UNIT 7  DESIGN OF FORMING TOOLS

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7.1 INTRODUCTION

Forming a tool or die or designing a forming tool is one of vital factor of tool engineering, which must be known by every design engineer. Forming a tool means giving a particular and useful shape with required dimensions to the part. The part formed by forming operation is generally takes the shape of the dir or punch. In the forming operation, the metal flow is not uniform and localised to some extent, depending upon the shape of the workpiece. Bending along a large radius in a straight line may also be referred to as a forming operation. It is difficult to distinguish between a bending and forming tools. Forming operation may be simple and extremely complicated.

Objectives

After studying this unit, you should be able to

- know various types of forming tools, and
- understand design of forming tools

7.2 PURPOSE OF FORMING TOOLS

A form tool is defined as a cutting tool having one or more cutting edges with well defined profile or contour that is reproduced as the desired form on the workpiece surface. Form tools utilized for turning applications are classified according to type of cross section. The classification is shown in the tree diagram of Figure 7.1.

![Figure 7.1 : Classification of Form Tool](image-url)
Flat or blocked tools are further classified according to the setting of tool with respect to the workpiece, viz. radial-fed tools and tangential-fed tools. Further, form tools are also classified with respect to orientation of tools with respect to the workpiece axis.

### 7.3 VARIOUS TYPES OF FORMING TOOLS

#### 7.3.1 Flat Form Tool

Straight and flat form tools have a square or rectangular cross-section with the form being along the side or end. These tools are similar in appearance to the turning tools. These are usually set centrally so that they will cut their contour which is identical to the desired contoured of the workpiece. A typical example of V-notch tool is shown in Figure 7.2. This type of tool is suitable for making deep straight-sided form grooves. The cutting is restricted type due to the mixed chip flow. Because of the existence of the good surface finish, this type of tool must be operated at very low cutting speed.

![Section A-A](image)

**Figure 7.2 : V-notching Tool**

Figure 7.3 shows a typical flat form tool without rake angle. It is necessary to compute $x$ to be machined in the tool in order that the depth $BC$ is correct profile. This distance $x$ is to be planned by a fly cutter or planning tool and is measured normal to the clearance face. The amount of $x$ is less than actual depth of form $AB$ produced on the workpiece because of the clearance angle $\alpha$. From the geometry of the figure

$$x = AB \cos (\alpha) \quad \ldots (7.1)$$

Figure 7.3 shows a flat form tool with rake angle. The wedge angle is given by $(90 - \gamma - \alpha)$. Using geometry of the figure, the depth $x$ to be ground or machined can be determined in the following manner:

$$H = r \sin (\gamma_s), \quad l_s = r \cos (\gamma) \quad \text{and} \quad l_1 = \sqrt{R^2 - h^2}$$

Therefore,

$$L_2 = L_s - L_1 = \sqrt{R^2 - h^2} - r \cos (\gamma)$$

$$= \sqrt{(R^2 - r^2 \sin^2 (\gamma_s)) - r \cos (\gamma)}$$

Now,

$$x = L_2 \cos (\alpha + \gamma)$$

Hence,

$$x = \sqrt{(R^2 - r^2 \sin^2 ((\gamma_s)) - r \cos (\gamma)) \cos (\alpha + \gamma)}$$

Introduction of rake angle to facilitate cutting action modifies the profile on the tool.
7.3.2 Circular Form Tool

The circular form tool is circular in shape. It has depth $x$ or projection of distance $x$ produced all around the diameter in the form of annular grooves. The outside diameter of circular form tool is determined in accordance with the height of profile to be turned. The graphical method is recommended for this purpose. Circular form tool is shown in Figure 7.4.

7.4 GRAPHICAL METHOD OF DETERMINING PROFILE OF FORM TOOL

7.4.1 Profile of Flat Form Tool

The graphical method profile of flat form tool is shown in Figure 7.5.

The graphical method is described as follows:

(a) Draw profile of the workpiece in lower left corner.

(b) Project basic points on the axis $I-J$ viz. $1'$, $2'$, $3'$ etc. and form point $O$ as a centre. Draw circles corresponding to radius $r_1$, $r_2$, $r_3$ passes through $1'$, $2'$, $3'$ respectively.
(c) Assign proper value of $\alpha$, $\gamma$. Find outer diameter and centre of flat through point form tool.

(d) Through point 1, 2, 3, draw a line parallel to the flank.

(e) To construct the cross-section of the tool perpendicular to the flank (set $N-N$), draw line $LL$ (perpendicular to flank).

(f) From the line $LL$, we lay off the lengths $l_1$ and $l_2$, since the dimensions of the tool profile measured along the workpiece are equal to the corresponding axial dimensions of the workpiece.

(g) At lengths $l_1$, and $l_2$ draw lines parallel to $LL$ and obtain point of intersection as $1''$, $2''$, and $3''$, which on joining gives profile of form tool.

**Figure 7.5**: Graphical Method of Determining the Profile of Flat Form Tool

### 7.4.2 Profile of Circular Form Tool

The profile of circular form tool is shown in Figure 7.6.

**Figure 7.6**: Graphical Method of Determining the Profile of Circular Form Tool
The graphical method is as follows:

(a) Draw profile of workpiece in lower left corner.

(b) Project basic points on the axis I-I viz. 1', 2', 3' etc. and form point O as a centre. Draw circles corresponding to radius \( r_1, r_2, r_3 \) passes through 1', 2', 3' respectively.

(c) Assign proper value of \( \alpha, \gamma \). Find outer diameter and centre of circular form tool.

(d) Draw circles passing through point 1, 2, 3 with radius \( R_1, R_2, R_3 \) of tool corresponding to radii \( r_1, r_2, r_3 \) of workpiece.

(e) To construct tool profile in radial section, draw a radial line \( N-N \) to lay off distance \( l_1, l_2 \) to the right on line perpendicular to \( N-N \).

(f) Draw lines perpendicular to \( N-N \) to lay off distance \( P_2 \) and \( P_3 \) from points I, II, and III.

(g) On the intersection of the lines corresponding to the dimensions \( P_2 \) and \( P_3 \) with lines determining dimensions \( l_2 \) and \( l_1 \), obtain points 1'', 2'', and 3''.

(h) Connect the points 1'', 2'', and 3'' by straight lines; we obtain profile of form tool in radial cross section.

**SAQ 2**

Discuss the graphical method of determining the profile of circular form tool.

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**7.5 SUMMARY**

A form tool has one or more cutting edges with well defined profile or contour that is to be reproduced as the desired shape on the workpiece surface. Form tools are classified as flat form tools and circular form tools. Straight and flat form tools have square or rectangular cross-section with the form along its side or end. The graphical method to determine the profile of flat and circular form tool is depicted in this unit.

**7.6 KEY WORDS**

**Flat Form Tool**: A flat form tool is used to produce deep and straight sided grooves.