JIGS AND FIXTURES

.18 INTRODUCTION :

Jigs and fixtures are production devices usually associated with mass production where high accuracy is desired and workpieces are difficult to hold. They eliminate the necessity of special set up for each individual part. The other *advantages* of jigs and fixtures include the following.

- Reduce the operation time, and increase the productivity.
- Facilitates uniform quality and ensures interchangeable of components.
- Unskilled operator can do the job. Thus, saving in labour cost.
- Ensures higher accuracy and surface quality.
- Reduce the overall cost of the product.

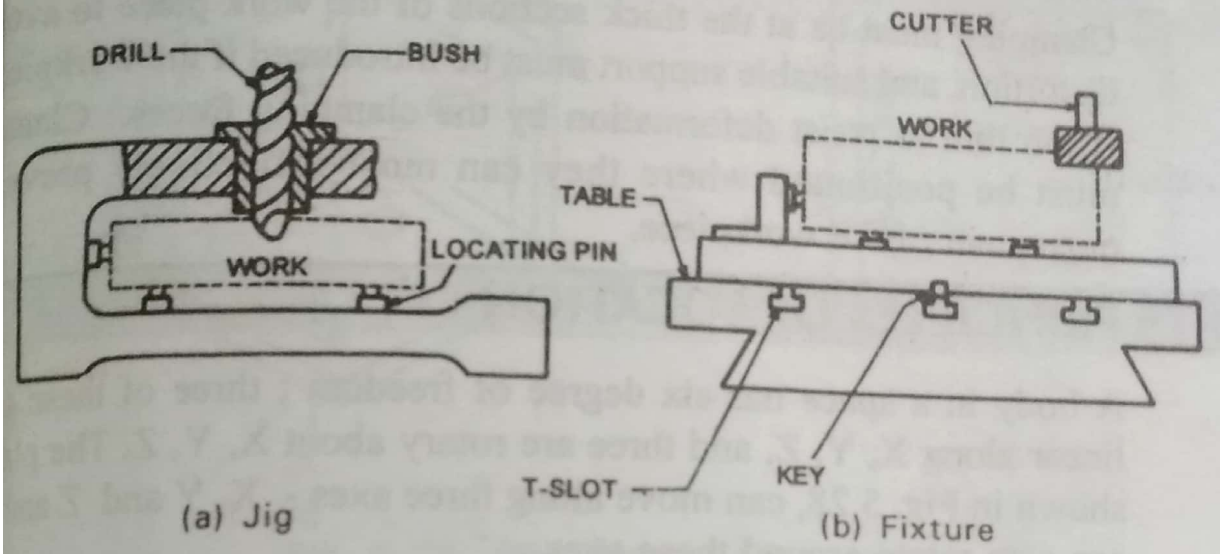
Definitions :

Jig : A jig may be defined as a device which holds and locates a work piece and guides and controls one or more cutting tools.

Fixture : A fixture may be defined as a device which holds and locates a work piece during inspection or machining. The fixture does not guide the cutting tool.

Differences between Jigs and Fixtures :

The features of jigs and fixtures are illustrated in Fig. 5.27. The essential differences are presented below in the tabular form.



(a) Jig (b) Fixture

Fig. 5.27

Jigs	Fixtures
1. Hold and locate the work piece and guide the cutting tool.	• Hold the work piece, but not guide the cutting tool.
2. Lighter in construction, usually not clamped on the table.	• Heavier and clamped on the machine table.
3. Used for holding the work and guiding the tool in	• Used for holding work in milling, turning, grinding, welding, etc. drilling, reaming and tapping.

Design Factors for Jigs and Fixtures :

The following factors are to be considered while designing jigs and fixtures.

(a) Location of the component

(b) Clamping of the component

(c) Positioning the fixture correctly relative to machine tool

(d) Positioning the tool correctly relative to component

(e) Safety to operator, and

(f) Idle machine time (time required for loading and unloading of components) must be kept to minimum.

Clamps : The clamps are used to hold the workpiece securely on the jigs and fixtures body against the cutting forces without causing damage to it.

Clamping must be at the thick sections of the work piece to avoid distortion, and suitable support must be introduced if the workpiece is too thin to resist deformation by the clamping forces. Clamps must be positioned where they can most effiectively prevent movement of the workpiece.

5.19 PRINCIPLES OF LOCATION :

A body in a space has six degree of freedom ; three of these are linear along X, Y, Z, and three are rotary about X, Y, Z. The plate shown in Fig. 5.28, can move along three axes - X, Y and Z and it can also rotate around these axes.

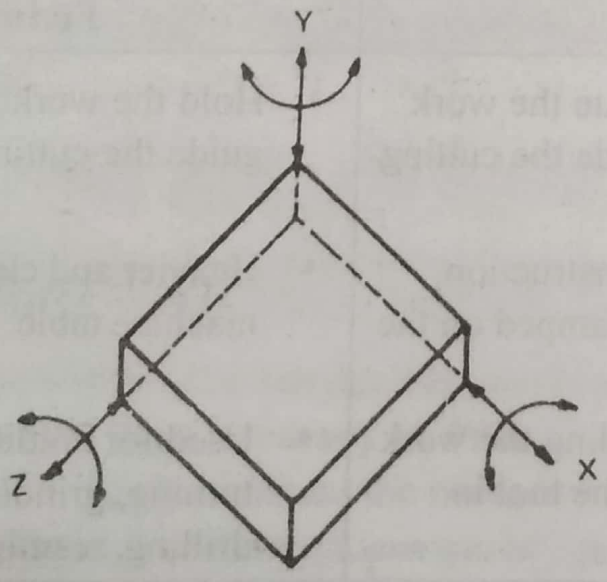


Fig. 5.28 Six Degree of Freedom

A locating system should eliminate degree of freedom so as to complete the operation with required quality. This can be achieved by six locations suitably applied as shown in Fig. 5.29.

In conjunction with the clamping system. Pins 1, 2, and 3 prevent linear motion along 'Y–Y' and rotation about 'Z–Z' and 'X–X'.

Pins 4 and 5 prevent linear motion along 'Z–Z' and rotation about 'Y–Y', and

Pin 6 prevents linear motion along 'X–X'. Thus, all the six degrees of freedom have been removed. This is generally referred as '3–2–1' principle of location.

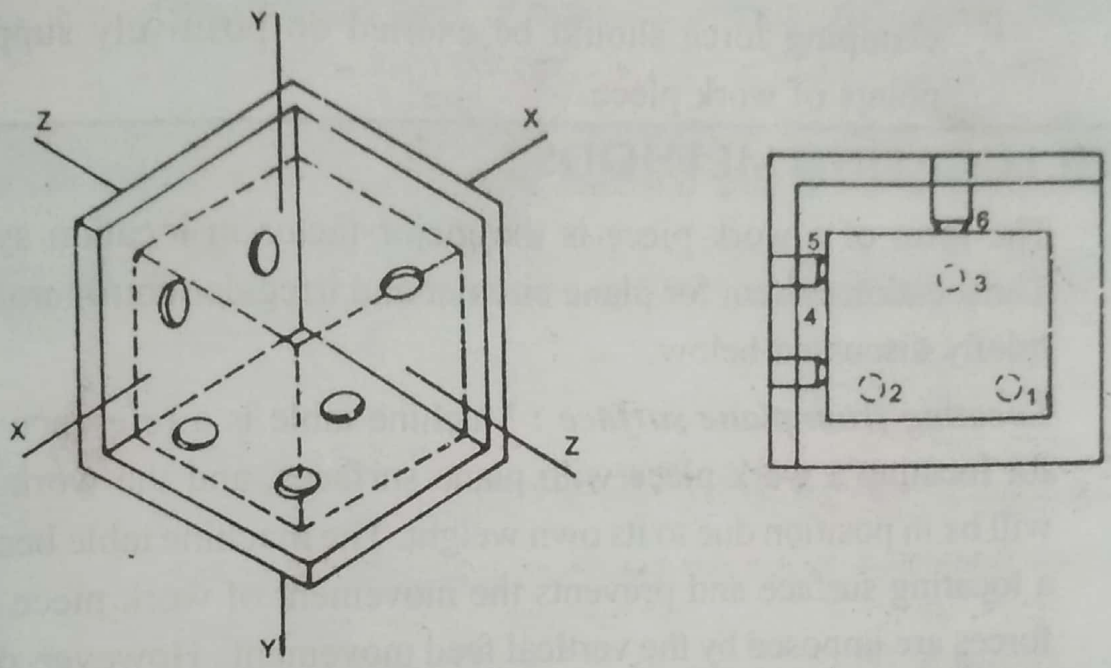


Fig. 5.29 Principles of Locations

The following factors are to be considered for location

- Ensure that work piece is given desired constraint
- Make sure the location is *fool proof i.e.* work piece can only be loaded in the correct position.
- Location points should be visible to the operator at working position .
- Locations should be such that swarf will not cause mal-alignment.
- Location points to be as far apart as possible to minimise inaccuracies.

5.20 PRINCIPLES OF CLAMPING :

One of the most important features of any jig and fixture is to clamp the work piece in a fixed position. The following factors are to be considered for efficient clamping of work piece.

- use rapid action clamping devices to minimise clamping time.
- must have positive clamping action to prevent undue movement .
- clamps should withstand rough usage
- clamps should be simple to handle and easy to control without danger to the operator.
- clamping force should be exerted on positively supported points of work piece.

.21 LOCATING METHODS :

The form of a work piece is the major factor in location system. The location system for plane circular and irregular configuration is briefly discussed below.

Locating from plane surface : Machine table is a reference plane for locating a work piece with plane surfaces, and the work piece will be in position due to its own weight. The machine table becomes a locating surface and prevents the movement of work piece when forces are imposed by the vertical feed movement . However, during machining operation, the work piece may move in any other direction i.e. except towards the surface of machine table . Complete location has been accomplished by use of three points with reference plane, two points in a second plane, and one point in third plane.

Locating from circular surface : In this case the axis of circular work piece is located parallel to the machine-table surface which is the reference plane. For locating cylindrical components, V–block of 90^0 angle is extensively used. The V–block is positioned in such a way that the variation of work piece diameter do not effect the location of the work piece and the work piece is positively supported against cutting and clamping forces. The standard chucks may be used as work locating and clamping devices.

Locating from irregular surface : The surfaces neither flat nor circular are called irregular surfaces. A rough surface with variable size from time to time (i.e., part to part) is also considered as irregular surface. Such a work piece can be located using eccentric locators (or adjustable rest pins) whose eccentricity can be set to suit the part (or adjusted according to the part).

Principle of Pin locators :

The basic principles to use pin locators are :

1. The principle of *minimum locating pins* - No more points than necessary should be used to secure location in any one plane.
2. The principle of *extreme positions* - locating points should be placed as far apart as possible on any one workpiece surface.
3. The principle of *mutual perpendicular planes* - The most satisfactory locating points are located on mutually perpendicular planes.

22 PRINCIPLES OF JIGS AND FIXTURES DESIGN :

The basic principles of Jigs and Fixtures are given below :

1. **Location :**
   - Ensure that the workpiece is given the desired constraints
   - Position the locators in such a way that swarf will not cause misalignment
   - Introduce fool proofing devices to prevent incorrect positioning of the workpiece
   - Make sure that the location points vissible to the operator from his working position.
2. **Clamping :**
   - Position the clamps to give the best resistance to the cutting forces
   - Clamping should be such that no deformation of work piece is caused
   - If possible, make the clamps integral with the fixture body.
3. **Clearance :**
   - Provide sufficient clearance to allow for variation of work piece size.
   - Ensure that there is enough swarf clearance
4. **Stability and rigidity :**
   - Make the equipment stable so as to prevent displacement from its position during operation
   - Make the equipment rigid as required for the operation.

5. **Handling :**
   - Make the equipment light and easy to handle
   - Avoid sharp corner.
6. **Cost and safety :**
   - Adopt simple design to minimise cost
   - Location and clamping methods should minimise the idle time.
   - Use of standard parts is recommended
   - Ensure safety during the operation.

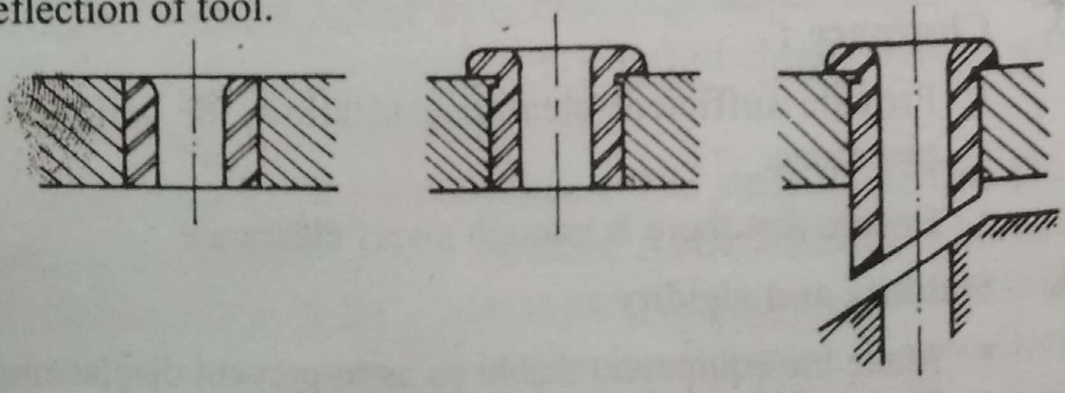
5.23 DRILL BUSHES :

In drill jig, the tools are guided properly by using drill bushes in a jig plate. They are usually made for case hardered steel. For easy entrance of the tool, an adequate chamfer should be made at the top of the bore, and also chamfer should be made at the bottom of their external diameter to facilitate entry into the bush plate.

The following types of bushes are widely used in drilling

1. Fixed bushes
   (i) plain, (ii) headed (or flange), (iii) shaped end
2. Slip bushes
3. Liner bushes.

1. Fixed bushes : Fixed bush is 'pressed' to fit into the jig plate and is used mainly when hole is produced with one tool. Headed bushes are preferred to headless (plain) bushes because it controls the hole depth, and chances of bush getting loose and sliding axially with the tool are lesser in headed (collar) bushes. Some times the bottom end of the bush is shaped to suit the profile of work piece to prevent deflection of tool.



(i) (ii) (iii)

2. Slip bushes : Slip bushes are used when two or more tools are necessary for completing a hole. They should be prevented from rotating during drilling by using a retaining screw as in Fig. 5.31. The head of slip bushes is knurled to facilitate handling.

3. Liner bushes : The main functions of liner bushes are to act as hardened guide for slip or renewable bushes and to guide the tool. Liner bushes are *'forced'* to fit into jig plate.

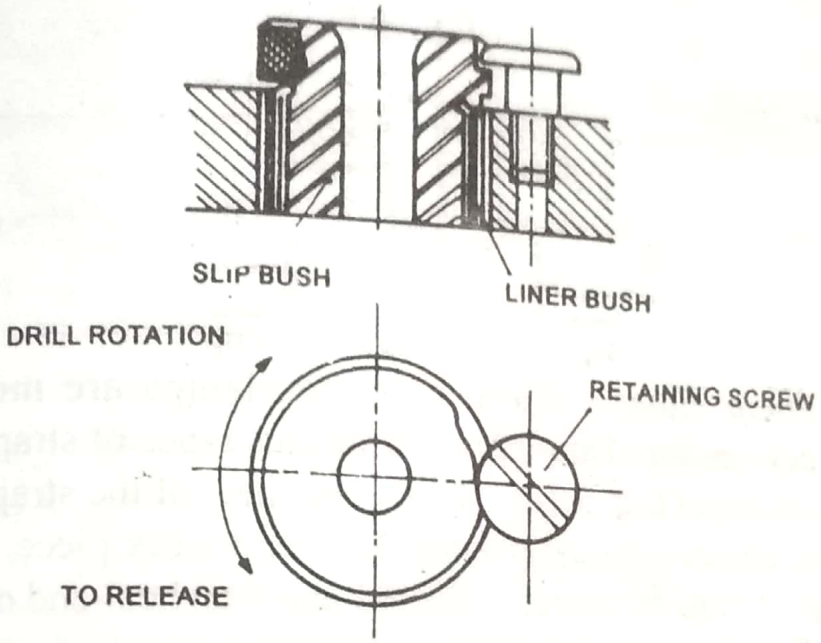


Fig. 5.31 Slip Bush

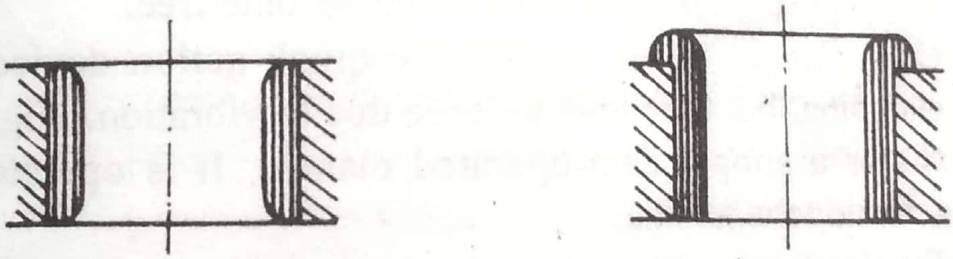


Fig. 5.32 Liner Bushes

24 TYPES OF CLAMPS :

The following types of clamps are generally used

1. Screw clamp
2. Strap clamp
3. Cam clamp
4. Toggle clamp
5. Hydraulic and pneumatic clamps.

1. *Screw clamp :* These are threaded parts with knurled collar or head (square or hexagonal) for rotating and tightening the screw. To incrase the clamping area pads are provided. The use of pad prevents damage to the work piece by allowing the screw to rotate at the point of clamping without scoring the work piece. Screw clamp is simple, but the clamping force is not uniform and requires more time for its operation.

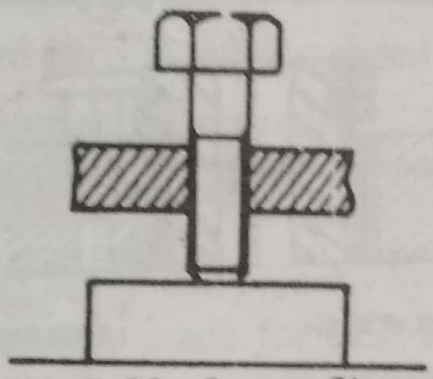
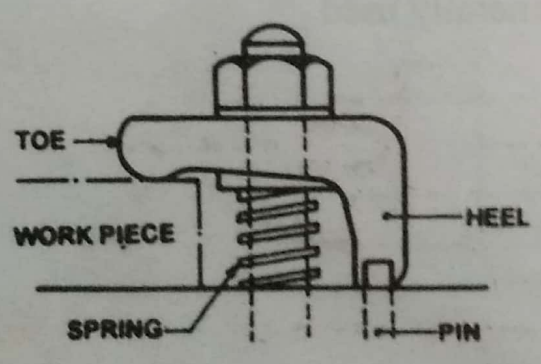
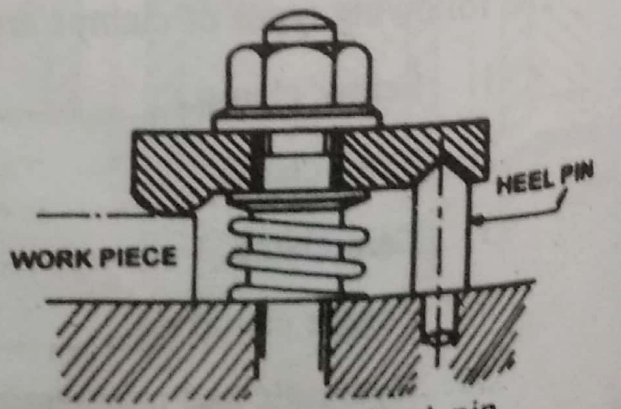


Fig. 5.33 Screw Clamp

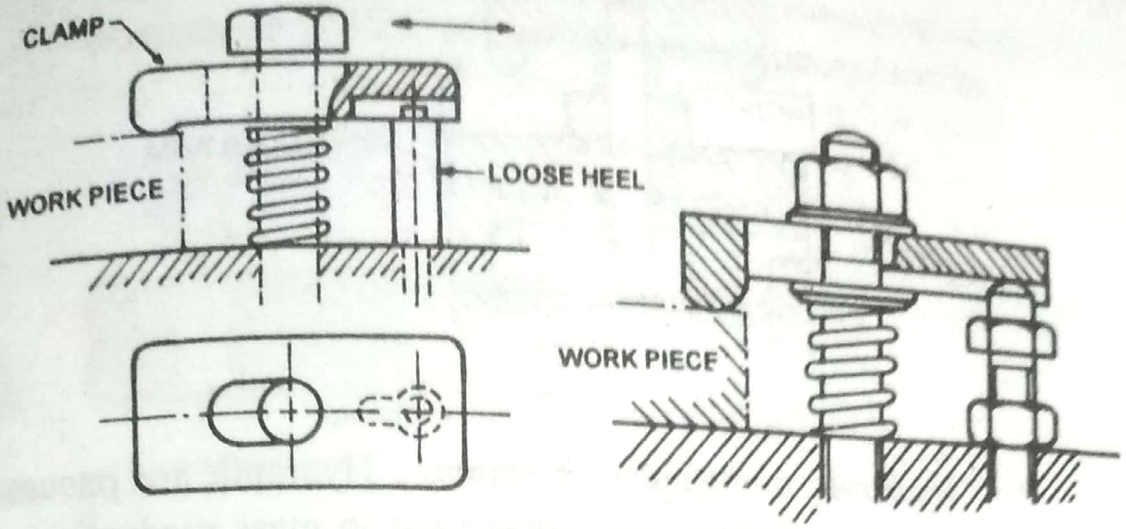
2. *Strap clamp :* Strap or plate clamps are most popular devices for clamping. The various types of strap clamps are shown in Fig. 5.34. The toe and heel of the strap are shaped to ensure adequate clamping over a work piece. The clamp stud must be nearer to the toe-end than heel-end of the clamp. The clamp is tightened by turning hexagonal nut on a stud. The spring, provided below the clamp, lifts the clamp as nut is loosened. Thus the work piece become free.
3. *Cam clamp :* Cam clamps are quick action devices for clamping, but they tend to loose due to vibration. Fig. 5.34 shows a simple cam-operated clamp. It is operated by actuating the handle.
4. *Toggle clamps :* Toggle clamps are quick action clamps and their operation depends upon the movement of rigid link. They are widely used for holding sheet-metal parts in position. Toggle clamp gives ample clearance for loading and unloading of work pieces, and provide heavy clamping force.



(i) Solid clamp



(ii) Clamp with heel pin



(iii) Sliding clamp with heel pin (iv) Clamp with adjustable heel pin

Fig. 5.34 Types of strap clamp

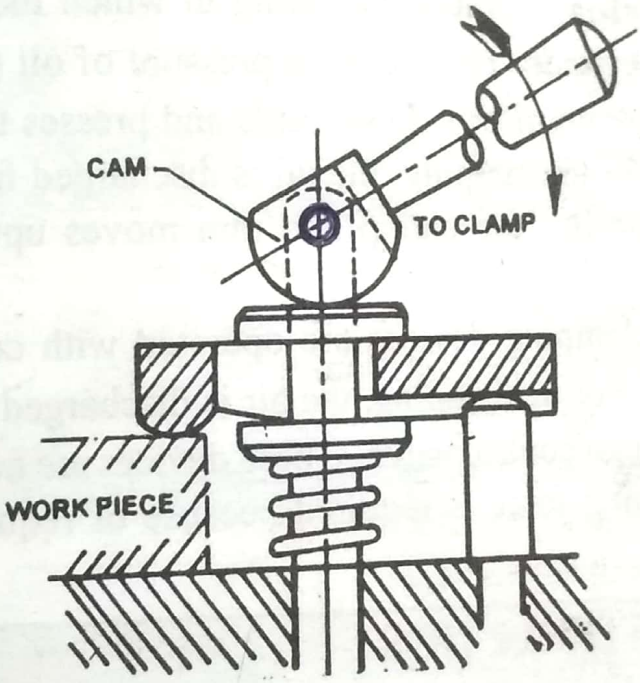


Fig. 5.35 Cam-operated clamp

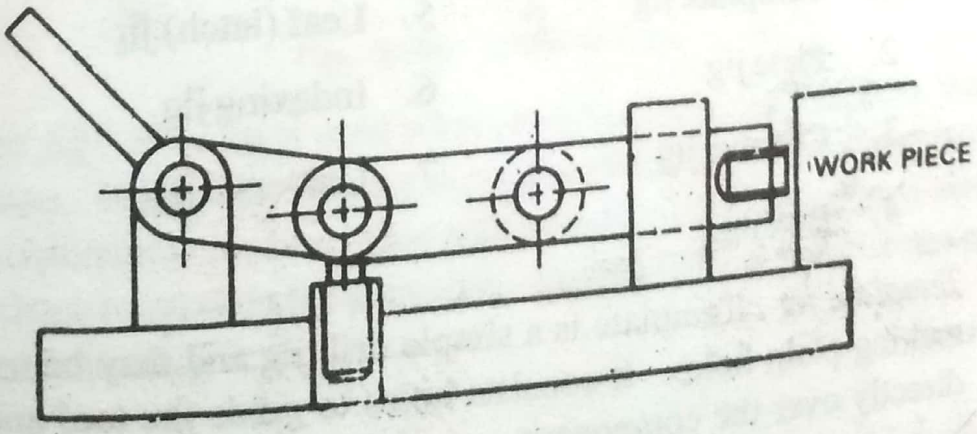


Fig. 5.36 Toggle clamp

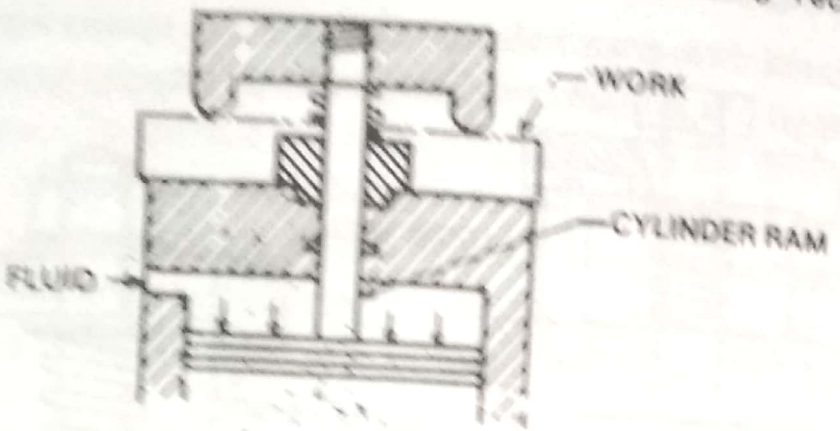


Fig. 5.37 Fluid power clamp

5. *Hydraulic and pneumatic clamps :* Hydraulic and pneumatic clamping devices are widely used in mass production, and ensures reliable clamping of work pieces with uniform and equilised clamping pressure.

Hydraulic clamps uses incompressible fluid such as an oil. Fig. 5.37 shows hydraulic clamping in which the clamping nut is attached to cylinder ram. Due to pressure of oil (8 N/mm^2) in the cylinder, the ram moves downwards and presses the clamp against the work. For unclamping, the oil is discharged from the cylinder, the spring pushes the clamp and ram moves upward to free the work piece.

Pneumatic clamping devices are operated with compressed air at 0.6 N/mm^2. For unclamping, the air is discharged into atmosphere directly through control valve. These devices are not suitable where heavy clamping force is required because of requirement of large cylinder.

5.25 TYPES OF DRILL JIGS :

A drill jig may be designed for drilling one or more holes.The following types of jigs are widely used in industry.

1. Template jig
2. Plate jig
3. Channel jig
4. Box jig.
5. Leaf (latch) jig
6. Indexing jig
7 Universal jig.

Template jig : Template is a simple drill jig and may be used when making plain holes. It consists holes to guids the tool and is used directly over the component.

Plate jig : Template jig in which drill bushes are provided is called plate jig. It is used for accurate drilling on large parts.

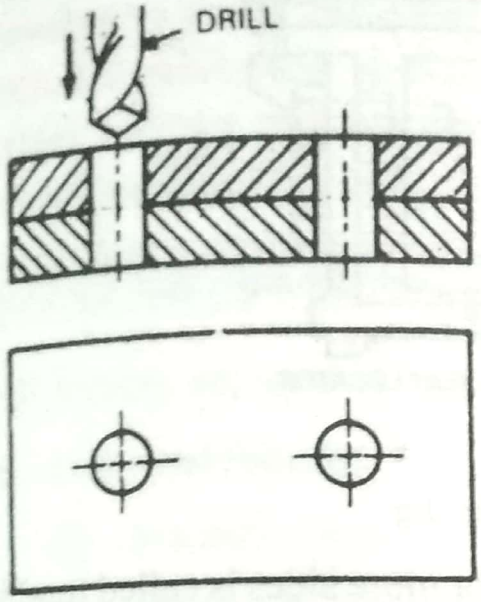


Fig. 5.38

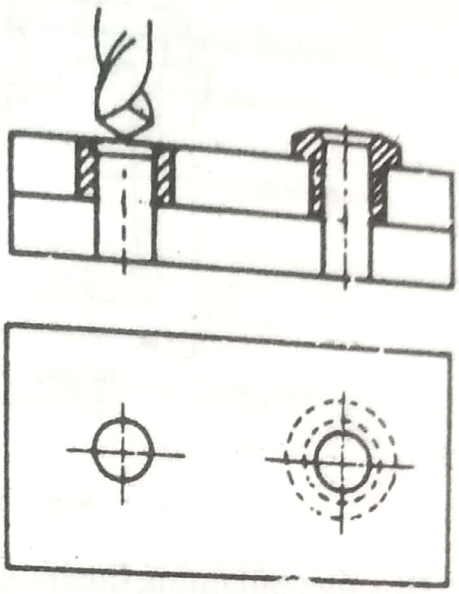


Fig. 5.39

Channel jig : The body of channel jig is in the form of standard channel. The component is located in a channel and is clamped by screw. It is used for drilling simple symmetrical shapes.

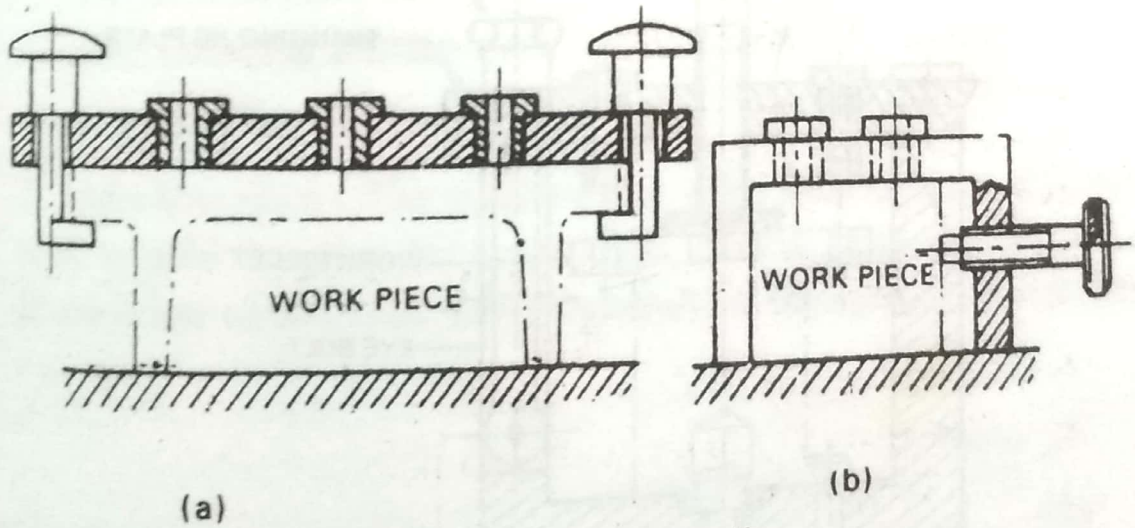


Fig. 5.40 Channel Jig

Box jig : Box jig is used when drilling is required on more than one plane. The body of the jig is made of box-like structure in which the component is located. One side of the box would be fitted with cam or latch to provide the necessary opening for inserting the component and unloading it.

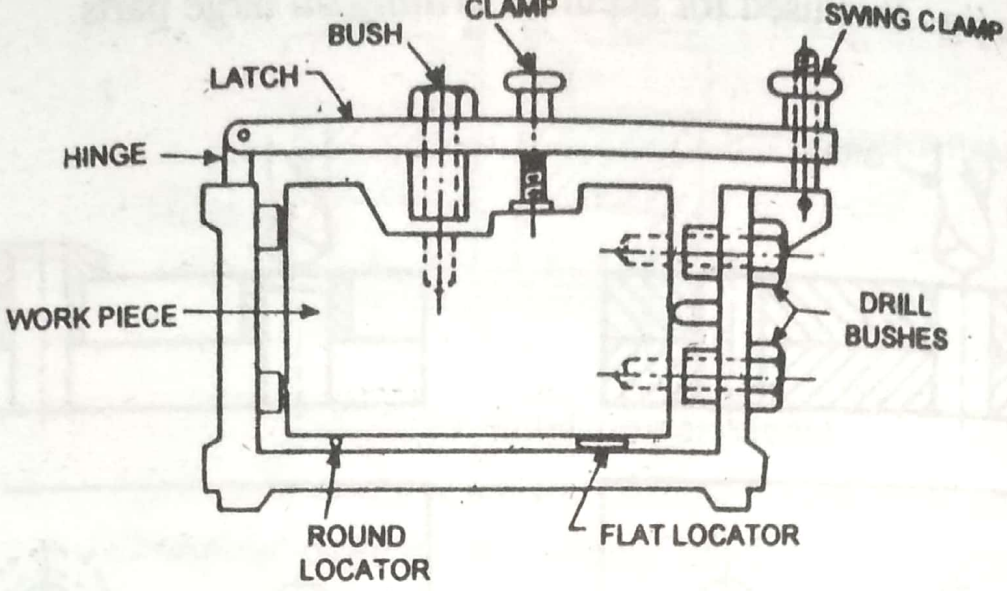


Fig. 5.41 Box Jig

Box jig containing bushing on two or more sides is called tumble jig.

Leaf (or latch) jig : A drill jig with a hinged jig plate in which one or more drill bushes are fitted is called leaf or latch type jig. The jig plate must be positively located such that the axes of bushes are vertical during drilling. The latch is clamped by nut and the workpiece by clamping screw.

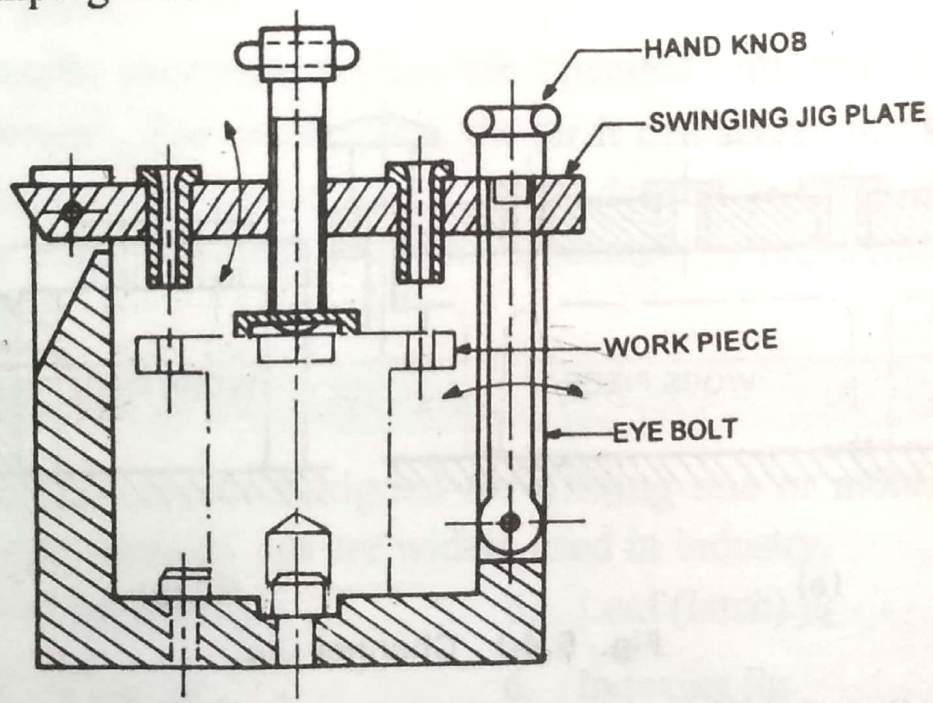


Fig. 5.42 Leaf (or Latch) Jig

Indexing jig : Drill jig in which index plate is incorporated so that the workpiece can be indexed successively for drilling a series of holes on its surface under a single bushing is called indexing jig. It is used for drilling a series of holes, equally spaced in a circle on the work surface.

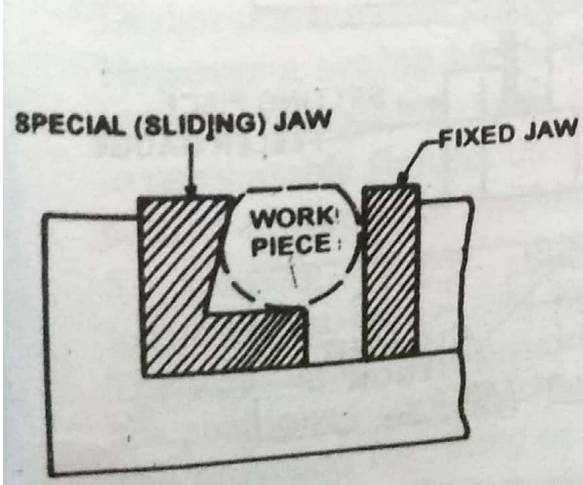
Universal jig Universal or pump jigs are plate jigs with guide pillars. The guide pillars position the drill bushes correctly with respect to the workpiece located on the base plate. The jig plate is lowered to touch and clamp the workpiece, and after drilling it is raised to relieve the workpiece. The jig plate is moved by handle which operates rack and pinion. Universal jigs are used for drilling workpieces having parallel surfaces.

.26 TYPES OF FIXTURES :

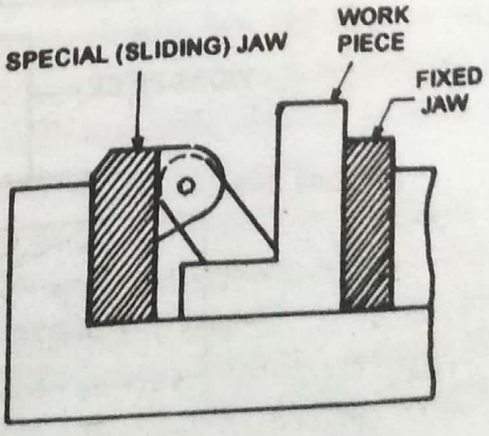
All fixtures are used in industry can be divided into two groups.

1. Universal fixtures
   - (i) Machine vices
   - (ii) Three jaw self-centering chuck
   - (iii) Universal dividing head
   - (iv) Magnetic chucks, etc.
2. Special fixtures for specific operations.
   - (i) Milling fixture,
   - (ii) Boring fixture,
   - (iii) Grinding fixture,
   - (iv) Welding fixtures, etc.

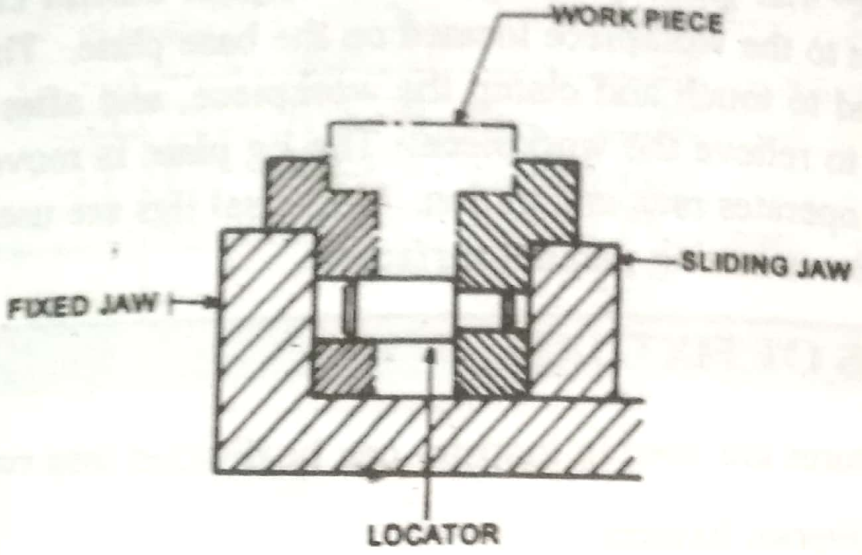
1. Machine vices : The machine vice is the simplest form of fixtures used to hold the parts for machining. Special jaws are designed to accomodate odd-shaped workpieces and at the same time to prevent damage to machined surfaces.



(i) For round work piece



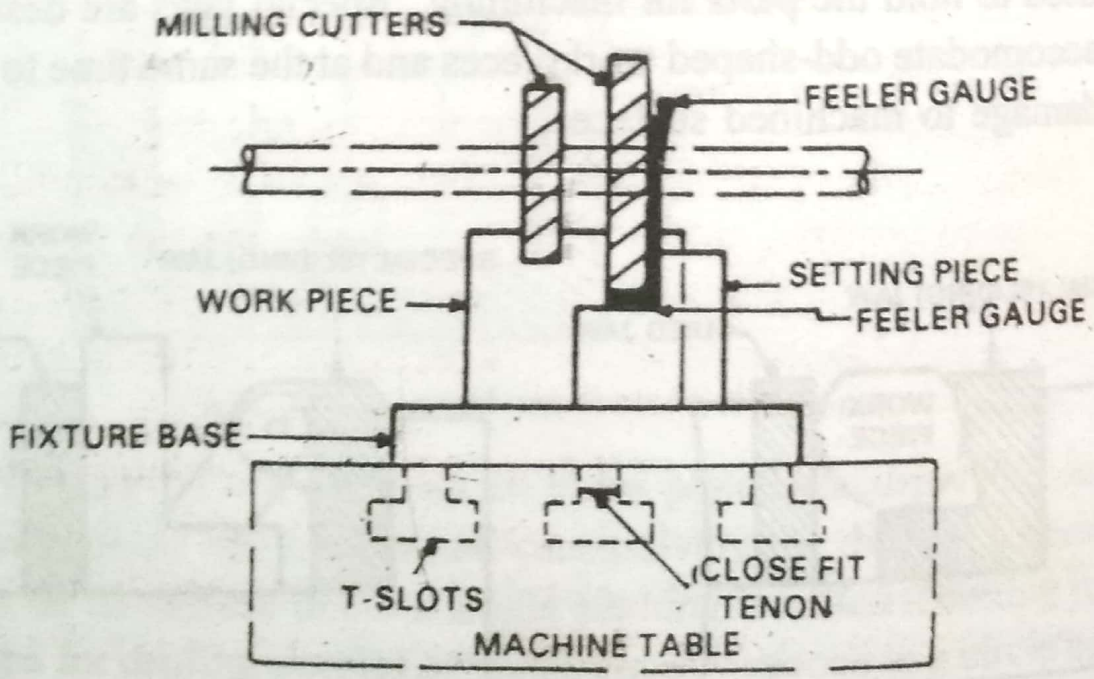
(ii) For angle section



(iii) For large work piece

Fig. 5.43 Vice Fixtures

2. *Milling fixtures :* The cutting force induced in milling is heavy and therefore, the fixture is rigidly attached to the table. Cast iron fixtures are more efficient than steel and is recommended for accurate work. The milling fixture essentially consists of base, tenon strips, setting blocks, T-bolts, clamps and locating pins. The work piece is located on fixture base which is bolted in position on the machine table. The cutter is set in a correct position by mounting a feeler gauge (0.4 to 0.5 mm thick) as shown in Fig. 5.44.



3. Boring Fixture : Boring is the operation of enlarging the hole, and is achieved by rotating the boring bar in the work or by rotating the work piece around the boring bar. The purpose of boring fixtures is to guide the boring bar as in drilling or to hold the work piece in position with respect to boring bar, as in milling fixture. The boring fixture to hold the work piece in correct relation to the boring bar is shown in Fig. 5.45. Boring fixture do not require to be as rigid as milling fixtures because the cutting force induced in boring is small than the milling.

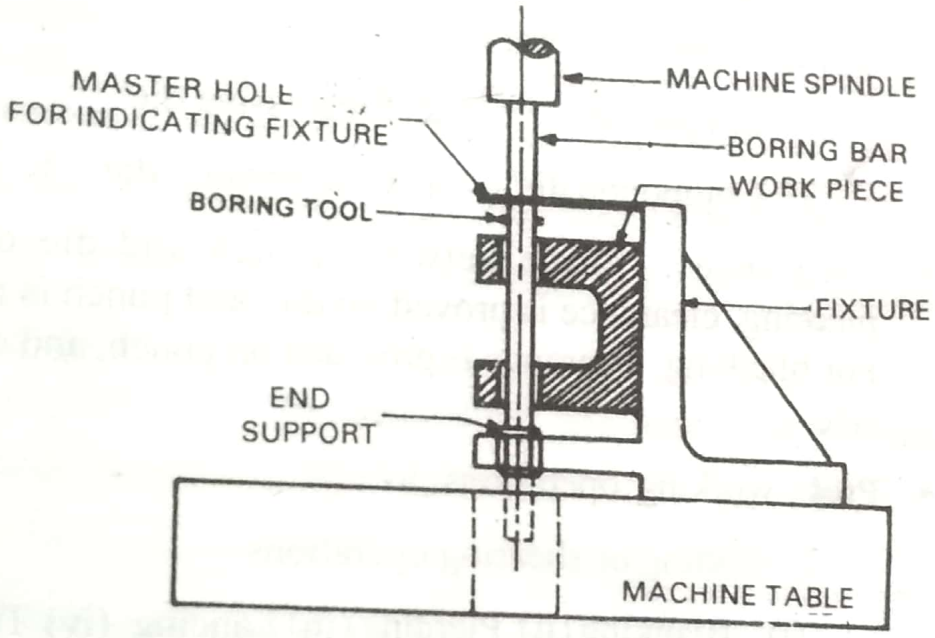


Fig. 5.45 Boring Fixture

4. Grinding Fixture : The following fixture are used for different grinding operations.

1. Mandrels for external grinding
2. Magnetic chucks for surface grinding, and
3. Special jaws chucks for internal grinding.

Design characteristics of grinding fixture are similar to milling fixture. However a setting block is not necessary, but the fixture directly bolted to the machine table. It is common practice, in surface grinding, to use suitable fixtures directly with magnetic chucks. In such cases bolting of fixture to machine table is not necessary.

5. Welding Fixture : The basic purpose of welding fixtures is to locate and hold the parts together in their position during welding. The welding fixtures comprises usual locators and clamping devices are positioned such that the welding heat does not damage them. The provision for tilting or rotation of the fixtures should be made for ease welding from various sides.