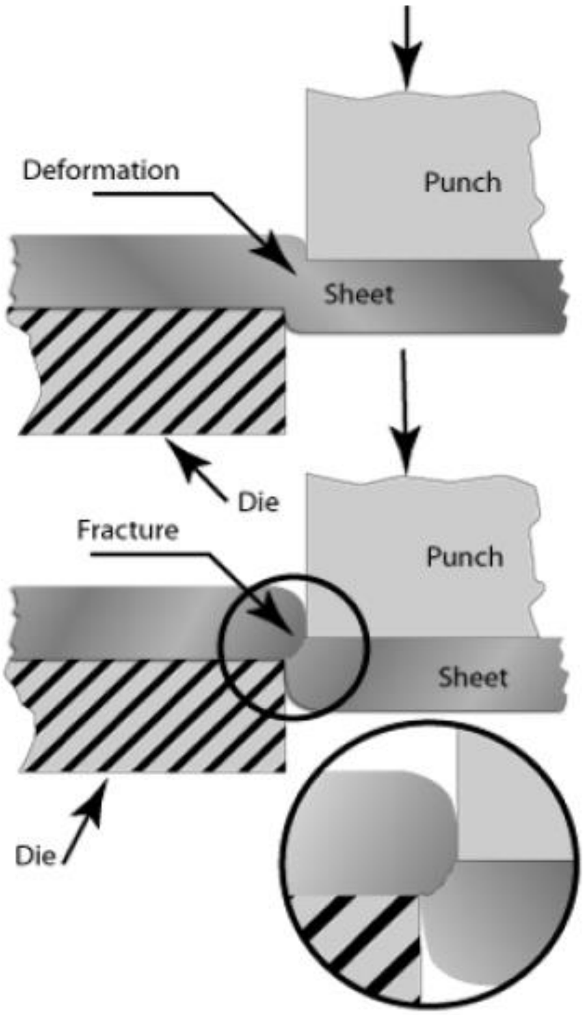


Figure 1. Shearing involves two separate deformation and fracture stages.

Figure 2. Metal slugs with visible deformation and tearing marks.

Fine Blanking

Another shearing operation is **fine blanking.** After a typical blanking operation, the edge of the blank has two distinct portions. Part of the edge is smooth due to deformation of the metal. However, another edge portion is rougher because the metal fractures after a certain depth of penetration. This rougher portion is often undesirable for precision parts.

An alternative to blanking is fine blanking. Fine blanking simultaneously compresses and shears the metal. As you can see in Figure 1, V-shaped projections compress the metal slightly away from the cut while the punch shears the metal. The result is an edge that is entirely smooth, as shown in Figure 2.

Fine blanking is usually reserved for a sheet thickness less than 1/4 in. (6.4 mm), particularly when close **tolerances** are critical. This operation requires a punch and dies with less clearance and the punch often moves slower than normal. Fine blanking can effectively create intricate shapes.

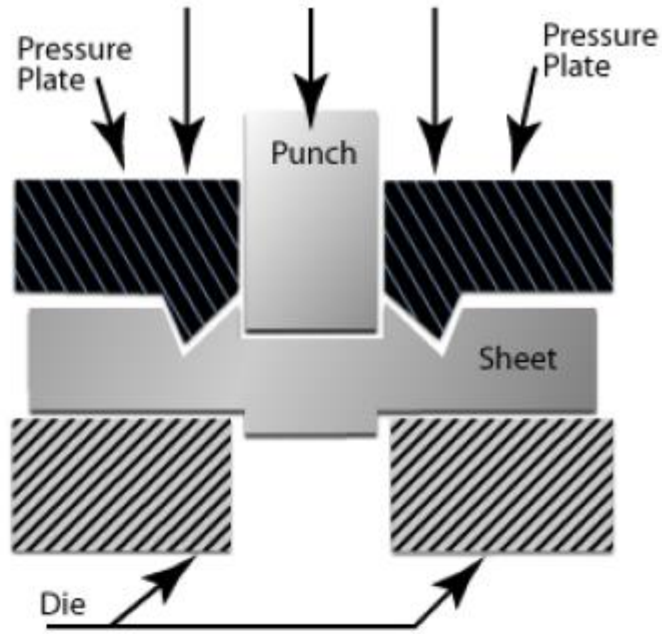


Figure 1. Fine blanking compresses the sheet around the edges of the blank.

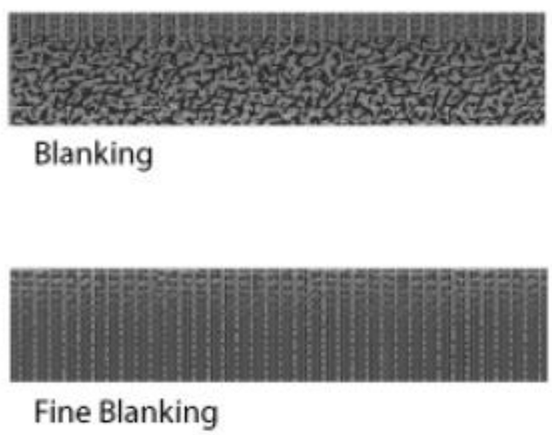


Figure 2. A fine-blanked edge is entirely smooth.

Cutoff and Parting

The formation of parts during sheet metalworking is often a multi-step process. Frequently, the final step in this process is a cutoff or parting operation. These shearing operations separate the sheet metal into multiple parts.

A cutoff operation creates a part from the sheet stock with a single cut. Each cut separates another part, as shown in Figure 1.

Cutoff lines may be straight, curved, or jagged.

Parting is very similar to a cutoff, except two simultaneous cuts are required instead of one. A parting operation leaves a small amount of scrap between blanks, as shown in Figure 2.

A key goal with press operations is to reduce the amount of leftover scrap.

Nesting is the arrangement of the cuts that will produce the parts, as shown in Figure 3. A cutoff operation will not produce any extra scrap. However, parts with more complicated shapes will require parting instead. This produces unwanted, but necessary, scrap.

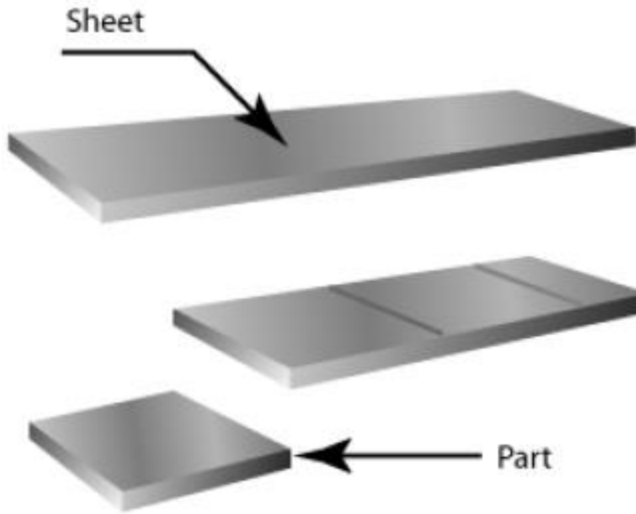
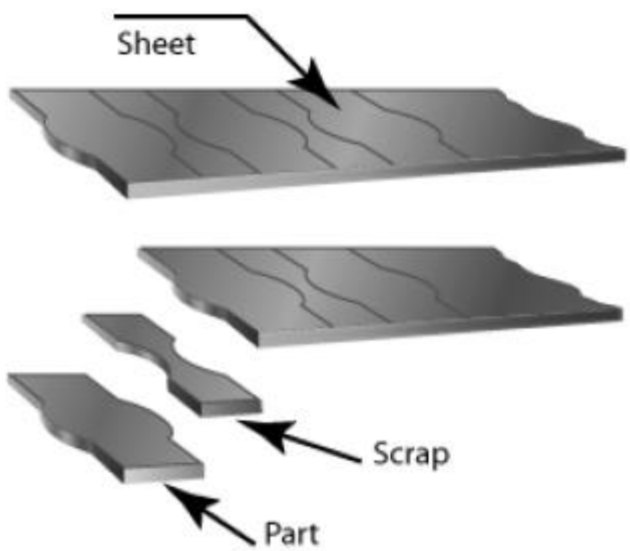


Figure 1. Cutoff operations do not produce scrap.



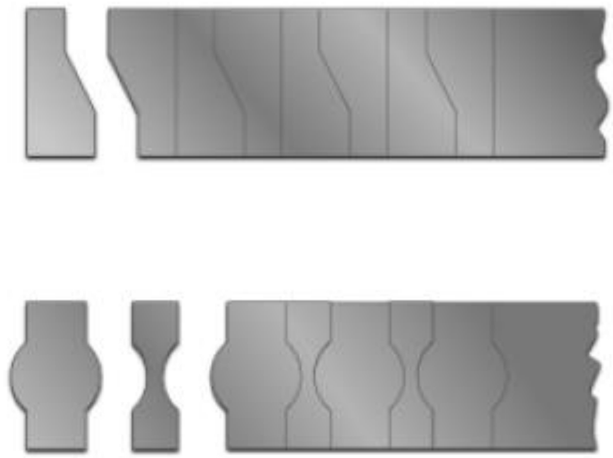


Figure 3. Appropriate nesting reduces scrap.

Notching, Lancing, and Shaving

Many other shearing operations can be performed on the punch press. Each one of these operations fulfills a particular function:

- **Notching** removes a portion of metal from the side. As shown in Figure 1, this notch appears as part of the outer edge of the final blank.
- **Lancing**, shown in Figure 2, shears an interior portion of the sheet to create a bent tab that remains attached on one end. Lancing is often done to improve ventilation in equipment.
- **Shaving** finishes a previously cut edge by shearing off the small amount of the remaining rough portion, as shown in Figure 3. shaving increases accuracy and smoothness.

Beyond the operations mentioned, there are still many more. After a while, similarities begin to emerge.

Unfortunately, the terminology of the same operation may vary from shop to shop. Be sure to compare the mechanics and result of the operations in addition to the names.

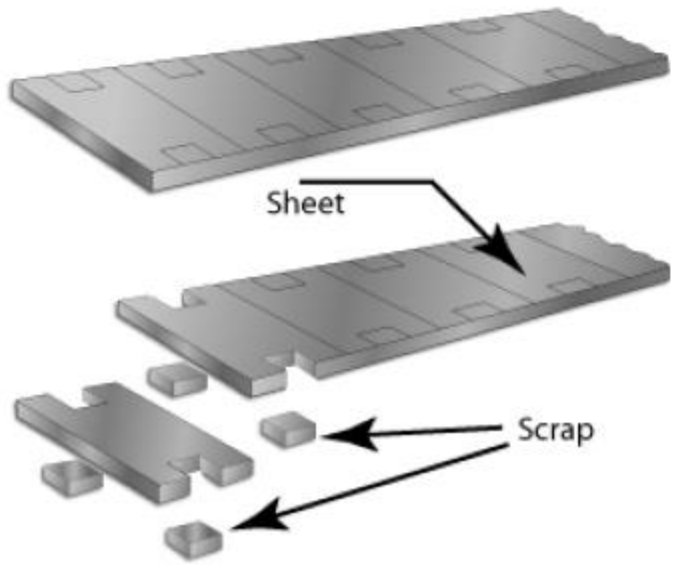


Figure 1. A notching operation removes a section fr
the edge.

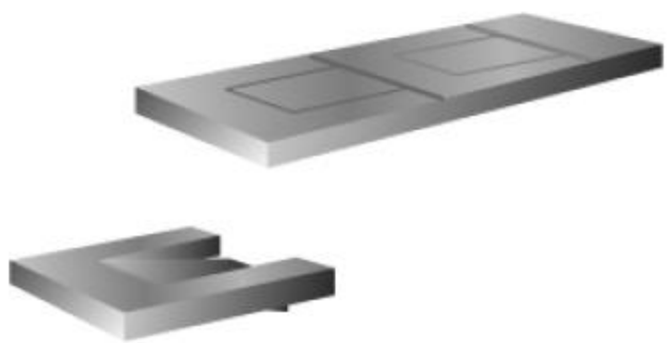


Figure 2. A lancing operation creates a bent tab.

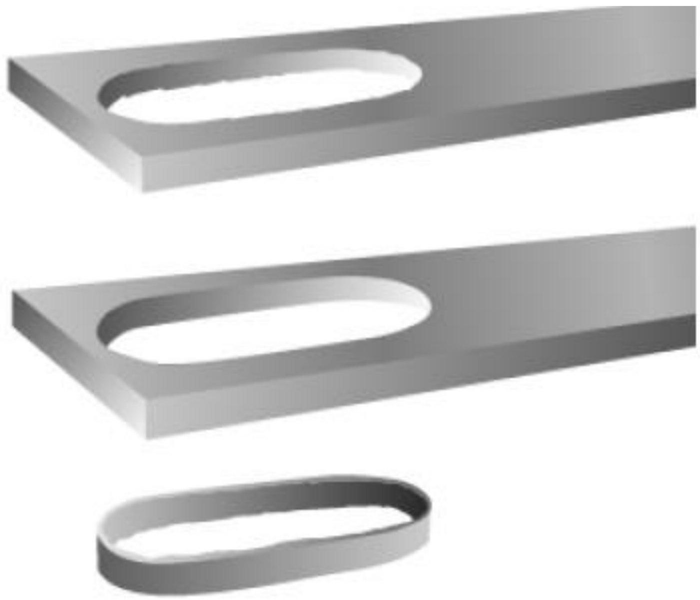


Figure 3. A shaving operation removes a slim amount of metal.

Bending

Another major category of sheet metalworking operations is bending. Bending is the straining of metal around a straight **axis,** with very little change in thickness. Figure 1 illustrates a basic bending operation. During bending, the inside of the bend compresses along the axis of bend. The outside of the bend stretches instead. This can be observed when bending foam. The little holes elongate on the outside and compress on the inside.

The two main methods for bending are V-bending and edge bending, which are shown in Figures 2 and 3. V-bending forces the sheet into a long V-shaped die. Edge bending holds down the sheet metal while a punch bends down the extended edge over a **wiping die.**

With any bending operation, there will likely be **spring back.** In other words, the metal slightly recovers some of its original shape. Manufacturers design punch and die combinations that reduce the amount of spring back and incorporate the slight change in thickness.

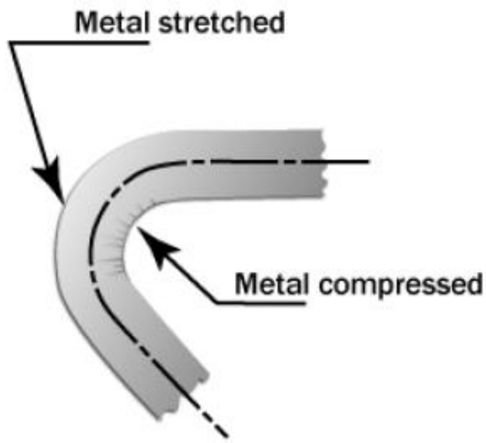


Figure 1. Bending simultaneously stretches and compresses the sheet.

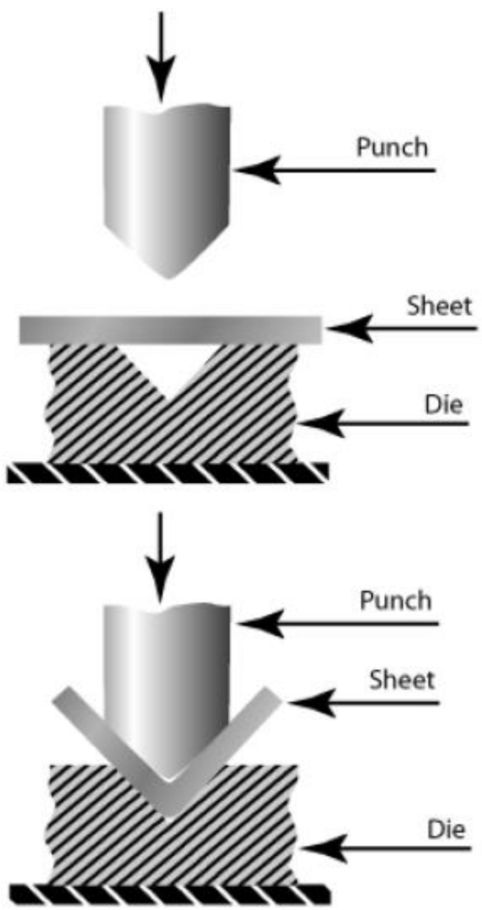


Figure 2. V-bending uses a V-shaped punch and die.

Flanging, Hemming, and Seaming

Just as there are a variety of shearing operations, there are numerous bending operations:

- **Flanging** creates a bend that strengthens an edge, as shown in Figure 1. A flange can be straight or curved. A **stretch flange** bends inward, and a shrink flange bulges out.
- **Hemming** bends and folds the edge of sheet metal back upon itself, as shown in Figure 2. Hemming increases stiffness, improves appearance, and removes any sharp edges. Hemming is sometimes called **flattening.**
- Seaming joins the edges of two separate sheets of metal together by folding them over one another, as shown in Figure 3. A seam is essentially two interlocking hemming operations. Seaming is often used to create cylindrical containers from a single sheet.

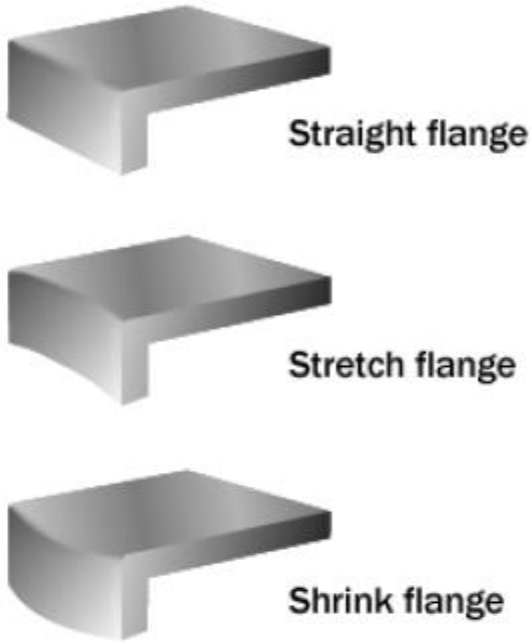


Figure 1. Flanging operations create a 90° bend.

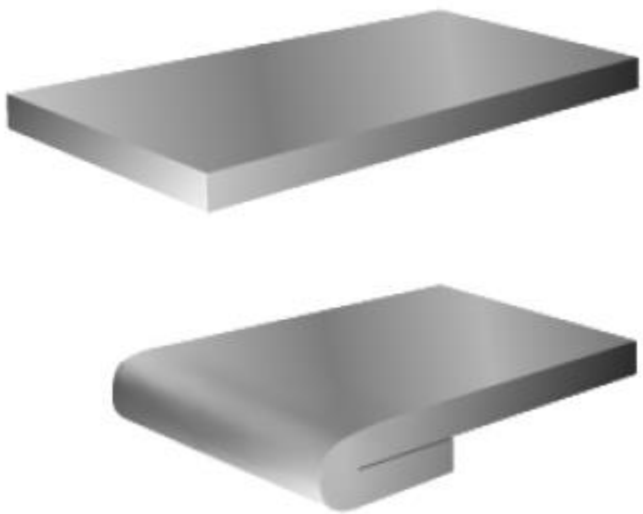


Figure 2. Hemming folds back the sheet to hide sharp edges.

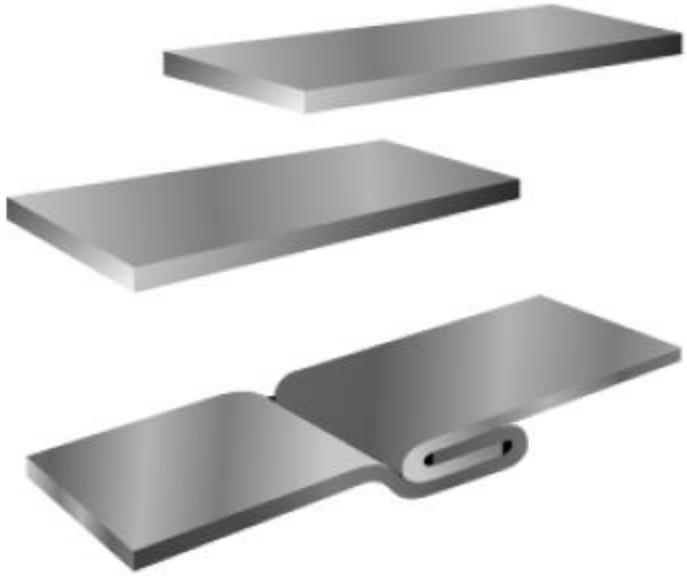


Figure 3. Seaming joins two edges by folding them over one another.

Embossing and Coining

Two main press operations that primarily involve compression are **embossing and coining.** Embossing compresses sheet metal against a patterned die in order to create a raised surface, as shown in Figure 1. Embossing may also be used to create ribs that add strength to the sheet metal. Coining, which is shown in Figure 2, is very similar to embossing. This operation also compresses the metal to create indentations and raised surfaces.

The key distinction between embossing and coining is in the shape of the die. With embossing, the cavities in the upper and lower die shoes match. The result is a sheet that does not drastically change in thickness. Embossed shapes resemble the raised lettering on business cards or greeting cards. On the other hand, the upper and lower dies do not match for coining. Consequently, variations in sheet thickness occur. A quick glance at the coins in your pocket illustrates that the two sides do not match. There is much greater deformation during coining operations.

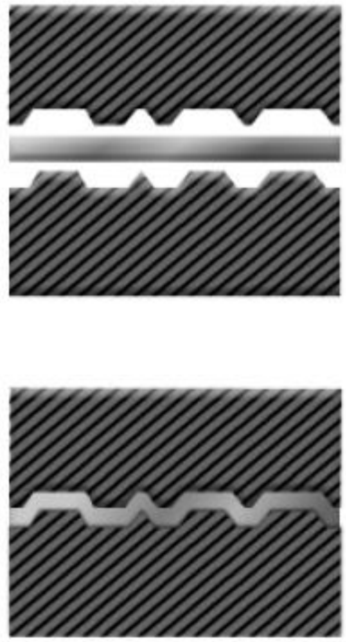


Figure 1. Embossing shapes metal without changing the thickness.

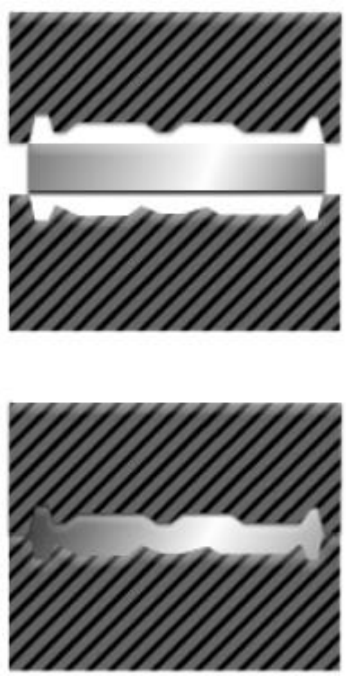


Figure 2. Coining changes sheet thickness in different locations.

Drawing

Punches and dies are often used to shape flat metal parts or parts with simple bends. However, drawing is capable of actually producing hollow cylindrical shapes from a fiat metal disc. Figure 1 illustrates the result of a basic drawing process.

Figure 2 shows a basic drawing die. During drawing, sheet metal experiences a variety of forces. The punch gradually pushes the metal into a hollow cavity, which bends the metal disc. As the metal flows into the die cavity, it thins and stretches. However, the diameter of the final shape is smaller than the original, Consequently, compressive forces also take place as the metal shrinks at the top. Drawing is very sensitive to material imperfections, die misalignments, etc.

A successful drawing operation requires an even, gradual motion of the punch and careful die construction to prevent wrinkling or tearing. Drawing is an incredibly useful sheet metal operation. Soft drink cans and auto body parts are easily made in a drawing operation.

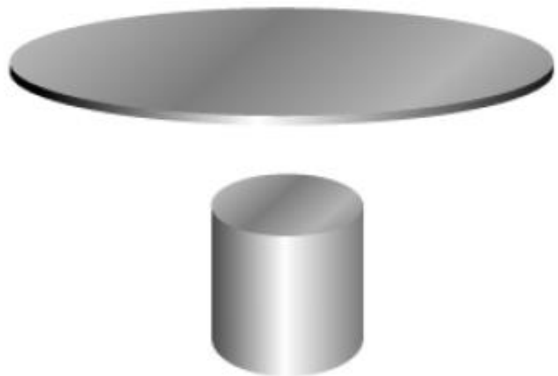


Figure 1. Drawing creates a hollow cylindrical part.

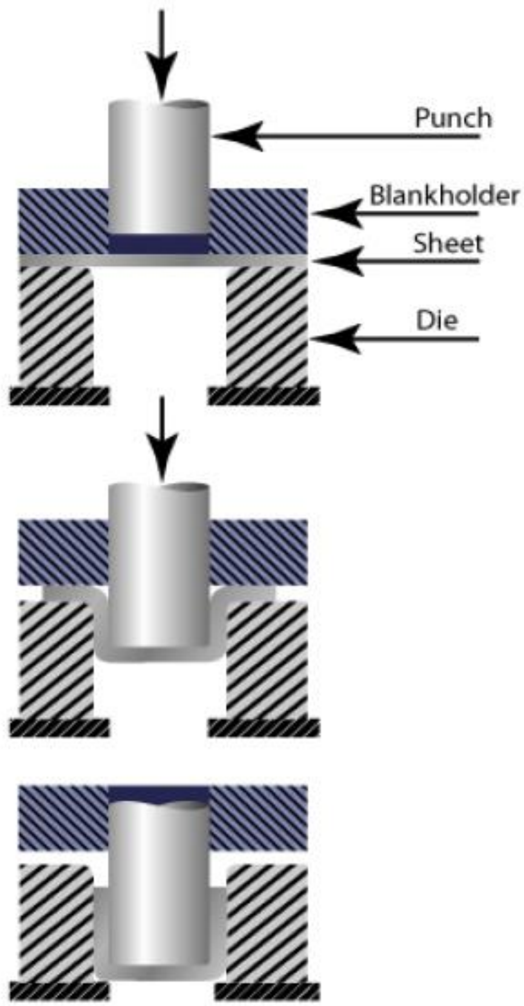


Figure 2. The punch gradually forces the sheet into the die cavity.

Trimming and Curling

Drawing is a relatively severe metalworking operation. The sheet metal experiences a variety of forces, and there are often imperfections in the resulting shape. Consequently, drawing is often followed by other operations.

Many drawn parts also experience trimming. As you can see in Figure 1, the top rim of a drawn part is frequently uneven. Trimming is done to remove this excess metal to create an even rim at the top of the hollow part.

A common operation used to shape the rim is curling. Curling turns the edge of the rim in on itself, as shown in Figure 2. It is also called beading. The curling process may take two or more steps to create the final curved edge. Just like flanging or hemming, a curled formation adds stiffness at the edge and improves the appearance of the part. Cooking pans are often curled at the edge.

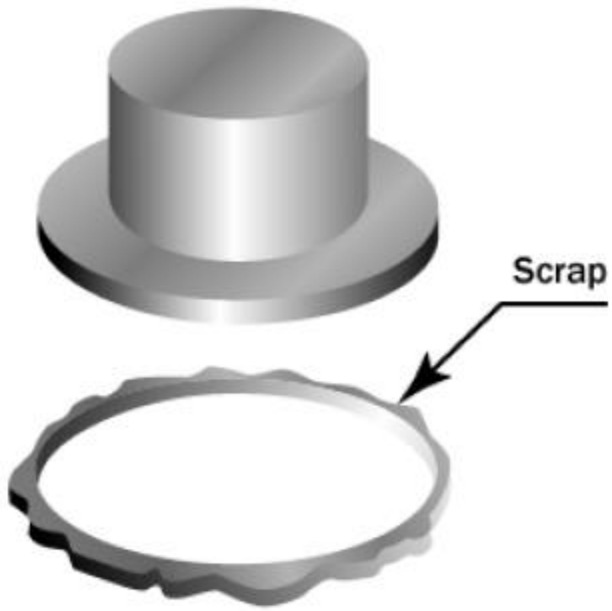


Figure 1. Trimming cuts off the uneven rim.

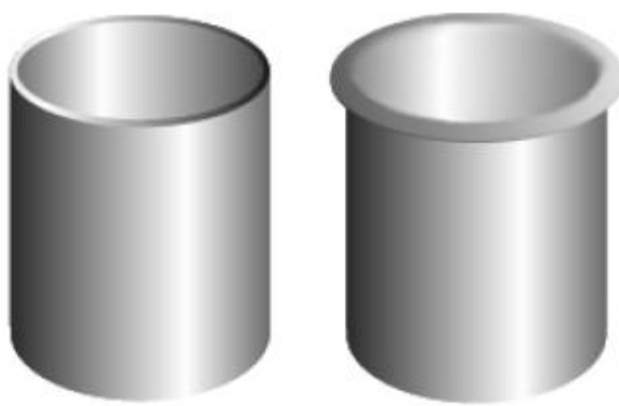


Figure 2. Curling strengthens the rim by bending it back.

Necking arid Bulging

The basic drawing operation creates a cylinder with straight sides. However, other operations can be performed to contract or expand areas of the cylinder walls. A necking operation compresses a section of the cylinder to reduce its diameter. **Bulging** forces out a section instead. Figures 1 and 2 compare these operations.

With necking, a typical punch and die setup can be used to shape the cylinder. The punch is forced down, and the walls of the cylinder are compressed. This action also slightly lengthens the cylinder. Necking is also referred to as **swaging.**

Bulging operations frequently require a more unusual die setup. During bulging, a die made of rubber is inserted into the cylinder. As the punch compresses the rubber die, its sides expand and bulge out the walls of the cylinder until they meet the sides of the die. This action also slightly shortens the length of the cylinder. A fluid such as water or oil can also be used to bulge a part.

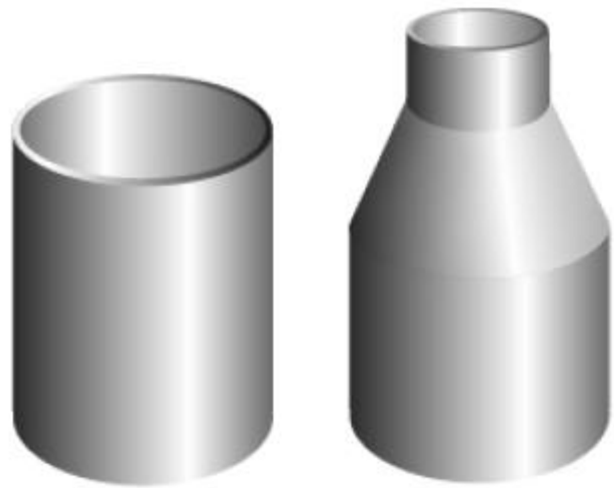


Figure 1. Necking compresses and lengthens the hollow part.

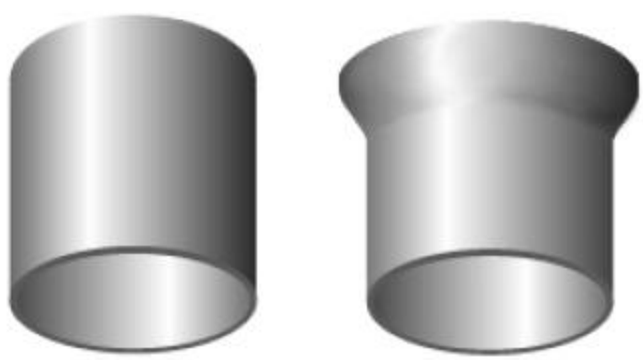


Figure 2. Bulging expands and shortens the hollow part.