

## UNIT IV DIE DESIGN

Type of operations, type of power press, press specifications, material handling equipment, Shear action in cutting , center of pressure, clearance, cutting forces , stripping forces , press tonnage , methods to reduce force , pilot , stripper , pressure pad and automatic stop strip layout, selection of die sets . Design of simple, progressive and compound die.

### THE FUNDAMENTALS OF DIE-CUTTING OPERATIONS

The product of a punch and die cutting operation is partially finished or semi-finished part or scrap. The process of making hole is called piercing and it produces a scrap slug. If the produced blank is useful, it is called blanking. Cutting of metal strip takes place due to the shearing in blanking and piercing operations. The cutting operation of metal strip takes place due to the plastic deformation, shear and break.

#### Plastic Deformation

As the punch descends, it touches the workpiece. The downward movement of punch exerts a force on the workpiece material. Plastic deformation starts as soon as the material exceeds elastic deformation. The combination of elastic and plastic deformation results in upper radius band on the scrap strip and a lower radius band on the workpiece.

#### Shear

The cutting of strip material is known as shearing. The principle of sheet metal working is shown in Figures (a) and (b). The diameter of punch is smaller than the diameter of die opening. Here, the material is subjected to both tensile and compressive stresses as shown in Figures (a) and (b). The stresses start to develop at this point. If the clearance between the die and punch is correct, the crack starting from the edges of punch and die meet, whereas the cracks do not meet up if the clearance is slightly more or less. Hence, shearing action does not take place.

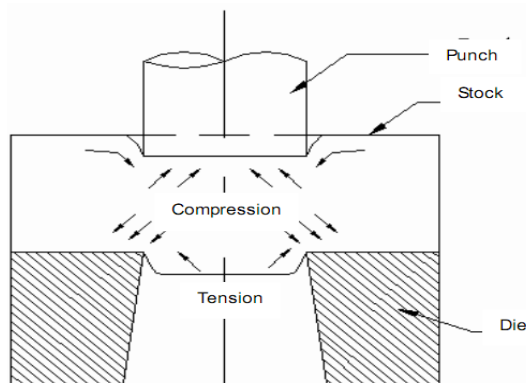


Figure (a) : Principle of Sheet Metal Working

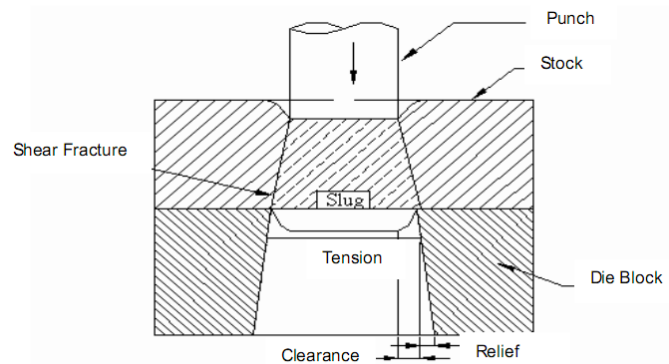
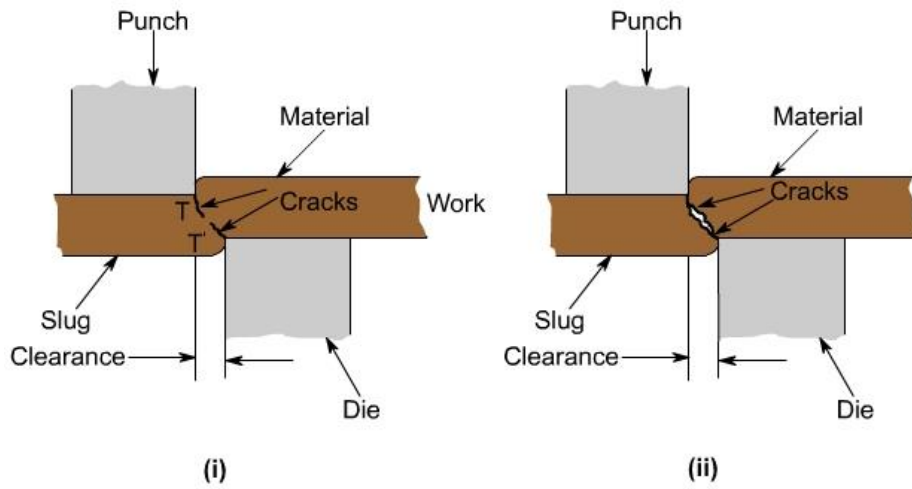
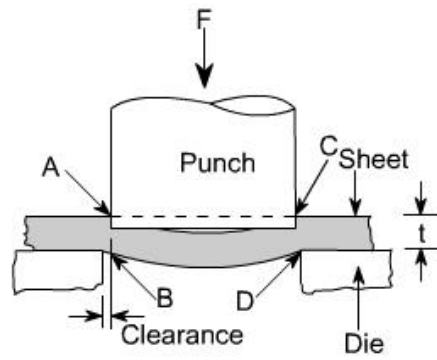


Figure (b) : Principle of Sheet Metal Working

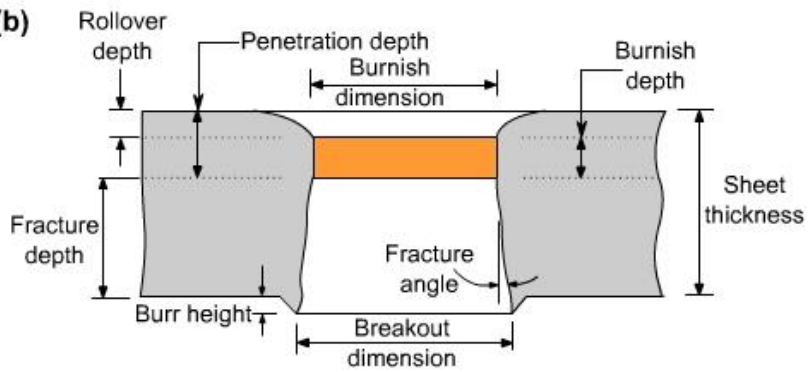
### SHEARING

Shearing is a cutting operation used to remove a blank of required dimensions from a large sheet. To understand the shearing mechanism, consider a metal being sheared between a punch and a die, Fig. Typical features of the sheet and the slug are also shown in this figure. As can be seen that cut edges are neither smooth nor perpendicular to the plane of the sheet.

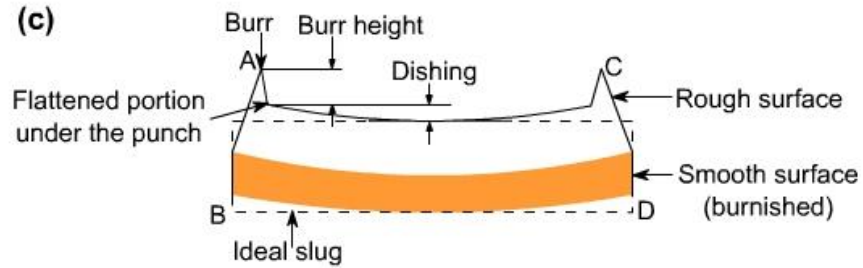
(a)



(b)



(c)



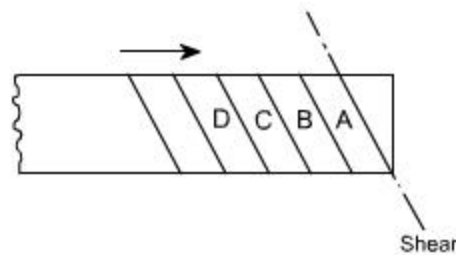
**Fig (a)** Shearing with a punch and die (b) features of a punched hole and (c) features of the slug.

Shearing starts as the punch presses against the sheet metal. At first, cracks form in the sheet on both the top and bottom edges (marked T and T', in the figure). As the punch descends further, these cracks grow and eventually meet each other and the slug separates from the sheet. A close look at the fractured surfaces will reveal that these are quite rough and shiny; rough because of the cracks formed earlier, and shiny because of the contact and rubbing of the sheared edge against the walls of the die.

The clearance between the punch and the die plays an important role in the determination of the shape and quality of the sheared edge. There is an optimum range for the clearance, which is 2 to 10% of the sheet thickness, for the best results. If the clearance increases beyond this, the material tends to be pulled into the die and the edges of the sheared zone become rougher. The ratio of the shining (burnished) area to the rough area on the sheared edge decreases with increasing clearance and sheet thickness. The quality of sheared edge is also affected by punch speed; greater the punch speed better the edge quality.

### Shearing Operations

For general purpose shearing work, straight line shears are used. as shown in Fig, small pieces (A, B, C, D.....) may be cut from a large sheet.



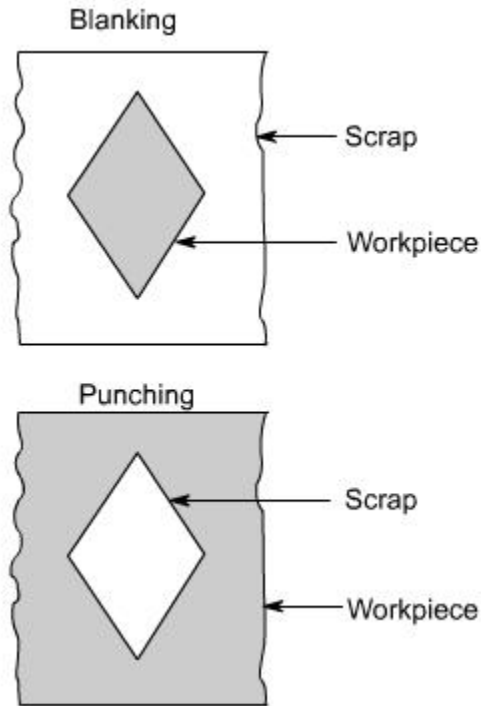
Shearing may also be done between a punch and die, as shown in Fig. The shearing operations make which use of a die, include punching, blanking, piercing, notching, trimming, and nibbling.

Plain blanking: The material used is called the stock and is generally a ferrous or non ferrous strip. During the working stroke the punch goes through the material, and on the return stroke the material is lifted with the punch and is removed by the stripper plate. The stop pin is a gage for the operator. In practice, he feeds the stock by hand and locates the holes to be punched as shown. The part that is removed from the strip is always the work piece (blank) in a blanking operation.

### Punching/Blanking

Punching or blanking is a process in which the punch removes a portion of material from the larger piece or a strip of sheet metal. If the small removed piece is discarded, the operation is

called punching, whereas if the small removed piece is the useful part and the rest is scrap, the operation is called blanking,.



In punching, the metal inside the part is removed; in blanking, the metal around the part is removed. A typical setup used for blanking is shown in Fig.

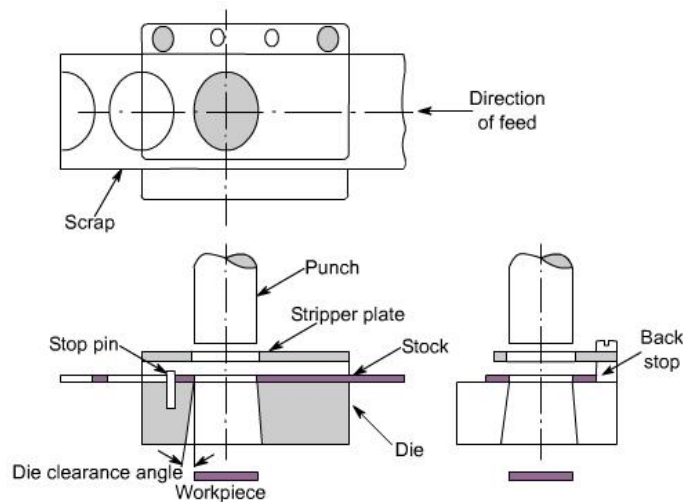


Fig Blanking punch and die.

The clearance between the die and punch can be determined as  $c = 0.003 t$ .  $t$  where  $t$  is the sheet thickness and  $t$  is the shear strength of sheet material. For blanking operation, die size =

blank size, and the punch is made smaller, by considering the clearance. The maximum force, P required to be exerted by the punch to shear out a blank from the sheet can be estimated as

$$P = t \cdot L \cdot \tau$$

where  $t$  is the sheet thickness,  $L$  is the total length sheared (such as the perimeter of hole), and  $\tau$  is the shear strength of the sheet material.

Stripping force. Two actions take place in the punching process – punching and stripping. Stripping means extracting the punch. A stripping force develops due to the spring back (or resiliency) of the punched material that grips the punch. This force is generally expressed as a percentage of the force required to punch the hole, although it varies with the type of material being punched and the amount of clearance between the cutting edges. The following simple empirical relation can be used to find this force

$$SF = 0.02 L \cdot t$$

where SF = stripping force, kN

$L$  = length of cut, mm

$t$  = thickness of material, mm

### **Piercing:**

It is a process by which a hole is cut (or torn) in metal. It is different from punching in that piercing does not generate a slug. Instead, the metal is pushed back to form a jagged flange on the back side of the hole.

A pierced hole looks somewhat like a bullet hole in a sheet of metal.

### **Trimming:**

When parts are produced by die casting or drop forging, a small amount of extra metal gets spread out at the parting plane. This extra metal, called flash, is cut – off before the part is used, by an operation called trimming. The operation is very similar to blanking and the dies used are also similar to blanking dies. The presses used for trimming have, however, relatively larger table.

### **Notching:**

It is an operation in which a specified small amount of metal is cut from a blank. It is different from punching in the sense that in notching cutting line of the slug formed must touch one edge of the blank or strip. A notch can be made in any shape. The purpose of notching is generally to release metal for fitting up.

### **Nibbling:**

Nibbling is variation of notching, with overlapping notches being cut into the metal. The operation may be resorted to produce any desired shape, for example flanges, collars, etc.

**Perforating:**

Perforating is an operation in which a number of uniformly spaced holes are punched in a sheet of metal. The holes may be of any size or shape. They usually cover the entire sheet of metal.

**Piercing:**

This operation consists of simple hole punching. It differs from blanking in that the punching (or material cut from stock) is the scrap and the strip is the work piece. Piercing is nearly always accompanied by a blanking operation before, after, or at the same time.

**Lancing:**

This is a combined bending and cutting operation along a line in the work material. No metal is cut free during a lancing operation.

Sheet metal working may be defined as a chip-less manufacturing process by which various components are made from sheet metal. The thickness of sheet is generally less than 20 mm.

**PRESS**

The machine used for sheet metal working is called press.

The main features of a press are: A frame which supports the ram or slide, a bed, a source of mechanism for operating the ram in line with and normal to the bed. The ram is equipped with suitable punch and die block is attached to the bed. The sheet metal working components are produced by downward motion of punch and towards the die block. The punch and die block assembly is called die set. These operations are usually done at room temperature.

**Types of Presses:**

- (1) type of frame
- (2) source of power
- (3) method of actuation of slides
- (4) number of slides incorporated and
- (5) intended use.

The selection depending upon the type of operation. Most presses are not classified by only category one but several. For example, a straight-side press may be mechanically or hydraulically driven and may be either single or double acting.

Classification by frame type:

The presses are classified according to the source of power used. The two main source of power for applying force to the ram or slide of a press are mechanical and hydraulic. The linear movement of the ram is obtained with the help of a flywheel driven system in mechanically operated press. The heavy flywheel absorbs energy from the motor continuously and delivers its stored energy to the workpiece when required. The flywheel is attached to the main shaft of the press (non-gear) or it is attached to the main shaft with the help of gear train. For short stroke and low tonnage, non-gear drives are useful. Number of strokes per minute is usually quite high for non-gear drives. Gear train may contain single or double reduction gear. The single reduction gear is suited for heavier blanking operations or shallow blanking. Double reduction gear is used for high tonnage, but with less number of strokes per minute. These are faster than

hydraulic presses and require less maintenance and capital cost. Hydraulic presses consist of large cylinder and piston arrangement coupled to a hydraulic pump. The piston and press ram form one unit. The ram can be operated by oil press on the piston in the cylinder. The capacity of hydraulic press depends upon the cross section area of the piston and pressure developed by the pump. The hydraulic press can exert full pressure at any position of the ram stroke. The speed and pressure is constant throughout the entire stroke. It is easy to operate.

### **Type of Frames**

The presses are classified according to the type of frames such as gap frame and straight side frame.

#### **Presses with Gap Frame**

Presses with gap frame are produced with solid frames in a vertical or inclined position. They are cut back in the form of letter “C” below the ram so that strip is fed from the side. Some presses have open-back so that strip is fed from front to back. A press is inclined so that the parts may fall through the open-back by gravity. Now-a-days, open-back inclination (OBI) is widely used for blanking and piercing operations on small workpieces.

#### **Presses with Straight Side Frame**

Presses with straight side frame consist of a slide or ram which travels up and down between two straight slides or housings. They are extensively used for large and heavy work. The size of a press is limited due to the presence of housings. It has longer strokes due to the frame construction. These presses are further classified as single point, two point and four point suspensions, depending upon the number of connections between the slide and the main drive shaft.

#### **According to the Number of Slides**

There are three presses according to the number of slides, viz. single-action presses, double-action presses and triple-action presses.

A single-action press has one slide, whereas a double-action press has two slides, viz. one inner and the other outer slide. It is generally used for drawing operation in which outer slide carries the blank holder and inner slide carries the punch. Outer slide has shorter stroke than inner. Two slides move in the same direction and against the fixed bed of the press. The working of a triple-action press is same as the double-action press with the addition of third ram. Three rams are located in the press bed. It moves upwards immediately after other two ram moves down. All three actions are properly synchronized for drawing, redrawing and forming.

#### **According to the Method of Actuation (Slide)**

These presses consist of flywheel attached to the main shaft. The rotary motion of flywheel is converted into the linear motion of the slide or ram. This is achieved by using crankpins or eccentrics into the main drive shaft. The number of points of suspension of the slide determines the number of throws or eccentric on the main shaft. The points of suspensions are places where pressure is transmitted by connection to the slide. The shut height of the press can be varied with the help of adjustable connecting rods or pitmans. The main advantage of eccentric is that it offers more surface area for bearing the support for pitman. The limitation of eccentric is that the length of stroke is limited. Crankshaft driven device provides longer strokes. The slides are also actuated by cams, toggle, rack and pinions, screws and knuckles.

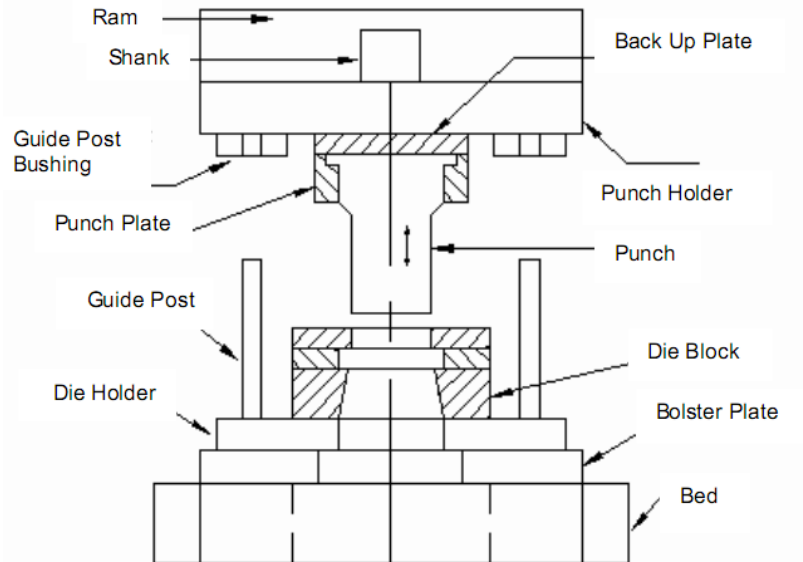


Figure : Simple Cutting Die

## Die

Die is the female part of a complete tool for producing work in a press. It is also referred to a complete tool consisting of pair of mating members for producing work in press.

## Die Block

It is the block or a plate which contains the die cavity.

## Lower Shoe

The lower shoe of a die set is generally mounted on the upper plate of a press. The die block is mounted on the lower shoe. The guide posts are also mounted in it.

## Punch

Punch is the male component of the die assembly which is directly or indirectly moved by or fastened to the press ram or slide.

## Upper Shoe

It is the upper part of the die set which contain die post bushings.

## Punch Plate

The punch plate or punch retainer fits closely over the body of the punch and holds it in proper relative position.

## Back Up Plate

It is also called pressure plate. It is placed so that the intensity of pressure does not become excessive on punch holder. The plate distributes the pressure over a wide area and intensity of pressure on the punch holder is reduced to avoid crushing.

## Stripper

Stripper is a plate which is used to strip the metal strip from a cutting or non-cutting punch or die. It may also guide the strip.

## Knock Out

Knock out mechanism is used to remove the workpiece from a die. It is connected to and operated by the press ram.

## Pitman

Pitman is a connecting rod which is used to transmit the motion from the main drive shaft to the press slide.

### **Bed**

The bed is lower part of press frame that serves as a table on which a bolster plate is mounted.

### **Bolster Plate**

Bolster plate is a thick plate secured to the press bed, which is used for locating and supporting the die assembly. Its thickness is usually 5 to 12.5 cm.

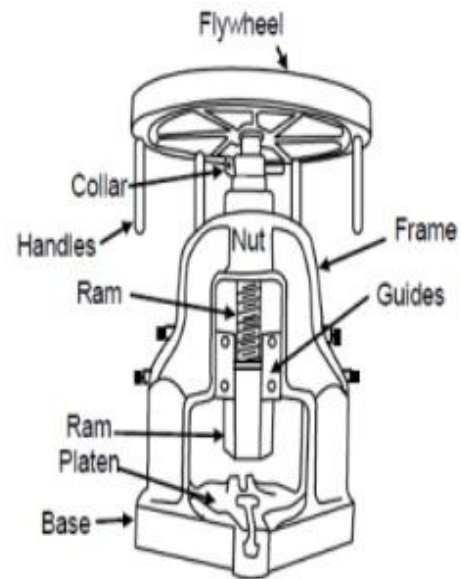
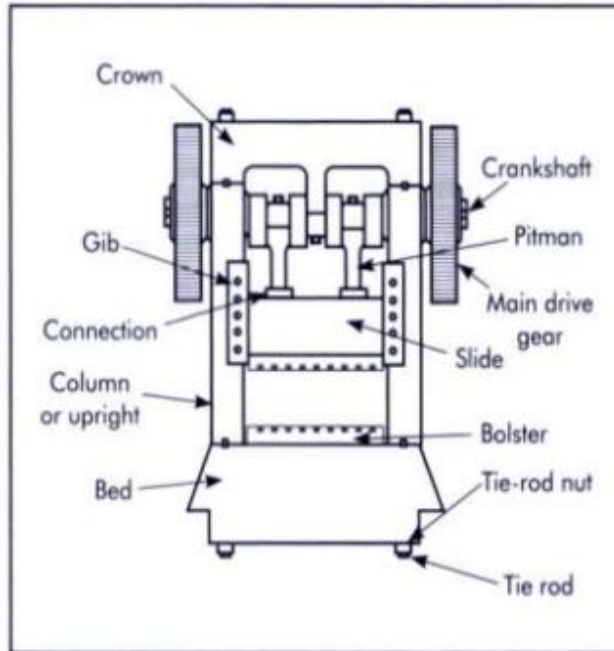
### **Die Set**

Die set is unit assembly which incorporates a lower and upper shoe, two or more guide posts and guide post bushings.

The frame of a press is fabricated by casting or by welding heavy steel plates. Cast frames are quite stable and rigid but expensive. Cast frame construction also has the advantage of placing a mass of material where it is needed most. Welded frames are generally less expensive and are more resistant to shock loading because of the greater toughness of steel plate. The general classification by frame includes the gap frame and the straight side. The gap frame is cut back below the ram to form the shape of a letter C. This allows feeding a strip from the side. Some gap-frame presses have an open back to permit strip feeding from front to back or ejection of finished parts out the back. Gap-frame presses are manufactured with solid frames fixed in a vertical or inclined position. Others are manufactured with a separate frame mounted in a base, which allows the frame to be inclined at an angle in three different positions. The reason for inclining the press is to allow parts to fall through the open back by gravity. The three-position inclinable press is frequently referred to as an open-back inclinable (OBI) press. Solid gap-frame presses are obtainable in higher tonnages than inclinable ones because of the rigid base and solid construction. The OBI press is the most common press in use today. It ranges from a small 1-ton bench press to floor presses rated up to 150 tons. Its main use is for blanking and piercing operations on relatively small work pieces, although bending, forming, and drawing operations can also be done. Fig. shows the major components of an OBI press, as follows:

- 1) A rectangular bed, the stationary and usually horizontal part of the press, serving as a table to which a bolster plate is mounted.
- 2) A bolster plate, consisting of a flat steel plate from 50 mm. to 125mm. thick, secured to the press for locating and supporting the die assembly.
- 3) The ram, sometimes called the slide, which reciprocates within the press frame and to which the punch or upper-die assembly is fastened.
- 4) A knockout, consisting of a crossbar through a slot in the ram that contacts a pin in the die to eject the work piece.
- 5) The flywheel, which absorbs energy from the motor continuously and delivers its stored energy to the work piece intermittently, making it possible to use a smaller motor.
- 6) The pitman, consisting of a connecting rod to convey motion and pressure from the main shaft or eccentric to the press slide.

# Power press parts



Single action straight side eccentric shaft mechanical press incorporates a slide or ram, which travels up and down between two straight sides or housing and commonly used for large and heavy work. The size of the press is limited to some extent because reduce the working area. However the frame construction does permit large bed areas and longer strokes. The drive mechanism is generally located above the bed, The straight slide press incorporates a slide or ram, which constant throughout the entire stroke.

## **Classification by method of slide actuation:**

The flywheel of a press drives the main shaft, which in turn changes the rotary motion of the flywheel into the linear motion of the slide or ram. This is generally accomplished by incorporating crankpins or eccentrics into the main drive shaft. The number of points of suspension of the slide determines the number of throws or eccentrics on the main shaft. Points of suspension are places where pressure is transmitted by connection to the slide. Press connections, called connecting rods or pitman, are usually adjustable in length so that the shut height of the press can be varied. The most common driving device is the crankshaft, although many newer presses use the eccentric for ram movement. The main advantage of the eccentric is that it offers more surface area for bearing support for the pitman and main disadvantage is its limitations on the length of stroke. Therefore, presses having longer strokes generally utilize the crankshaft. In addition to eccentrics and crankpins, cams, toggles, rack and pinions, screws, and knuckles actuate slides. Space does not permit discussion of

these mechanisms in this text. Information may be obtained by referring to the various die-design and press handbook.

Classification by the number of slides incorporated:

The number of slides incorporated in a single press is called the action, i.e. the number of rams or slides on the press. Thus a single-action press has one slide. A double-action press has two slides, an inner and an outer slide. This type of press is generally used for drawing operations during which the outer slide carries the blank holder and the inner slide carries the punch. The outer, or blank-holder, slide, which usually has a shorter stroke than the inner, or punch-holder slide, dwells to hold the blank while the inner slide continues to descend, carrying the draw punch to perform the drawing operation. A triple-action press is the same as a double-action with the addition of a third ram, located in the press bed, which moves upward in the bed soon after the other two rams descend. All three-slide movements are properly synchronized for triple-action drawing, redrawing, and forming.

## **Fundamentals of Press Operation**

### **Press tonnage:**

The force by which press ram is able to exert safely is called tonnage of the press. Press slides exert a force which is greater than the rated tonnage because of built-in safety factor. The tonnage of hydraulic press is equal to the product of the piston area and oil pressure in cylinder. The tonnage is varied by changing the oil pressure. Tonnage of mechanical press is equal to the size of bearings for the crankshaft or eccentric. The tonnage of mechanical press is approximately equal to the product of shear stress of crank shaft material and area of crankshaft bearings. The tonnage of mechanical press is maximum when the slide is near to the bottom of its stroke.

### **Stroke**

Reciprocating motion of a press slide is called the stroke. Stroke is expressed as the number of inches between terminal points of the motion. The stroke is constant for mechanical press while it is adjustable for hydraulic press.

### **Shut Height**

The distance from the top of the bed to the bottom of the slide with the stroke down and the adjustment up is called shut height. The thickness of the bolster plate must always be taken into consideration when determining the maximum die height. The shut height of the die must be equal to or less than the shut height of the press. The shut height of a press is always given with the adjustment up. Lowering the adjustment of the slide may decrease the opening of the press from the shut height down, but it does not increase the shut height. Thus the shut height of a die must not be greater than the shut height of the press. It may be less, because lowering the adjustment can reduce the die opening in the press.

### **Die Space**

Die space is the area available for mounting dies in the press.

### **Stripping force:**

Two actions take place in the punching process – punching and stripping. Stripping means extracting the punch. A stripping force develops due to the spring back (or resiliency) of the punched material that grips the punch. This force is generally expressed as a percentage of the force required to punch the hole, although it varies with the type of material being punched and

the amount of clearance between the cutting edges. The following simple empirical relation can be used to find this force

$$SF = 0.02 L.t$$

where SF = stripping force, kN

L = length of cut, mm

t = thickness of material, mm

### **Methods of reducing cutting forces:**

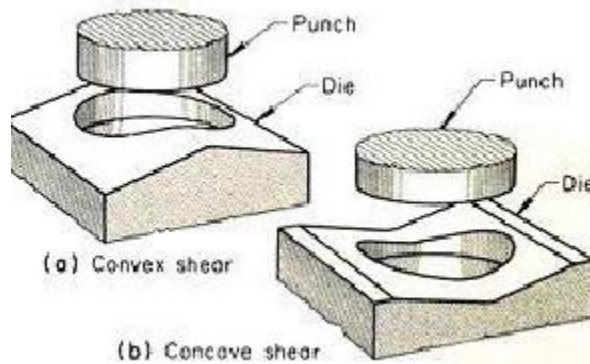
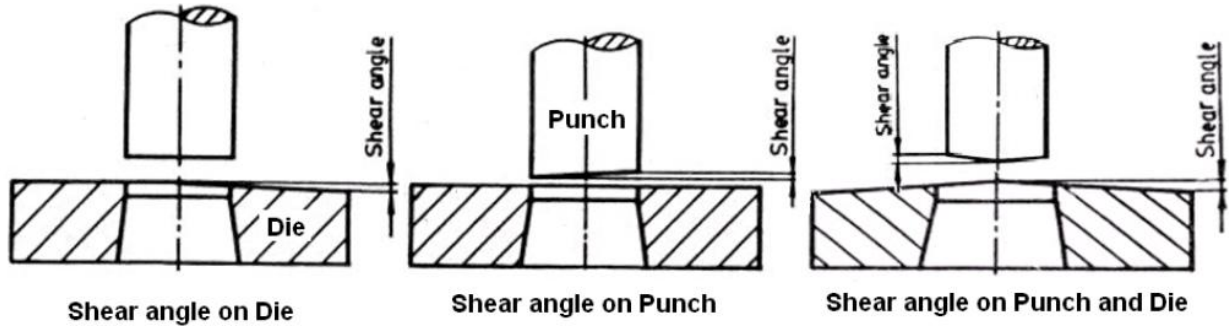
- a)Stepping punches
- b)Single shear on punch
- c)Single shear on die
- d)Double shear on punches
- e)Double shear on punches
- f) Convex & concave shear

### **Cutting forces:**

The force required to penetrate the stock material with the punch is the cutting force. If the die contains more than one punch that penetrates the stock material simultaneously, the cutting force for that die is the sum of the forces for each punch. Knowledge of cutting forces is important in order to prevent overloading the press or failure to use it to capacity. The formula for determining cutting forces takes into account the thickness of the stock material, the perimeter of the cut edge and the shear strength of the stock material. The shear strength of the stock material is the force necessary to sever 1 sq. in. of the material by direct shearing action.

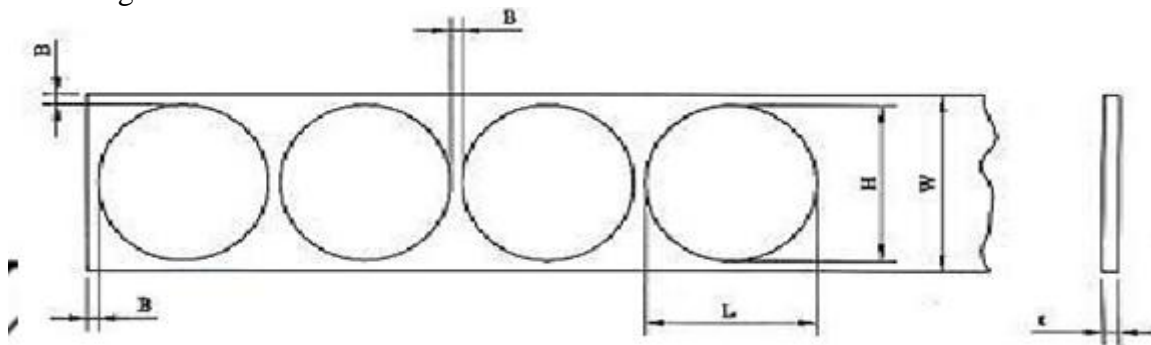
It sometimes becomes necessary to reduce cutting forces to prevent press overloading. One method of reducing cutting forces is to step punch lengths, as shown in Fig. Punches or groups of punches progressively become shorter by about one stock-material thickness. This will result in distribution of force during the blanking or piercing action on the punches thus reducing in total force. During shearing action lengthier punches will take cutting action at first time and once the sheet is pierced for a sheet thickness, other shorter punches will enter the sheet to get the required holes. This type is mainly used in piercing of more number of holes on the component. materials require more stripping force because more material is in contact with the punch. Holes punched close to the strip edge do not require as much stripping force because there is less backing and the metal can give. Punches with polished sidewalls tend to strip easier than those with rough surfaces. More force is also required to strip punches that are close together. A second method is to grind the face of the punch or die at a small shear angle with the horizontal. This has the effect of reducing the area in shear at any one time. Shear also reduces shock to the press and smoothes out the cutting operation. The shear angle chosen should provide a change in punch length of from 1 to 1 ½ times the stock thickness. Shear that is equal to or greater than the stock thickness is called full shear. Cutting forces are reduced by approximately 30 percent when full shear is applied. Various types of shear angle are shown in the figure. Double shear angle is preferred force acting on the punch. Double shear angle on punches should

be concave to prevent the stretching of the material before it is cut. Shear angle may be applied either to the punch face or to the die face, depending on whether the operation is blanking or piercing because shear will distort the work material. The shear angle for blanking operation will be on the die member, while, as the piercing operation the shear angle will be given on the punch member.



### Scrap–Strip Trip Layout For Blanking

In designing parts to be blanked from strip material, economical stock utilization is of high importance. The goal should be at least 75 percent utilization. A very simple scrap-strip layout is shown in Fig.



### SCRAP ALLOWANCE

A scrap-strip layout having insufficient stock between the blank and the strip edge, and between blanks, will result in a weakened strip, subject to breakage and thereby causing mis-feeds. Such troubles will cause unnecessary die maintenance owing to partial cuts, which defect the punches,

resulting in nicked edges. The following formulas are used in calculating scrap-strip dimensions for all strips over 0.8 mm. thick.

$t$  = specified thickness of the material

$B = 1.25 t$  when  $C$  is less than 64 mm

$B = 1.5 t$  when  $C$  is 64 mm or longer

$C = L + B$ , or lead of the die

### **Screws and Dowels**

Components of dies are held together by using socket head cap screws. The dowel provides and maintains accurate positioning of the component, i.e. dowel avoids misalignment. To avoid projection of screw heads, the head is recessed in counter bored hole. Cap screws that are used to hold die components are counter bored and 1/8 inch deeper than cap screw head. This allows additional material for die sharpening. To position and hold a die component accurately, minimum one cap screw or dowel is necessary for positioning. Designer can use two dowels but one can also use two or more cap screws. One cap screw is generally sufficient for small components, whereas in order to hold the die components at least two cap screws are required for large components. Normally, screws of diameter 3/8 inch are used for die components of area up to 6 square inch and screws of diameter 1/2 to 5/8 inch are opted for heavy die components. Dowel diameter is same as that of cap screws. Dowels should be located diagonally from each other and as farthest as possible to increase accuracy of location All the screws and dowels should be located at 1.5 to 2 times the diameter of screws or dowels from the component edge. Screw and dowel hole should be placed near to the outer edge of the die block and as far as possible from blanking contour. Dowel holes extrude through the die components so that dowels can be easily removed. The effective thread depth for screws should be 1.5 times the screw diameter for general applications and two times the screw diameter when subjected to shock loads. Threading hard components should be avoided as far as possible. The die block should be drilled with clearance and counter bored to accept the cap screw. The thread should be cut in the die shoe. The application of screws and dowels has been shown in Figures 5.1(a) and (b) respectively.

### **Die Block:**

The design of die block depends upon workpiece size and thickness. The type of die and contour of workpiece also play an important role while designing of the die block. The selection of size of die block also depends upon experience. The die blocks are made from a solid block of tool steel for small workpieces. The distance between the die opening and outside edge of the die block should be 1.25 times the thickness of the die block for smaller dies. This distance should be 1.5 to 2 times the die thickness for large dies or when sharp corners are present in the die opening contour. The solid blocks that are symmetrical face the problem of incorrect assembly, which can be avoided by fool proofing the die block. Fool proofing is achieved by placing one dowel at some other distance from its nearest screw hole. It is possible to save a large amount of material by using insert dies in the construction of die blocks. In the construction of large die block or the complex contour die, die blocks are made in two or more sections in order to save the tool steel. The die may also be sectioned when the size of the die opening is not large enough to permit internal machining. In case of failure, only one component needs to be replaced and hence, it is one of the advantages of sectional die blocks. Figure 5.2 shows the method of sectioning large die. Sectional components may be screwed and doweled to a die holder with

sections butting against each other. These sections are wide enough to avoid tilting. Figure 5.2 : **PUNCH**

The design of the punch mainly depends upon the plan area to be blanked or pierced. Design of the punch also depends upon the pressure which is required to penetrate through the workpiece. The method of mounting the punch is determined by the plan area to be blanked or pierced. For example, a punch for small workpiece may require a punch block for mounting the punch into the die holder, whereas a punch of large workpiece may be made up of solid block of tool steel and bolted to the punch holder. A punch must withstand the maximum blanking or piercing pressure. Small punches require a punch support to avoid breakage. The basic types of punches can be summarised as plain punch, pedestal punch, perforated punch and punches mounted in punch plate. Plain Punch This type of punch is economical and easy to operate. It is a simple block of hardened tool steel. The shape of punch depends upon the required profile. Plain punch is directly mounted onto the punch holder of die set. A plain punch is shown in Figure. When extra length is needed, plain punch is mounted on to the flat punch plate. Screws and dowels hold plain punch in the same way as they hold solid die blocks. The length and width of plain punch should at least be equal to the punch height for the stability. When high and unbalanced blanking and piercing pressures are required, it is necessary to use heights greater than either punch length or width. In such situations, some other kind of punch should be considered.

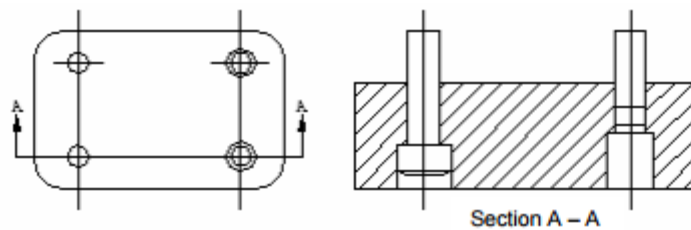


Figure : Plain Punch

### **Pedestal Punch**

These are constructed by machining in a way that leaves a flange around the base of the punch. The pedestal punch is shown in Figure 5.4. Its base area is larger than its cutting face area. Pedestal punches are advantageous because of large base and solid construction, hence, are stable. As cutting force distributed uniformly over large base, pedestal punches are capable of withstanding heavy cutting force. The flange of pedestal punch should be wide and thick enough to provide space for holes. These holes are used for mounting.

### **Perforator Punches**

These types of punches may be fabricated or purchased from market. **Punches Mounted in Punch Plate** Punch plates are used to hold and position the punch. The punch plate is also used to increase the strength of punch. Perforated punch has rounded head and shank; hence they are easily mounted in punch plates.

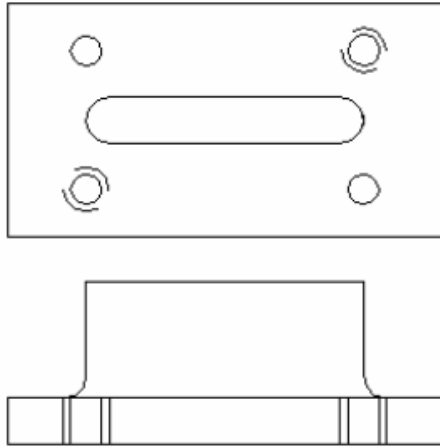


Figure 1 : Pedestal Punch

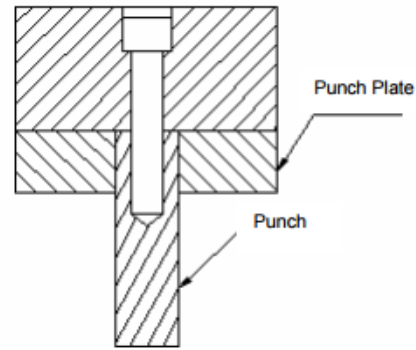


Figure 2 : Method of Mounting Punches in Punch Plate

Rectangular or odd shaped punches are not easily mounted in punch plates. Figure shows method of mounting punches.

Punch Support Diameter of piercing punches should not be smaller than thickness of the strip which is to be pierced. If diameter of piercing punch is smaller than thickness of the strip, diameter of punch shank should be at least twice the hole size and cutting face should be ground to the hole size for a distance about twice the stock thickness. The punches having more than 4 inch unguided length are avoided. If the length of the punch is more than 4 inch, a spacer block should be used in between punch and punch plate.

Various methods of supporting slender punches are shown in Figures.

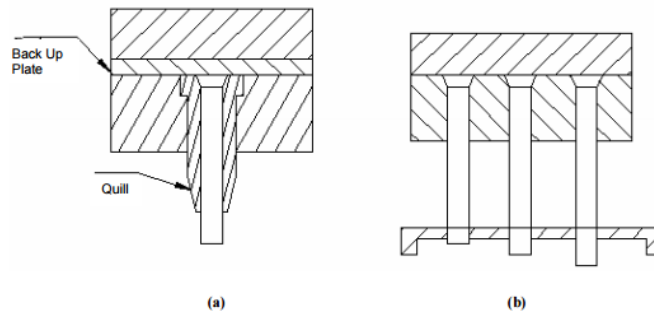


Figure 3 : Methods of Mounting Slender Punches

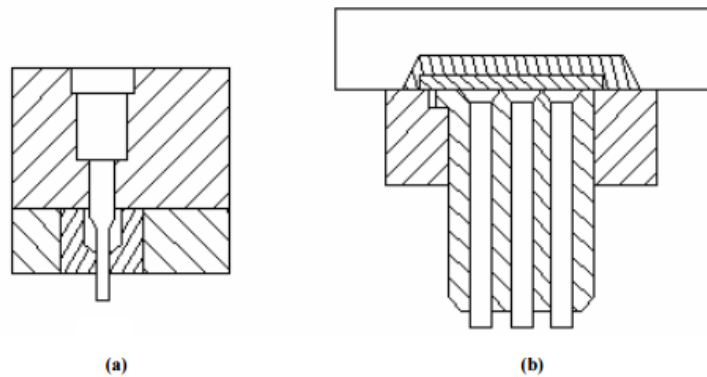


Figure 4 : Methods of Supporting Slender Punches

A quill that is used to 9 Design of Die Making Tools increase the strength of slender punch is shown in Figure (a). The punch is made up of tool steel and can be easily replaceable if it fails. The punch is assembled in a quill with tight press fit. The quill is made up of mild steel.

**Punch Shedders** The slug and blank sticks to the punch face and comes out with punch during blanking and piercing operation. The slug sticks to the die wall due to spring back in the blank and slug during normal operation. When the amount of spring back is proportionate to the stock thickness and area of slug, small holes in thin material show very little spring back and doesn't stick to the die wall. Hence slug may adhere to the punch face. Slug may also stick to the punch face due to heavy lubrication. Sticking of slug can be reduced by using low viscosity lubricants. The sticking of slug can also be reduced by using shedder pins. Shedder pins break the oil bond between punch face and slug. Shedder pins break the bond between punch face and slug. The spring operation of shedder pin is shown in Figure 5.8. The shedder pin is located in the centre of the punch. The use of shedder pin is limited only for punches of diameter greater than 3/32 inch. For diameter below 3/32 inch, concave shear may be provided on the face of the punch. This helps to avoid it from sticking to the punch face.

**Pilots**

The main purpose of a pilot is to position the stock strip accurately. Pilots also bring the stock strip into proper position for blanking and piercing operation simultaneously. If strip is fed by hand, it may go beyond proper position due to strip stop. In such a situation, pilot takes it back to proper position in a direction away from the strip stop. Pilot also prevents buckling of strip. When the strip is fed by hand, under feeding of strip occurs and pilot pulls the strip forward. Diameter of pilot is generally 0.002 to 0.003 inch smaller than punch diameter for average work and 0.0005 to 0.001 inch smaller than punch diameter for precision work.

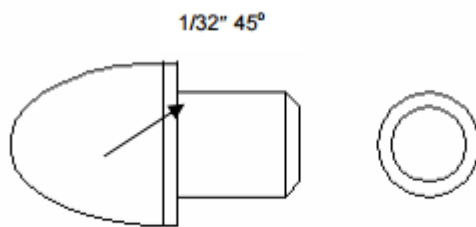


Figure : Pilot

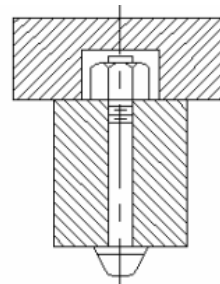


Figure : Direct Pilot

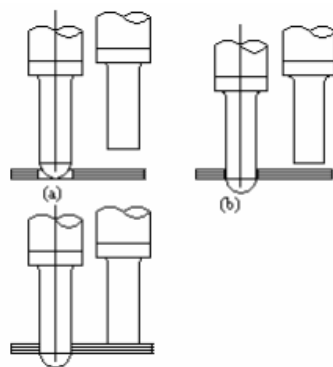


Figure : Indirect Pilot

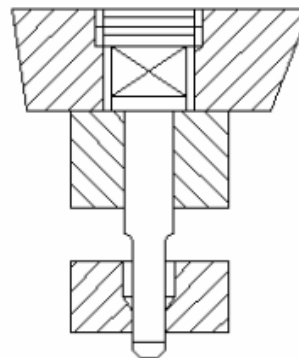


Figure : Spring Loaded Pilot

Length of pilot is at least 1/4 inch longer than punches. In this way, pilot will take care of proper positioning before actual cutting. Pilot nose contour is shown in Figure . Classification of Pilot Pilots are classified as : direct pilot, indirect pilot and spring loaded pilot. Direct Pilot Direct pilots are mounted on punch face. A direct pilot is shown in Figure. It acts as a misfeed detector, which detects overfeeding or underfeeding of strip. If it finds misfeed, it actuates a switch to cut off the electric power to press. Indirect Pilot Indirect pilot is used with previously pierced hole at a certain distance from blanking punches. Figure shows typical indirect pilot. The distortion is avoided by using indirect pilot as it provides support to strip. Spring-loaded pilot is generally used for workpiece having more than 1/16 inch thickness. A spring-loaded pilot is shown in Figure. Spring retracts the pilot from misfeed. This pilot pierces the hole if it is used for thin plate.

### Strippers

The main purpose of stripper is to remove the stock from the punch after blanking or piercing operation. Classification of Strippers Fixed Stripper Fixed stripper is solid attached to the die block or die shoe as shown in Figure 5.13. Spring Operated Stripper Spring operated stripper goes up and down on the shank of the punch. Channel Strippers Channel strippers are widely used because they are simple in construction and easy in operation.

#### Fixed Stripper

A rectangular plate is mounted on the top of the die block. The strip is passed through the milled channel. In general, the height of the channel should be 1.5 times the stock thickness whereas width must be equal to the summation of strip width and clearance. The clearance is provided to take care of dimensional variation in the width of strip. Enough clearance is provided around the punch for its easy removal; but clearance should be less than 1.5 times the thickness of strip. The back edge of the channel is used as a back gauge to position the strip accurately. A stock pusher is used to hold the strip against the back edge. It is also desirable to help in reducing the wear. The wear resistance is also increased by using inserts of mild steel. The wear resistance is increased by pressing hardened dowel pin along with the back guide. This is shown in Figure. The thickness of channel stripper is found out from the size of the socket head cap screw which is used to hold the strip in position.

#### Spring Operated Stripper

This type of stripper is also called pressure pad stripper. Its main advantage over other stripper, is that it holds the strip flat during the operation. Spring operated stripper is shown in Figure. Spring operated stripper is generally mounted on socket head stripper bolts. Spring stripper may also be mounted on rods. To minimize the bending, length of the rod should provide adequate support to the inner diameter of the spring. This is achieved by pressing a dowel of proper diameter and length into one plate and drilling a clearance hole in other plate to provide passage for dowel to pass through other plate.

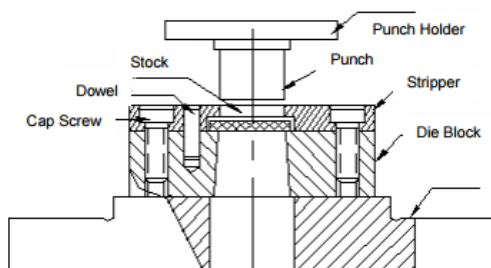


Figure 5.13 : Channel Type Fixed Stripper

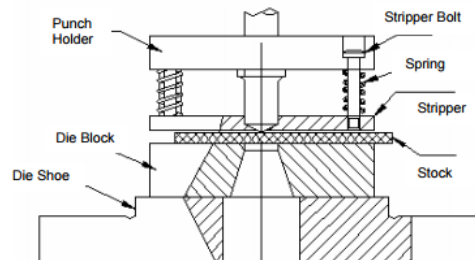


Figure : Spring Operated Stripper

### Guiding Stock with Spring Operated Strippers

Guide stock consists of guide rail which is mounted on the die block as shown in Figures shows a stripper acting as a pressure pad and withstanding against the workpiece. The stock guide does not make contact with the stripper. If clamping of strip is not practical, guide rails may be used to avoid stripper from clamping the work. This is shown in Figure. If space is limited, button stock strip guide may be used as shown in Figures(a) and (b). Minimum 3 button guides on each side of the strip will satisfactorily guide the strip. But best method for guiding the strip is the use of guide rails.

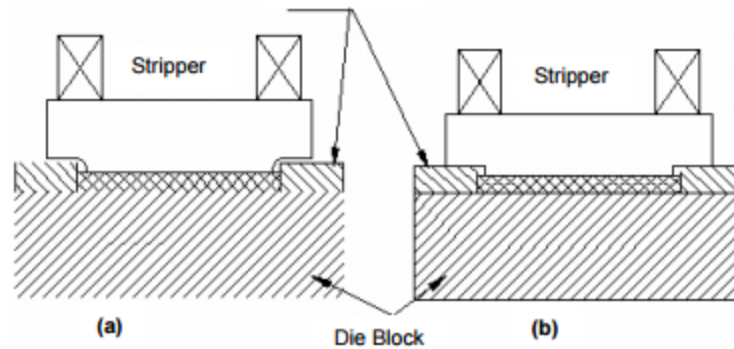


Figure : Method of Guiding Stock with Spring Operated Stripper

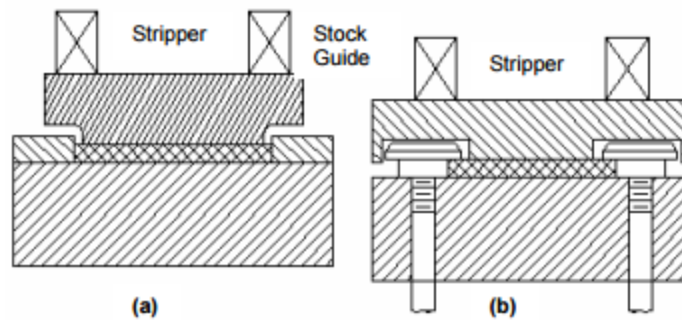


Figure : Method of Guiding Stock with Spring Operated Stripper

### STOCK STOPS AND AUTOMATIC STOPS

The device by which the strip has to be advanced correct distance after each blanking is called stock stops. Sometimes dowel pin is used as a stock stop. After each stroke of the press, an edge of previously blanked hole is pushed against a dowel pin. To release the strip from the pin, enough clearance is provided in a strip channel to allow the stock to be lifted above the pin during upward stroke of the press. Skilled operator is required for such type of operation.

#### Finger Stops:

In its simplest form, a stock stop may be a pin or small block, against which an edge of the previously blanked opening is pushed after each stroke of the press. With sufficient clearance in the stock channel, the stock is momentarily lifted by its clinging to the punch, and is thus released from the stop. Figure shows an adjustable type of solid block stop which can be moved along a support bar in increments up to 25 mm to allow various stock lengths to be cut off.

A starting stop, used to position stock as it is initially fed to a die, is shown in Fig., view A. Mounted on the stripper plate, it incorporates a latch, which is pushed inward by the operator

until its shoulder (1) contacts the stripper plate. The latch is held in to engage the edge of the incoming stock; the first die operation is completed, and the latch is released.

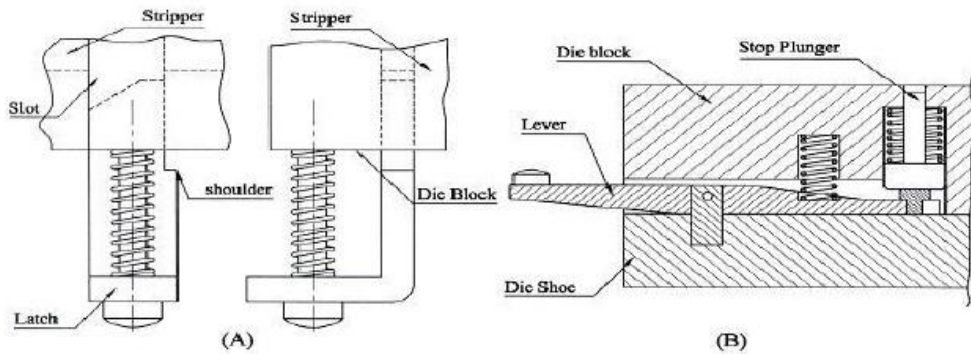


Fig. 5-23 Starting stops

### Trip stop

Trip stop is shown in Figure. The pawl rises on ratchet principle as the stock is fed forward manually. The pawl drops and positions the stock accurately against the vertical surface of the pawl after the stock is pulled back by operator.

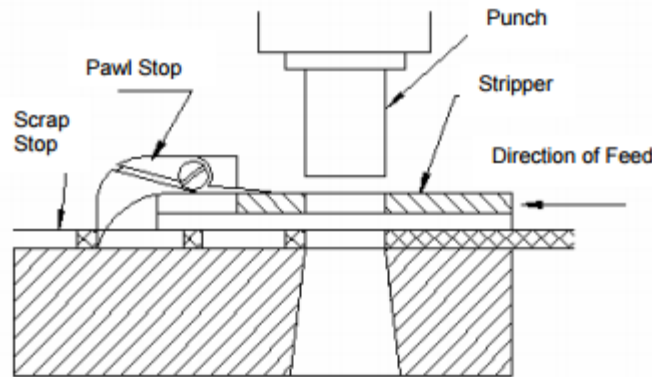


Figure 5-24: Trip Top

### Automatic Stops:

The starting stops shown at view B, mounted between the die shoe and die block, upwardly actuates a stop plunger to initially position the incoming stock. Compression springs return the manually operated lever after the first die operation is completed. Trigger stops incorporated pivoted latches 1. At the ram's descent, these latches are moved out of the blanked-out stock area by actuating pins, 2. On the ascent of the ram, springs, 3. control the lateral movement of the latch (equal to the side relief) which rides on the surface of the advancing stock, and drops into the blanked area to rest against the cut edge of the cut-out area.

When feeding the stock strip from one stage to another, some method must be used to correctly locate and stop the strip. Automatic stops (trigger stops) register the strip at the final die station. They differ from finger stops in that they stop the strip automatically, the operator having only to keep the strip pushed against the stop in its travel through the die.

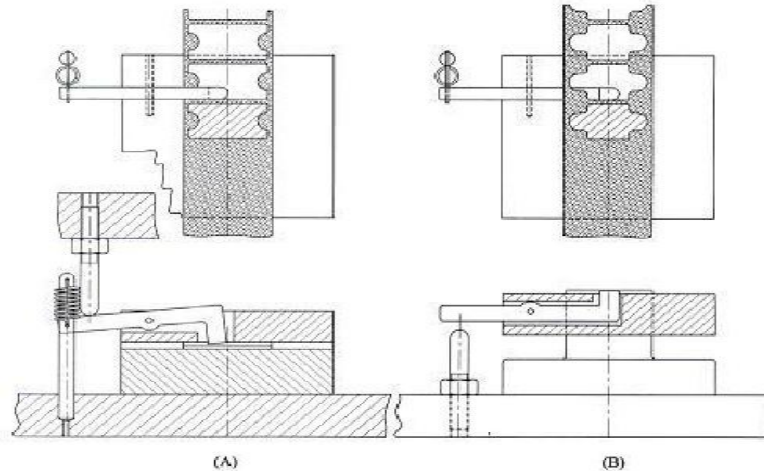


Fig. 5-24 Trigger stops: (A) Top stock engagement; (B) Bottom stock engagement

A typical automatic stop designs shown in fig.

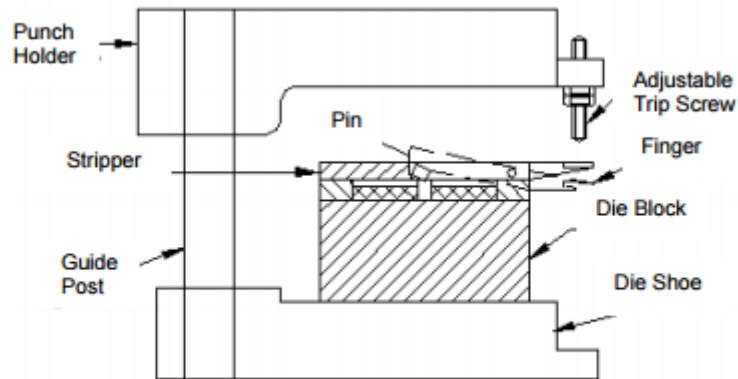


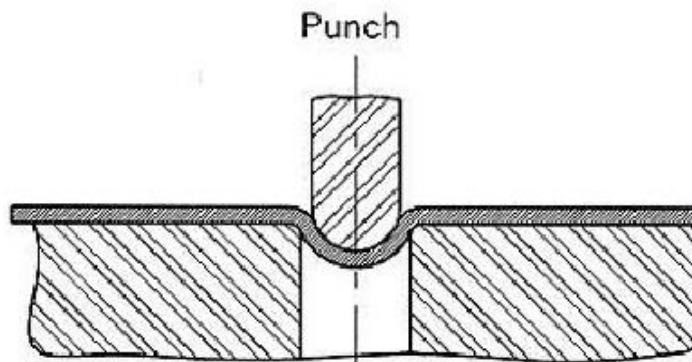
Figure : Automatic Stop

Automatic stop is shown in Figure . It uses pin-ended finger. On the forward stroke, the pin end of finger is lifted by the trip screw. The pin end of finger is dropped onto the top surface of the stock during return stroke. The finger is mounted loosely on pivot so that it can move endwise. Due to this endwise movement of the finger, its pin end does not drop onto the top surface of the stock instead of into the former position. The pin drops into the next blank, as the stock is fed forward. This helps the operator to locate the stock strip accurately.

In this lever end is raised by the trip screw as punch descends and cut the blank. On the return stroke end of lever drops and lever end would drop it former position if it were not for the endwise action o the lever, which causes the lever end to drop onto the top surface of the stock instead of into blank space. The mounting of the finger on the pivot is loose enough to allow for this endwise movement. When feeding the stock strip from one stage to another, some method must be used to correctly locate and stop the strip.

In an embossing operation of shallow surface detail is formed by displacement of the metal between two opposing mated tool surfaces. In one surface we have the depressed detail, on the other the relief detail. The metal is stretched into the detail rather than being compressed. Embossing is used for various purposes, the most common being the stiffening of the bottom of a pan or container; the embossing is designed to follow the outside profile of the part. A round can may have an embossed circle or raised grooves of various widths or panels. When the can or box is square or rectangular, such embossments follow their contours. Embossing often are ribs or crosses stamped in the metal to help make a section of a blank stronger by stiffening. An embossing die can be a male and female set of lettering dies, or profile of one of various shapes. The method of constructing the die blocks for an embossing operation depends on the size and shape of the form, also the accuracy and flatness required. When embossing simple shapes such as stiffening ribs, it is not necessary to fit up the die to strike the bottom. The metal stretches over the punch and across the two radius edges of the die hole (Fig.).

The die opening has the same width of the rib or embossing  $a$ , and a slight radius  $b$  is added to the edges of the opening to allow the metal to flow freely. The punch is made slightly smaller than the required metal thickness per side, so that it does not strike along this area. By constructing it in this manner the pressure required to stamp the embossing is reduced. When embossing are of the lettering type, such as depressed or raised letters for name plates, care must be taken to see that both dies are properly located and doweled in place (Fig).



The male die is located in a pocket or recess, and keyed in place. By lining up the female die profile to correspond with the male die profile, and keying it in place, a good stamping or embossing can be made. Stamping operations of this kind require precision work by the toolmaker; the dies are easily damaged by misalignment. As small embossing is often used as a weld projection nib. These nibs are used to weld piece-parts together. There are two kinds: a button type, which we use for light-gage metal, 3/32 in, or less thick, and a cone type for heavier-gage metal (Fig). Care must be taken in their design, because if the projection is too weak the nib will collapse before a good weld can be made. A nib that is too thick or heavy through the section will require too much pressure to produce good welds. The piece-parts are heated electrically, and this causes the projections to melt, so if the projections are too heavy or too light, the heat and pressure required can cause trouble.

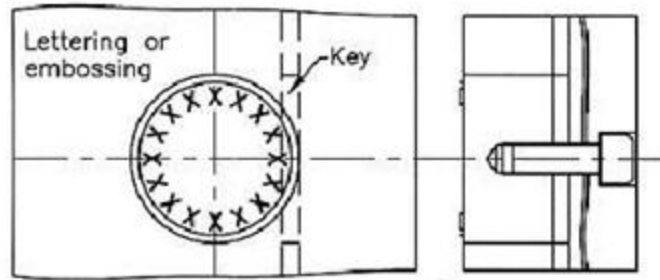


Fig. Lettering (embossing) die detail.

### **PRESSURE-PAD IMPINGEMENT RINGS**

The most important consideration in the design of a pressure pad for fine-edge blanking is the special construction required to lock the work piece tightly against the die and force the metal to flow against the punch. A V-shape impingement ring is provided on the pressure pad surrounding the outline of the part. The lip of the pressure pad between the ring and the shear line has a difference in elevation of 0.05 to 0.125 mm. from the outer surface of the pressure pad. The ring (which penetrates to its full depth into the scrap metal outside the shear line) and the lip of the pressure pad hinder metal flow at the shear line during blanking. The selection of the ring height and of the exact location within the range defined is based on experience. A shallow ring near the shear line has about the same effect as a deeper one farther from the shear line. If the ring is too near the die opening, a large portion of the metal in the zone will flow into the shear or edge radius and impair the efficiency of the ring. When a larger ring is located a greater distance from the die opening, a larger amount of stock is used, and more force is required to impress the ring into the work metal. Improper location and size of the impingement ring can cause rough sheared edges on the blank.

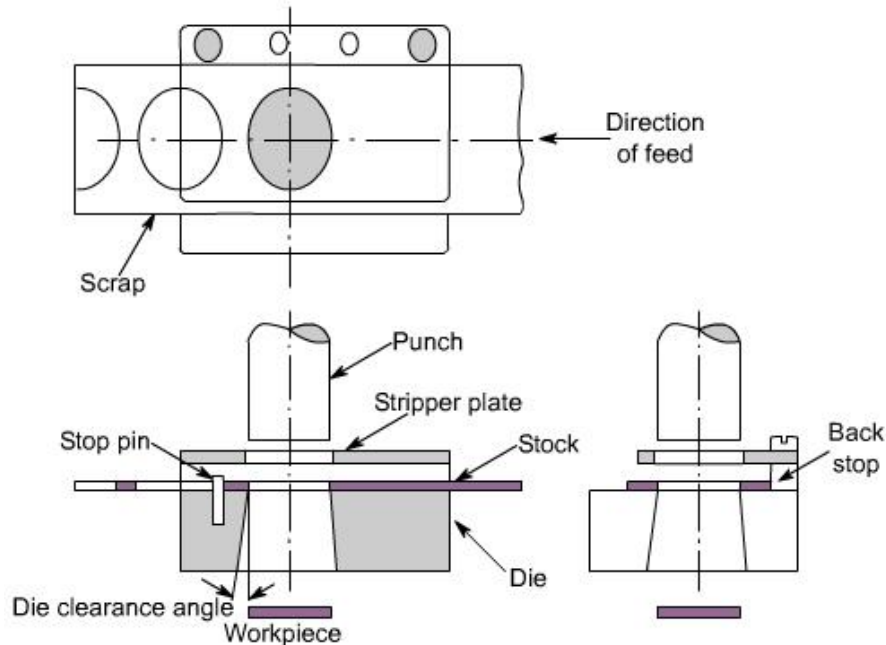
#### **Effect of Stock Thickness:**

Stock up to 4 mm. thick usually requires a ring on the pressure pad only. Stock up to 4.8 mm. thick may need a partial ring on the die in addition to a full ring on the pressure pad. Full rings on the pressure pad and the die may be necessary for stock over 4.8 mm. thick. Although an impingement ring on the die reduces the edge radius on the blank more than does a similar ring on the pressure pad, its use is avoided when possible, because it makes re-sharpening of the die difficult. The need for a full or partial ring on the die, to supplement the ring on the pressure pad, can be reduced by properly orienting the blank design on the strip. More precise and intricate cutting can be done on the side of the blank adjacent to the incoming strip, where ample stock is available to restrain metal flow, than along surfaces near the edges of the strip or along the narrow portion of the web where blanks have already been removed. When a blank cannot be oriented on the strip so that an ample width of stock is adjacent to all critical sections of the shear line, it is usually more economical to use partial rings or straight knife-edge projections on the die than to provide large edge and web widths.

**Effect of Part Shape:** The impingement ring ordinarily follows the contour of the part at a distance depending on ring height, but it cannot follow narrow slots in the part. Selection of die material for press tool depends mainly on the type of metal being cut, bend or formed and on production quantities.

## DIE AND PUNCH

A typical die and punch set used for blanking operation is shown in Fig 8.1. The sheet metal used is called strip or stock. The punch which is held in the punch holder is bolted to the press ram while die is bolted on the press table. During the working stroke, the punch penetrates the strip, and on the return stroke of the press ram the strip is lifted with the punch, but it is removed from the punch by the stripper plate. The stop pin is a gage and it sets the advance of the strip stock within the punch and die. The strip stock is butted against the back stop acting as a datum location for the centre of the blank.



The die opening is given angular clearance to permit escape of good part (blank). The waste skeleton of stock strip, from which blanks have been cut, is recovered as salvaged material.

The clearance angle provided on the die (Fig 8.1) depends on the material of stock, as well as its thickness. For thicker and softer materials generally higher angular clearance is given. In most cases, 2 degree of angular clearance is sufficient. The height of cutting land of about 3 mm is generally sufficient.

### Clearance

In blanking operation, the die size is taken as the blank size and the punch is made smaller giving the necessary clearance between the die and the punch.

$$\text{Die size} = \text{blank size}$$

$$\text{Punch size} = \text{blank size} - 2 \times \text{clearance}$$

$$\text{Clearance} = k \cdot t \cdot f$$

where  $f$  is the shear strength of material,  $t$  is the thickness of sheet metal stock, and  $k$  is a constant whose value may be taken as 0.003.

In a piercing operation, the following equations hold.

$$\text{Punch size} = \text{blank size}$$

$$\text{Die size} = \text{blank size} + 2 \times \text{clearance}$$

$$\text{Clearance} = k \cdot t$$

## TYPES OF DIES

### Types of Die

Dies are classified according to the type of press operation and according to the method of operation. According to the type of the press operation, dies are classified as cutting dies and forming dies.

#### Cutting Dies

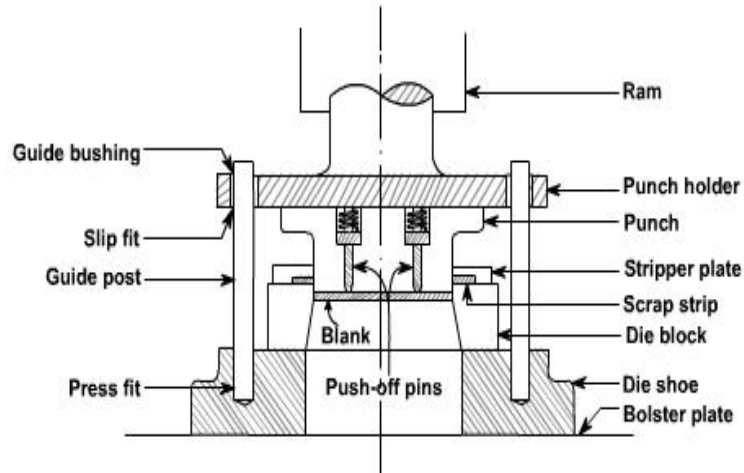
Cutting dies are used to cut the metal. They use cutting and shearing action for cutting the metal. Examples of cutting dies are blanking dies, piercing dies, perforating dies, notching dies, trimming dies, shaving dies and nibbling dies, etc.

#### Forming Dies

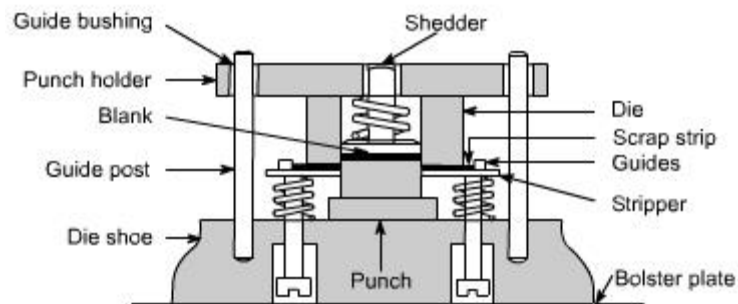
Forming dies change the shape of the blank without removing any stock. Example of forming dies are drawing dies, bending dies and squeezing dies. According to the method of operation, dies are classified as simple dies, compound dies, combination dies, progressive dies, transfer dies and steel rule dies, etc.

The components generally incorporated in a piercing or blanking die are shown in Fig . This Figure shows the die in the conventional closed position. The die set is made up of the punch holder which is fastened to the ram of the punch press and the die shoe which is fastened to the bolster plate of the punch press.

Generally, the punch is fastened to the punch holder and aligned with the opening in the die block. Fig shows one type of stripper plate and push – off pins. The stripper holds the scrap strip so that the punch may pull out of the hole. The push – off pins are needed to free the blank in instances where the material strip clings to the bottom of the punch. This may be necessary for thin material, or where lubricants are used on the material.



Sometimes the die and the punch positions may be interchanged. This may become necessary when the opening in the bolster plate is too small to permit the finished product to pass through the bolster opening. Fig shows such a die.



**Inverted die** is designed with the die block fastened to the punch holder and the punch fastened to the die shoe. During the downward stroke of ram, the blank is sheared from the strip. The blank and shedder are forced back into the die opening, which loads a compression spring in the die opening. At the same time the punch is forced through the scrap strip and a spring attached to the stripper is compressed and loaded. On the upstroke of the ram, the shedder pushes the blank out of the die opening and the stripper forces the scrap strip off the punch. The finished part (blank) falls, or is blown, out the rear of the press.

### Compound die

The die in which two or more cutting operations are performed in one stroke of the press and at one station only, is called compound die. In compound die, only cutting action, i.e. blanking and piercing is possible. A simple compound die is shown in Figure. The washer is produced by simultaneous blanking and piercing operation. Compound die is suitable for mass production. Simultaneous blanking and piercing is achieved by providing blanking and piercing element in both the member of die, i.e. the upper and the lower member of the die. These elements are set exactly opposite to each other so that piercing punch acts in the opposite direction with respect to the blanking punch. In this way blanking and piercing operations are performed simultaneously.

Angular clearance is provided in the piercing die. This helps in easy removal of scrap from the die. The blanking punch acts as a piercing die. The sidewall, which is adjacent to cutting edges of blanking die opening, is straight so that the blank does not pass through the die. Knock out stroke is actuated during the return stroke of the press. It ejects the blank. Compound dies are slow in operation but give close tolerance on workpiece. The flatness of the blank is achieved during cutting operation by knock out plate. Large parts can be blanked in a smaller press by using compound die. In compound die, very high force is required. Design of punch and die is also difficult for number of operation (more than five). Compound die is excellent for two operations. Compound die combines the principles of the conventional and inverted dies in one station. This type of die may produce a workpiece which is pierced and blanked at one station and in one operation. The piercing punch is fastened in the conventional position to the punch holder. Its matching die opening for piercing is machined into the blanking punch. The blanking punch and blanking die opening are mounted in an inverted position. The blanking punch is fastened to the die shoe and the blanking die opening is fastened to the punch holder.

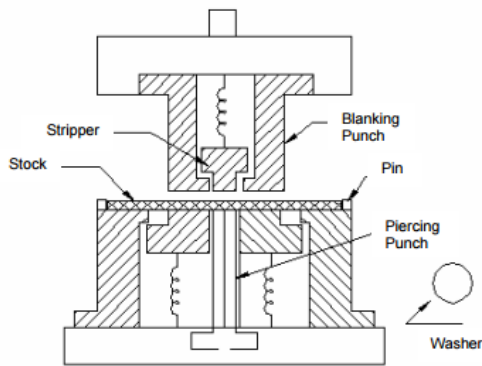
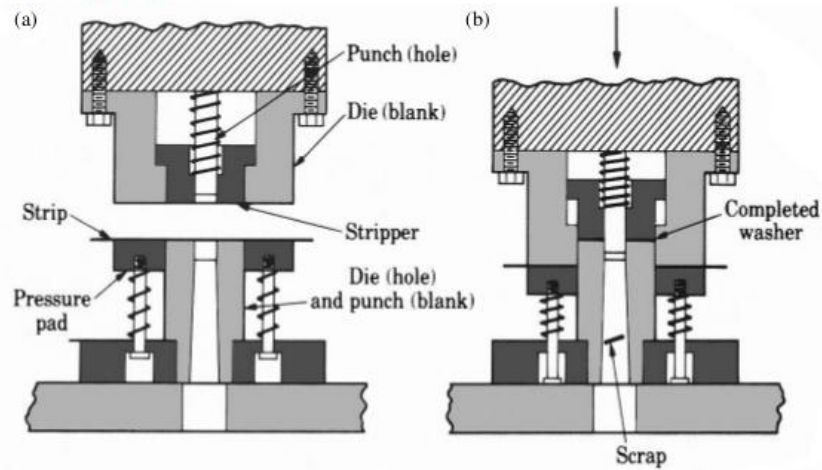
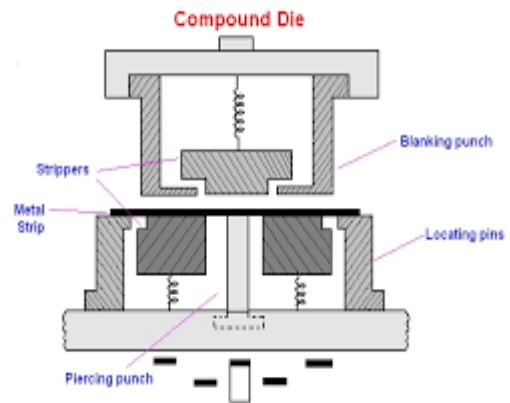


Figure : Compound Die

■ **Compound Die**



**Progressive Die**

It is also called a follow on die. The progressive die is shown in Figure. It performs two or more operations in one stroke of a ram at different stages. First operation is punching, which is followed by blanking. The metal strip is transferred to the next station in between the stroke to produce a complete workpiece. When the piercing punch cuts a hole in the strip, the blanking punch draws out a portion of the metal strip in which a hole had been pierced at a previous station. The metal strip is fed into the die mechanically or manually. The primary stop is pushed in by hand and lead end is then made

to contact with it. The press is now made to operate to pierce a hole at station 1. As the primary stop is released, the strip is transferred to the station 2. The strip contacts with automatic button die stop at station 2. During the next stroke, the pilot on blanking punch enters the previously pierced hole which ensures the exact alignment of the strip to be blanked next. The die stop activation pin pushes the die stop pin below the edge of the blank. Hence the strip is transferred to next station on return stroke of the ram. The button die stop pin returns to its normal position and holds the strip on the inside wall of the blanked hole. During the third stroke, another complete part is produced and thereafter parts are produced at each stroke of the ram. In a progressive die, force required is reduced to a large extent due to the staggering of punches. The disadvantage of progressive die is that it makes balancing of the punches difficult.

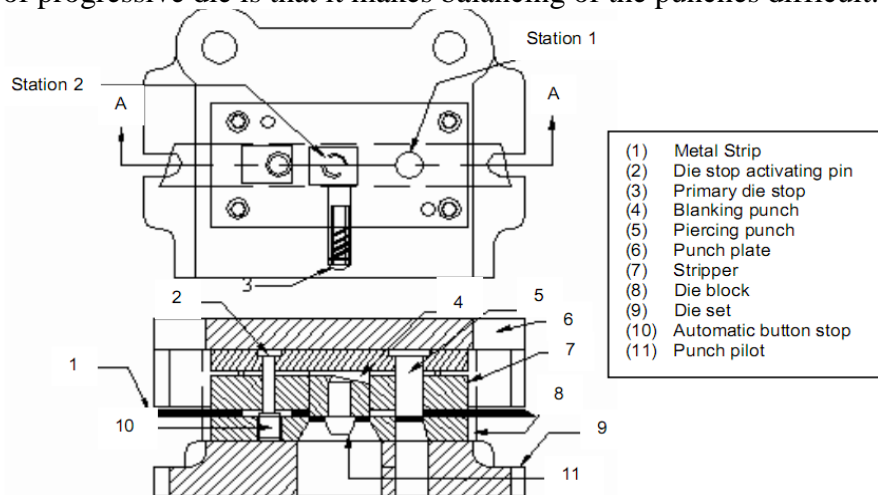
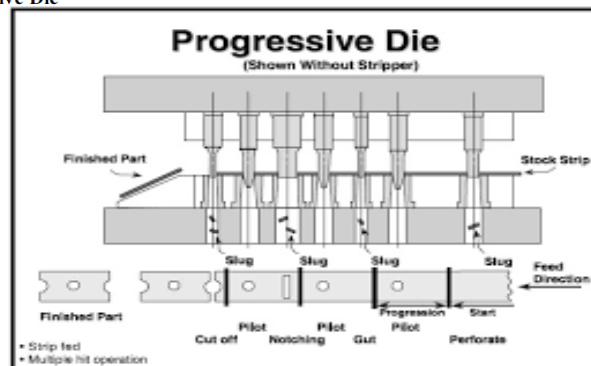
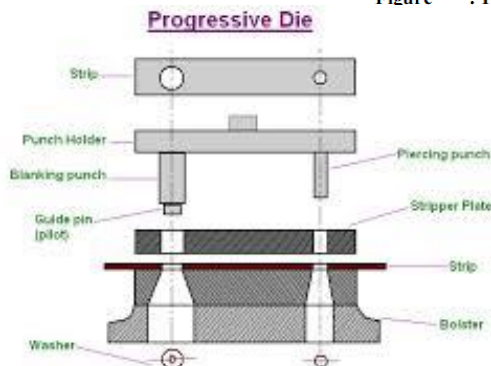


Figure : Progressive Die



### Combination Dies

In a combination die, cutting action is combined with non-cutting actions, i.e. forming. Non-cutting actions may be bending, drawing, extrusion or embossing. More than one operation is possible in one stroke at a single stage, but the die is more useful for two operations only. The principle of working of a combination dies is shown in Figure 6.3. The die ring is mounted on

the die shoe. The die ring is counter bored at the bottom to allow the flange of a pad to travel up and down. This pad is held flush with the face of die by a spring. The drawing punch of required shape is attached to the die shoe. The blanking punch is placed in the punch holder. The stripper (spring operated) strips the skeleton from the blanking punch. As the workpiece comes in contact with the knock out bar during the return stroke, knock out removes the part attached to the punch. As the part is blanked, the blank holding comes down. Then the drawing punch contacts and forces the blank into the drawing die which is made into the blanking punch.

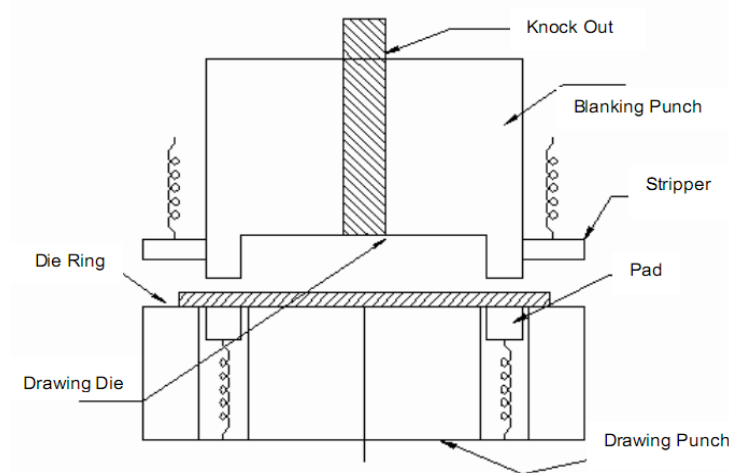


Figure : Combination Die

### Transfer Dies

Transfer dies are same as progressive dies, the only difference being that the already cut blanks are fed manually or automatically from station to station. First operation is blanking, which is followed by piercing.