UNIT 4 DESIGN OF FIXTURE

Structure

4.1 Introduction
   Objectives

4.2 Design of Fixtures

4.3 Types of Fixture and its Industrial Application
   4.3.1 Vise Fixture
   4.3.2 Milling Fixture
   4.3.3 Facing Fixture
   4.3.4 Boring Fixture
   4.3.5 Face Plate Fixture
   4.3.6 Turning Fixture
   4.3.7 Grinding Fixture

4.4 Summary

4.5 Key Words

4.1 INTRODUCTION

Fixture is a workpiece-locating and holding device used with machine tools. It is also used in inspection welding and assembly. Fixture does not guide the cutting tool, but is always fixed to machine or bench. By using fixture, responsibility for accuracy shifts from the operator to the construction of machine tool.

When a few parts are to be machined, workpiece clamp to the machine table without using fixture in many machining operations. However, when the numbers of parts are large enough to justify its cost, a fixture is generally used for holding and locating the work.

Objectives

After studying this unit, you should be able to understand

- the design consideration in fixtures, and
- types of fixture and its industrial application.

4.2 DESIGN OF FIXTURES

4.2.1 Design Consideration in Fixtures

(a) The main frame of fixture must be strong enough so that deflection of the fixture is as minimum as possible. This deflection of fixture is caused because of forces of cutting, clamping of the workpiece or clamping to the machine table. The main frame of the fixture should have the mass to prevent vibration and chatter.

(b) Frames may be built from simple sections so that frames may be fastened with screws or welded whenever necessary. Those parts of the frame that remain permanently with the fixture may be welded. Those parts that need frequent changing may be held with the screws. In the situation, where the body of fixture has complex shape, it may be cast from good grade of cast iron.

(c) Clamping should be fast enough and require least amount of effort.
(d) Clamps should be arranged so that they are readily available and may be easily removed.

(e) Clamps should be supported with springs so that clamps are held against the bolt head wherever possible.

(f) If the clamp is to swing off the work, it should be permitted to swing as far as it is necessary for removal of the workpiece.

(g) All locator’s clamps should be easily visible to the operator and easily accessible for cleaning, positioning or tightening.

(h) Provision should be made for easy disposal of chip so that storage of chips doesn’t interfere with the operation and that their removal during the operation doesn’t interfere with the cutting process.

(i) All clamps and support points that need to be adjusted with a wrench should be of same size. All clamps and adjustable support points should be capable of being operated from the fronts of the fixture.

(j) Workpiece should be stable when it is placed in fixture. If the workpiece is rough, three fixed support points should be used. If workpiece is smooth, more than three fixed support points may be used. Support point should be placed as farthest as possible from each other.

(k) The three support points should circumscribe the centre of gravity of the workpiece.

(l) The surface area of contact of support should be as small as possible without causing damage to the workpiece. This damage is due to the clamping or work forces.

(m) Support points and other parts are designed in such a way that they may be easily replaced if they break.

### 4.3 TYPES OF FIXTURE AND ITS INDUSTRIAL APPLICATIONS

#### 4.3.1 Vise Fixture

It is easy to clamp workpiece with regular shape and parallel sides in a vise. However, workpieces with round or irregular shapes are very difficult to clamp properly. Hence, special jaws are created to hold workpieces with irregular shape properly and at the same time, it also avoid damage to the important surfaces. Various types of vise fixture are shown in Figures 4.1(a), (b), (c), (d) and (e).

![Figure 4.1(a) : Vise Jaws](image)
Figure 4.1(a) shows simple pair of jaws for holding round workpiece. Figure 4.1(b) shows pair of jaws for holding a thin sheet of non magnetic material. Stop pin is used to prevent bending of the workpiece by the application of clamping force.

![Figure 4.1(b): Vise Jaws](image)

Extended jaws for large workpieces are shown in Figure 4.1(c). Here guide pins are used to secure alignment. When it is necessary to hold the workpiece firmly in all the directions, wedge type jaws are useful. This arrangement is shown in Figure 4.1(d). If the pressure exerted by the cutting tool is likely to tilt upward one end of the workpiece, then the link construction as shown in Figure 4.1(e) should be used. It is suitable for rough casting and forging because it permits considerable variation in dimensions of workpiece.

![Figure 4.1(c): Vise Jaws](image)

![Figure 4.1(d): Vise Jaws](image)
4.3.2 Milling Fixture

This holds the part in correct relation to the milling cutter. Fixture is attached to milling machine table. Milling fixture consists of the base, clamps, rest blocks or nest, locating points and gauging surfaces.

The base of milling fixture consists of a base plate. A base plate has a flat and accurate undersurface and forms main body on which various components are mounted. This surface aligns with the surface of the mill table and forms the reference plane with respect to the mill feed movement. It may be constructed of steel plate or cast iron, depending upon the size and complexity of the part. The slots are provided in the base for clamping the fixture to the mill table. The base plate also has keyways along with length of the base for two keys. These keys are used to align the fixture on the milling machine table. The keys are pressed into the keyway at both ends of fixture and held there by socket head caps screw. This arrangement is shown in Figure 4.2. It is necessary to adjust the table by using feed movements until the correct position is attained. This can be done by trial and error cuts in the workpiece. Milling is always first operation.

One must know the dimension of milling machine for designing the fixture. The various dimensions include the dimension of T-slots, centre-to-centre distance of T-slot, dimension of milling machine table and length of table travel in all three feed
movements. Tool designer should provide enough clearance space around hold down slots for a nut, washer and wrench. Clamps on mill fixture must be extremely rigid.

Cutting forces may change as the cutter enters or leaves the workpiece and throw an extra load on clamps. Clamps should not be loosened by vibrations, which are caused by interrupted cutting by the mill cutter at the beginning and at the end of the cut. Clamp should be located opposite to bearing surfaces and locating points. These should be designed in a way so that these can be easily operated by the operator.

![Figure 4.3](image)

Rest blocks or bearing surfaces are located with the nest and provide support for the workpiece. These surfaces change in design according to the shape and size of workpiece. These are usually in the form of pins, pads or plates that are accurately placed in the base of fixture as shown in Figure 4.3. These surfaces are raised above the surface of base to permit chips to fall away and allow easy cleaning.

### 4.3.3 Facing Fixture

Milling machines are extensively used for facing seating and mating flat surfaces. Milling is often the first operation on the workpiece. Figure 4.4 shows simple face milling fixture. The workpiece is positioned by three adjustable spherical ended pads ‘A’. These pads are adjusted to suit the variation in the size of workpiece and lock in the position by check nuts. Two self adjusting supports ‘A’ are pushed upward by light spring. These springs are used to make sure that the support ‘A’ is positively in contact with the workpiece. Clamping screw is used to lock support ‘B’. On tightening the edge clamp, the workpiece is pushed against the fixed jaw. This jaw is keyed in the fixture body to provide solid support to workpiece against the heavy thrust developed in the operation. The cutter should be fed to the workpiece in such a manner that the milling thrust should be directed towards the solid support of fixed jaws. The setting can be set in the path of cutter to set it before starting of facing operation. Four clamping slots are provided to take care of the heavy forces developed during the operation.

![Figure 4.4](image)
4.3.4 Boring Fixture

According to the type of boring operation, boring fixture are used. Boring Fixture may have characteristics of a drill jig or a mill fixture. The workpiece always has an existing hole which is enlarged by the boring operation. It may be final or may be preliminary to grinding and other sizing operation.

4.3.5 Face Plate Fixture

It can be used conveniently for machining of simple and small components. Addition of locators and clamps on face plate help in quick location and clamping of workpiece as shown in Figure 4.5. Face plate fixture is useful for facing number of workpieces simultaneously on the lathe.

![Figure 4.5 : Face Plate Fixture](image)

4.3.6 Turning Fixture

These are generally special face plates. Their swing should be lesser than the swing of the machine. These are used for quick location and clamping. Typical turning fixture is shown in Figure 4.6. The workpiece rests on angle plate and its boss is centralized with machine axis by sliding v-block which can be operated with knurled screw. The overhang of turning fixtures should be minimum bare necessary for the operation. Fixture should be balanced with workpiece in position. The clamping arrangement should be capable of withstanding the various forces developed during operation.

(a) Cutting force tangential to cutting circle.
(b) Axial force and radial force due to feed of tool.
(c) Bending forces due to pressure of tool on workpiece.

![Figure 4.6 : Turning Fixture (Boring and Facing Fixture)](image)
Back Plate for Turning Fixture

It consists of workpiece locating and clamping elements. These fixtures are generally used for facing turning and boring operation. The workpiece should be located correctly with respect to rotating machine spindle for all these operations.

Example 4.1

For boring and turning, the axis of the bore or the outside diameter to be machined must be aligned with the machine spindle axis. Most of machines are provided with back plate, which is permanently mounted on the machine spindle. The back plate for turning fixture is shown in Figure 4.5. This plate is used to locate and clamp turning fixtures. Generally, outside diameter of the back plate is super finished. It is used for locating spigot for aligning axis of rotation of fixtures with machine spindle. Back plate is provided with three or more equispaced holes for clamping turning fixtures. Turning fixtures give quick loading, locating and clamping of workpieces in mass production.

4.3.7 Grinding Fixture

The standard magnetic tables are used to rest workpiece such that resting surface will be parallel to the surface to be ground. However, for light workpiece with lesser resting area, the resting area tends to tilt and fly off the magnetic table due to high speed of grinding wheel and due to high feed, also. Hence, it is necessary to provide additional support by nesting the workpiece. This can be done by placing the solid plates around the workpiece as shown in Figure 4.8. The nest plates are held firmly by the magnetic force of table with more weight and more resting area. The nest plates surround the workpiece from outside and arrest its movement in the horizontal plane. Thus, this arrangement will help in preventing it from flying off and tilting due to high speed and feed in grinding operation.

The maximum possible area of magnetic table should be utilized to grind as many workpieces as possible in a single batch.
Example 4.2

Numbers of rounded workpieces are arranged in rows with common supporting nest plate around. Thickness of nest plate should be less than finished height of workpiece to prevent disturbance of the grinding wheel as shown in Figure 4.9.

![Surface Grinding Layout](image)

Figure 4.9: Surface Grinding Layout

For odd shapes workpieces with little variation in size, an epoxy resin nest can be used as shown in Figure 4.10. The nest prevents tilting and sliding of the workpiece during grinding operation.

![Epoxy Resin Nest](image)

Figure 4.10: Epoxy Resin Nest

SAQ 1

(a) Explain necessary design consideration in fixtures.
(b) List different types of fixtures.
(c) Discuss in brief the working of turning and grinding fixtures.
(d) Explain the working of milling fixture.

### 4.4 SUMMARY

Fixture is used for locating and holding the workpiece. Fixture is always fixed to machine or bench. Fixture is generally used for mass production. Fixture reduces operator’s fatigue. The fixture also follows the principle of locating and clamping. The various types of fixture such as vise, milling, grinding, facing, turning, faceplate and boring fixture are explained with examples in this unit. The design of fixture depends upon the shape and size of workpiece. The fixture may be different for different workpieces.
### 4.5 KEY WORDS

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixture</strong></td>
<td>Fixture is a workpiece holding and locating device.</td>
</tr>
<tr>
<td><strong>Milling Fixture</strong></td>
<td>It is used with milling cutter.</td>
</tr>
<tr>
<td><strong>Turning Fixture</strong></td>
<td>It is greatly used for facing turning and boring operation.</td>
</tr>
</tbody>
</table>
FURTHER READINGS

Tool engineering is one of the important topics in the manufacturing processes. Without proper tool, it is difficult to manufacture a new product. You must also remember that if you get a tool and are making a product it is not a simple task. The tool should have a definite design and specifications with required quality. The maintenance and production of good quality tools will be the responsibility of the design engineer or tool design engineer.

The tool design engineer must go through the specialised training. Tool design engineer must know about the manufacturing processes. He should be familiar with the manufacturing machines and tools used in the production. The tool designer must understand how tools perform their functions. So the knowledge of tool engineering plays vital role in the production of goods.

In this course, we are discussing about the design and development of tools, fixtures, dies etc. used in the manufacturing of products.

In Block 1, we are discussing about various types of cutting tools, like single point cutting tools, multipoint cutting tools, jigs and fixtures etc. It also discussed about the application of above tools in the manufacturing of products.

Block 2 gives the clear picture about the principles of die making tools, design of sheet metal planning and piercing tools, design of forming tools and design of metal casting tools.

In Block 3, the layout design for the tool engineering will be explained elaborately. It also describes the tools used for basic layout and basic layout operations etc. Lastly, it concludes with the layout work and safety issues.

Finally, Block 4 covers various aspects of tool management in advance manufacturing systems, and design of guide ways and spindles. It also discusses about the design of machine structures and recent developments in tool design.
DESIGN OF CUTTING TOOLS AND HOLDING DEVICES

This block, consisting of 4 units deals with basics of tool engineering, design of single point cutting tools, and design of jigs and fixtures.

In Unit 1, basic elements of tool engineering have been discussed. It also elaborates the various types of machine tools and operational issues in tool engineering.

Unit 2 describes about the various design aspects of tool geometry and tool shank. This unit also explains about the selection of cutting tools and required design calculations for cutting forces.

Unit 3 deals with design of jigs and their types. In the design of jigs, comprehensive discussion on elements of jigs, presentation of workpiece, location and various changing methods is made.

Finally, Unit 4 explains the necessary design considerations required for design of fixtures. It also discusses in brief about the various types of fixtures and their working principles.