UNIT 6  DESIGN OF SHEET METAL, BLANKING AND PIERCING TOOLS

Structure

6.1 Introduction
   Objectives

6.2 Description of Press Working Tools
   6.2.1 Source of Power
   6.2.2 Type of Frames
   6.2.3 Fundamentals of Press Operation
   6.2.4 Press Working Terminology

6.3 Types and Applications of Blanking and Piercing Die

6.4 Principle of Sheet Metal Working and Piercing Tools
   6.4.1 Plastic Deformation
   6.4.2 Shear

6.5 Summary

6.6 Key Words

6.1 INTRODUCTION

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. 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.

Objectives

After studying this unit, you should be able to

- identifying various press working tools,
- know various piercing and blanking operation, and
- understand the principle of sheet metal working.

6.2 DESCRIPTION OF PRESS WORKING TOOLS

Press working tools include variety of press. The press may be classified according to source of power; type of frame; method of actuation of slides; and the number of slides incorporating the type of the work.

6.2.1 Source of Power

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.

6.2.2 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.

6.2.3 Fundamentals of Press Operation

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.

**Die Space**

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

6.2.4 Press Working Terminology

A simple cutting die is shown in Figure 6.1.

![Figure 6.1 : Simple Cutting Die](image)

**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**
Design of Metal Shaping Tools

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

**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.

**SAQ 1**

(a) Discuss various types of press working tools differentiated according to source of power.

(b) What are the different types of press working tools according to type of frame?
6.3 TYPES AND APPLICATIONS OF BLANKING AND PIERCING DIE

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.

**Progressive Die**

It is also called a follow on die. The progressive die is shown in Figure 6.2. 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.

![Figure 6.2: Progressive Die](image)

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.

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.

![Figure 6.3: Combination Die](image)

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.

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.

SAQ 2

(a) What are various types of blanking and piercing dies?
(b) Explain progressive dies.
6.4 PRINCIPLE OF SHEET METAL WORKING AND PIERCING TOOLS

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.

6.4.1 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.

6.4.2 Shear

The cutting of strip material is known as shearing. The principle of sheet metal working is shown in Figures 6.4(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 6.4(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 6.4(a) : Principle of Sheet Metal Working](image)

![Figure 6.4(b) : Principle of Sheet Metal Working](image)
SAQ 3

Explain the principle of sheet metal working.

6.5 SUMMARY

Press working tools include variety of presses. The presses may be classified according to the source of power; type of frame, method of actuation of slides, number of slides, and incorporating the type of the work. The fundamentals of press working are discussed in this unit. This unit also discusses various types of dies. Progressive die performs two or more operations in one stroke of a ram at different stages. In the case of combination dies, cutting action is combined with forming. Cutting of metal strip takes place due to shearing in blanking and piercing operations.

6.6 KEY WORDS

- **OBI**: Open Back Inclination (OBI) is a type of press which is widely used in press working operation.
- **Progressive Die**: In a progressive die, two or more operations are performed in a single stroke of the ram.
- **Combination Die**: In a combination die, cutting action is combined with forming actions.