MACHINING

Level - III

Learning Guide 8

Unit of Competence: **Manufacture Jigs and Fixtures**

Module Title: **Manufacturing Jigs and Fixtures**

LG Code: **IND MAC3 08 0217**

Instruction Sheet	Learning Guide #1

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

1. Determine and prepare job requirements
2. Select materials
3. Produce and assemble components
4. Assure quality prototype

This guide will also assist you to attain the learning outcome stated in the cover page.

Specifically, **upon completion of this Learning Guide, you will be able to**:

- ✓ determined type and design from customer's components drawings, prints or sample component
- ✓ Selected materials are tested for hardness according to specifications
- ✓ Appropriate machines and machining process are selected based on a range of standard/special tool room machines.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 34.
3. Read the information written in the information “Sheet.
4. Accomplish the “Self-check.
5. Do the “LAP test”.

Introduction

The people's quest for manufactured goods has been growing rapidly over the years. Therefore, to meet up with the high demand, manufacturers have reacted by introducing innovative ways of manufacturing high quality products at a faster rate. The production processes has witnessed numerous changes and evolution with the introduction of numerous innovative manufacturing concepts which include Lean Production System, Cellular Manufacturing, Single Minute Exchange of Dies, as well as Takt Time Analysis. These creative approaches have necessitated the need for a reliable and cheaper tools and work-holding devices.

As the efficient running of a manufacturing company which demands a prompt and simple work positioning strategy for correct operations depends largely on the interchangeability of machine components and work-pieces, to ensure un-complication of assembly, and unit cost reduction, as well as to become competitive, reduce the enormous manufacturing cost, and also increase their profitability, the industry has resorted to streamlining its supply chain in a bid to maintaining a very low amount of inventory. This has also led to the demand for a better and cost effective work-holding devices which will ensure better quality products, reduce lead time, and also increase throughput.

Also, although some machining operations are so straight-forward, like in turning where the job is secured tightly on the chuck while the turning operations are easily performed, some jobs in other operations may not be easily held on either the three or four jaw chucks, and may also require the tools to be guided by the means of a different device. This explains the need for production standard work-holding devices to increase the rate of manufacturing.

Jig is the device which guides the tool, while fixture is a device that securely holds the job in position during machining operations.

Jigs and Fixtures

Jigs and fixtures are manufacturing tools that are employed to produce interchangeable and identical components. They are unique tool-guiding and work-holding devices designed specifically for machining and assembling large number of parts. Chennu (2014), listed the following as the purposes of ***jigs and fixtures reduction of production cost, increase of production rate, high accuracy of products without any manufacturing defects, provision of***

interchangeability, easy machining of complex shaped parts, reduction of quality control costs, etc.

Jigs and fixtures eliminate the need for a special set up for every work-piece thereby facilitating production and also ensuring that every work piece is manufactured within a predetermined tolerance.

The major difference between a jig and a fixture is that jigs guide the cutting tool to its precise position, as well as locating and supporting the work-piece during operations.

The essential features of jigs and features include:

- Clamps position;
- Neatness of work-piece;
- Standardization;
- Idle time reduction;
- Set up time reduction;
- Hardened surfaces.

The application of jigs and fixtures in manufacturing operations lead to the production of faster, more accurate, and reliable products at a reduced cost.

The successful running of any mass production depends upon the interchangeability to facilitate easy assembly and reduction of unit cost. Mass production methods demand a fast and easy method of positioning work for accurate operations on it.

Jigs and fixtures are production tools used to accurately manufacture duplicate and interchangeable parts. Jigs and fixtures are specially designed so that large numbers of components can be machined or assembled identically, and to ensure interchangeability of components.

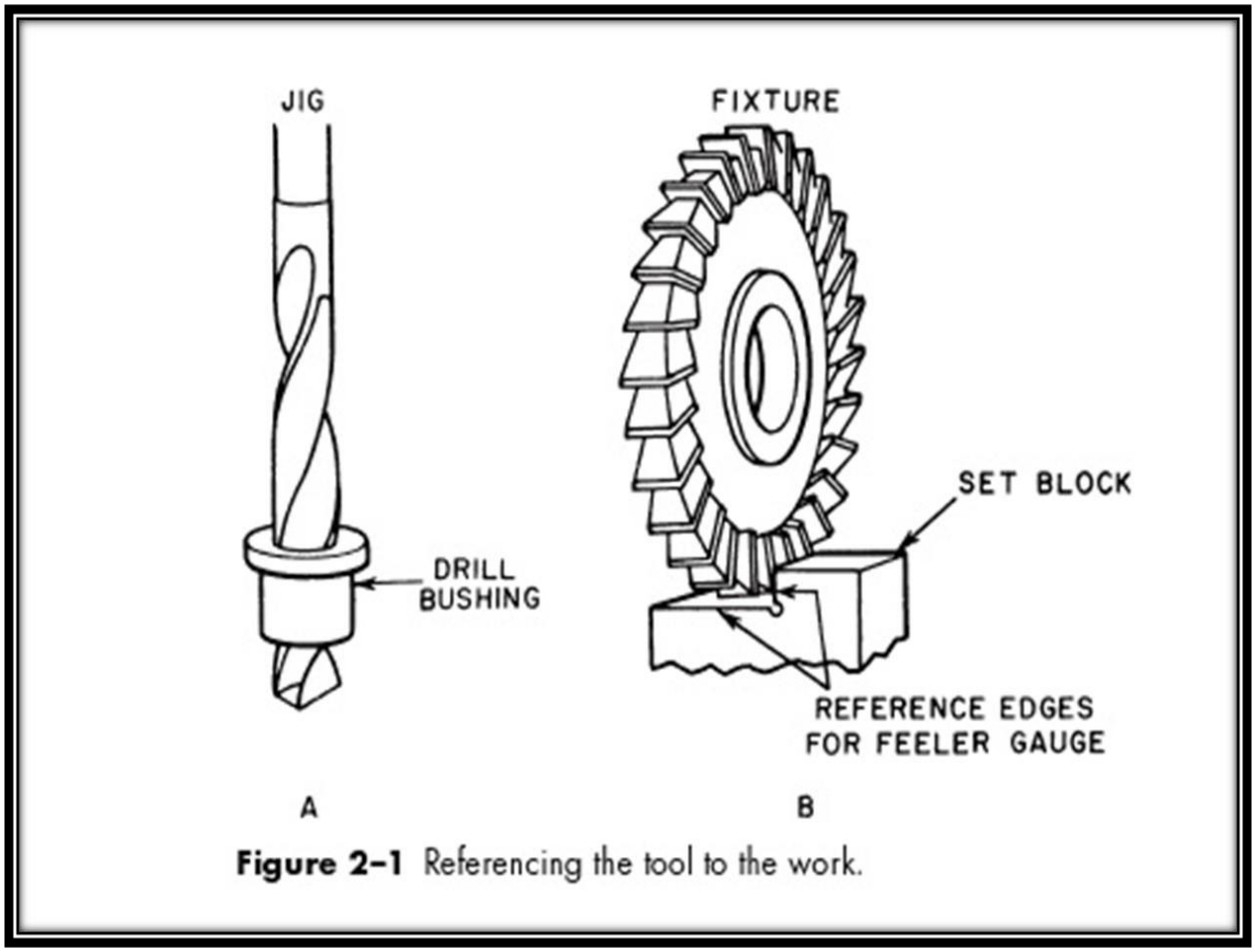


Figure 2–1 Referencing the tool to the work.

JIGS

It is a work holding device that holds, supports and locates the workpiece and guides the cutting tool for a specific operation. Jigs are usually fitted with hardened steel bushings for guiding or other cutting tools. a jig is a type of tool used to control the location and/or motion of another tool. A jig's primary purpose is to provide repeatability, accuracy, and interchangeability in the manufacturing of products. A device that does both functions (holding the work and guiding a tool) is called a jig.

An example of a jig is when a key is duplicated, the original is used as a jig so the new key can have the same path as the old one.

BORING JIG

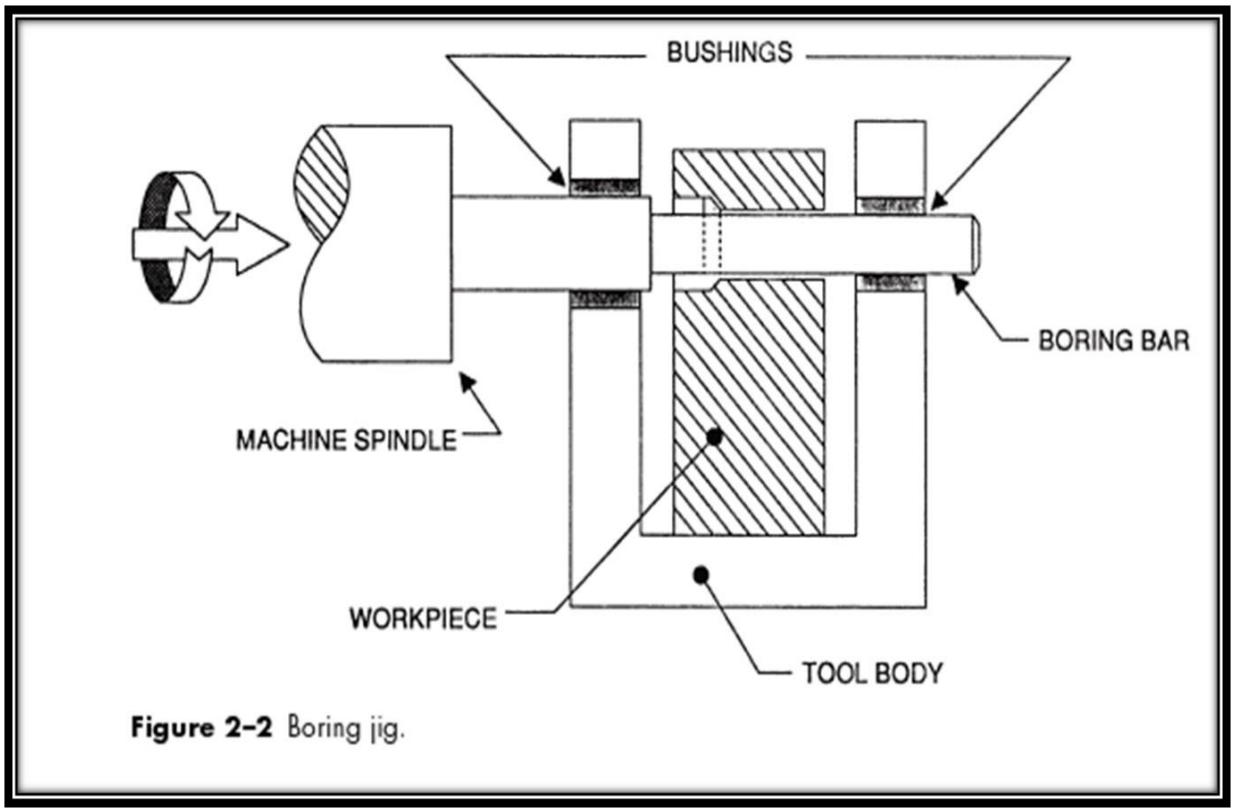


Figure 2–2 Boring jig.

FIXTURES

It is a work holding device that holds, supports and locates the workpiece for a specific operation but does not guide the cutting tool. It provides only a reference surface or a device. What makes a fixture unique is that each one is

built to fit a particular part or shape. The main purpose of a fixture is to locate and, in some cases, hold a workpiece during either a machining operation or some other industrial process. A jig differs from a fixture in that a it guides the tool to its correct position in addition to locating and supporting the workpiece.
Examples; vises, chucks

A VISE-JAW FIXTURE

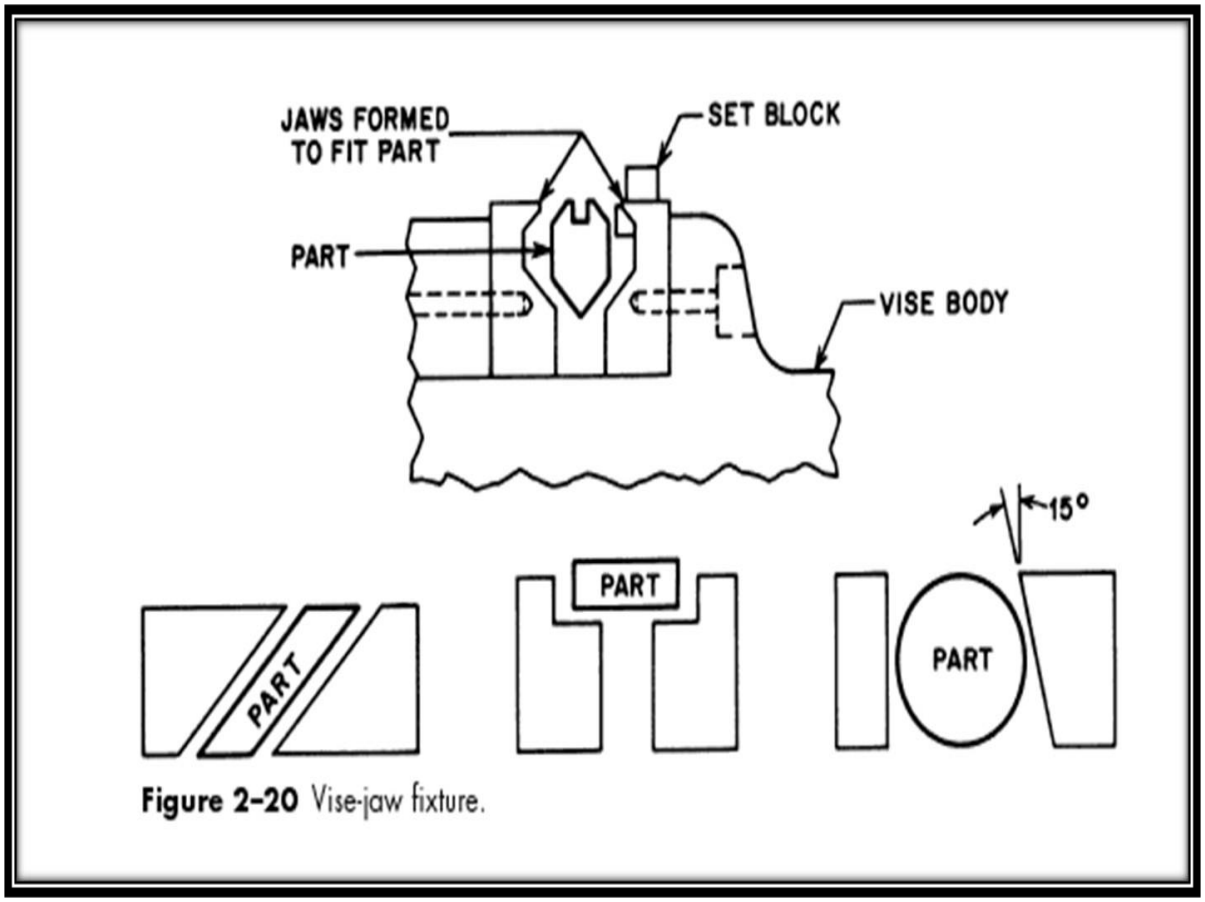


Figure 2–20 Vise-jaw fixture.

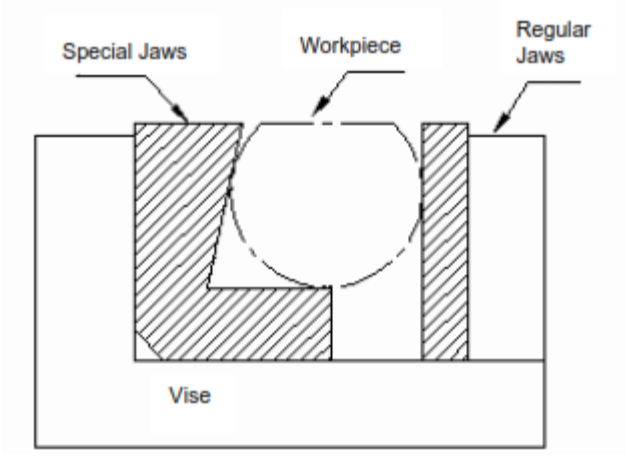
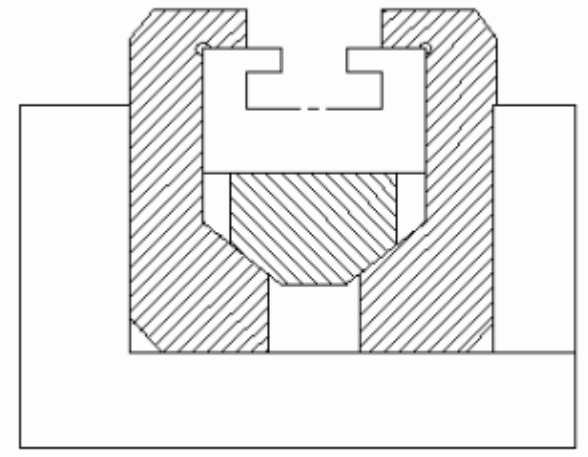


Figure 4.1(a) : Vise Jaws

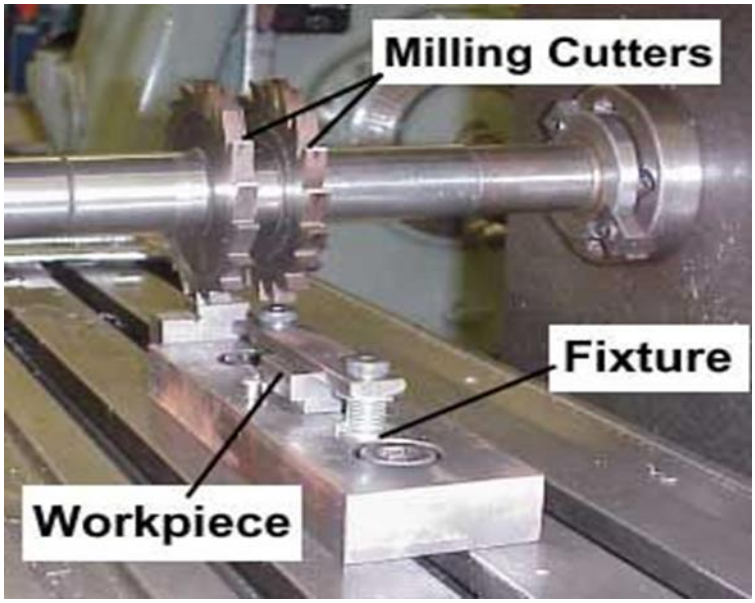


Milling Fixture

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. 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.



Facing Fixture

Milling machines are extensively used for facing seating and mating flat surfaces. Milling is often the first operation on the workpiece. 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.

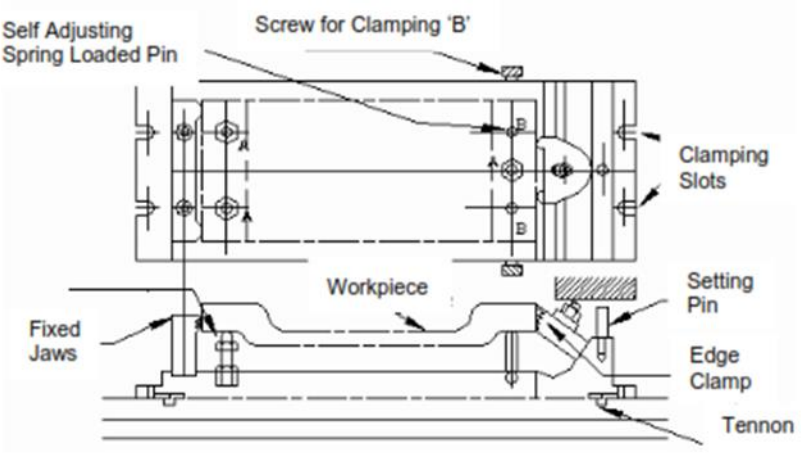


Figure 4.4 : Face Milling Fixture

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.

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.

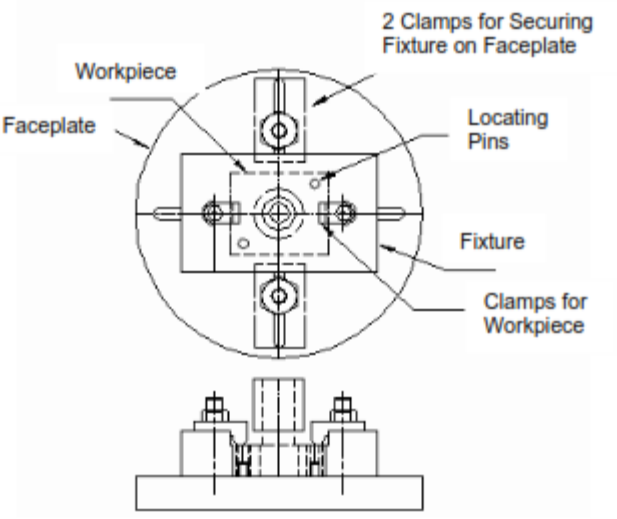


Figure 4.5 : Face Plate Fixture

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.

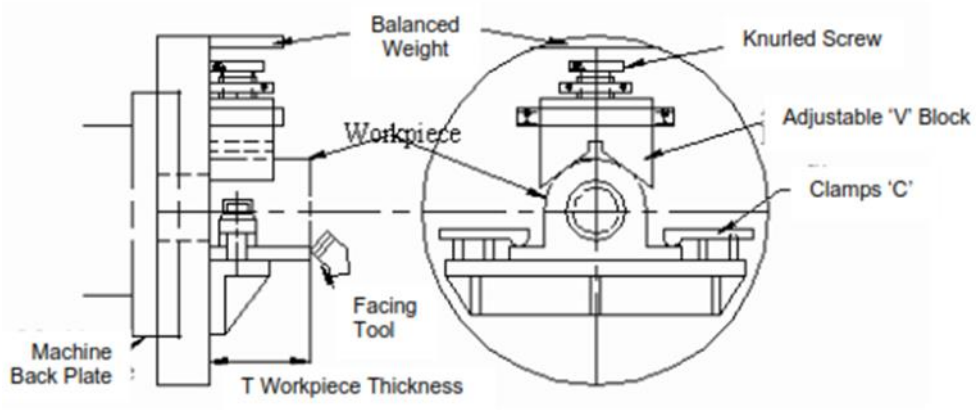


Figure 4.6 : Turning Fixture (Boring and Facing Fixture)

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.

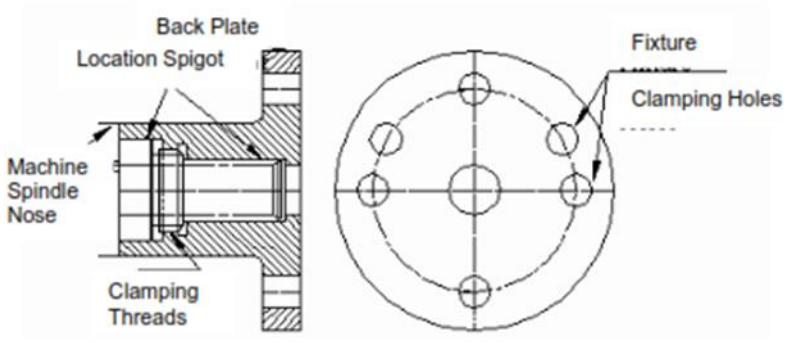


Figure 4.7 : Back Plate for Turning Fixture

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.

Elements of Jigs and Fixtures.

Various elements of jigs and fixtures and their details are follows.

1: Body 2: Locating devices

3: Clamping devices

4: Tool guide (jigs bushing)

1: Body:

The jig body is generally made of cost iron by casting process or fabricated by welding together various slabs and bars of mild steel. It may be heat treated to relief the stresses. Body is the most prominent feature of the jig. Its main purpose is to support and house the job.

The various jig body are follows:

(A): Plane Type Jig:

Plane type jig is the simplest type, it is used when plane holes are to be drilled. It has either drill bushes for guiding the tools or the holes without bushes.

(B): Channel Type Jig:

Channel type is made up from standard steel channel section.

(C): Box type Jig:

Box type jig is used where a component requires drilling in more than one plane and the jig is to be provided with on equitant number of drill bush plates. One side of the box is fitted with a lid which can be opened for inserting the component and for unloading it. It should be made as light as possible.

(D): The Built-Up Jig:

The built-up jig used dowels and screws for fabricating member welded type. Standard steel sections are used in it for the limited numbers of details, which are secured by means of screws and dowels, the locating pins and the blocks are positioned so that the greatest dimensional variation of the work piece may be accommodated.

(E): Leaf Type Jig:

Leaf type jig is simply made from a block of steel fitted with two adjustable locating screws and a spring-loaded plunger. It is used in case of measured large components where it may be both unnecessary and construct a jig to hold the complete component, where madding is purely confined to a local section of the work piece.

2: Locating Devices

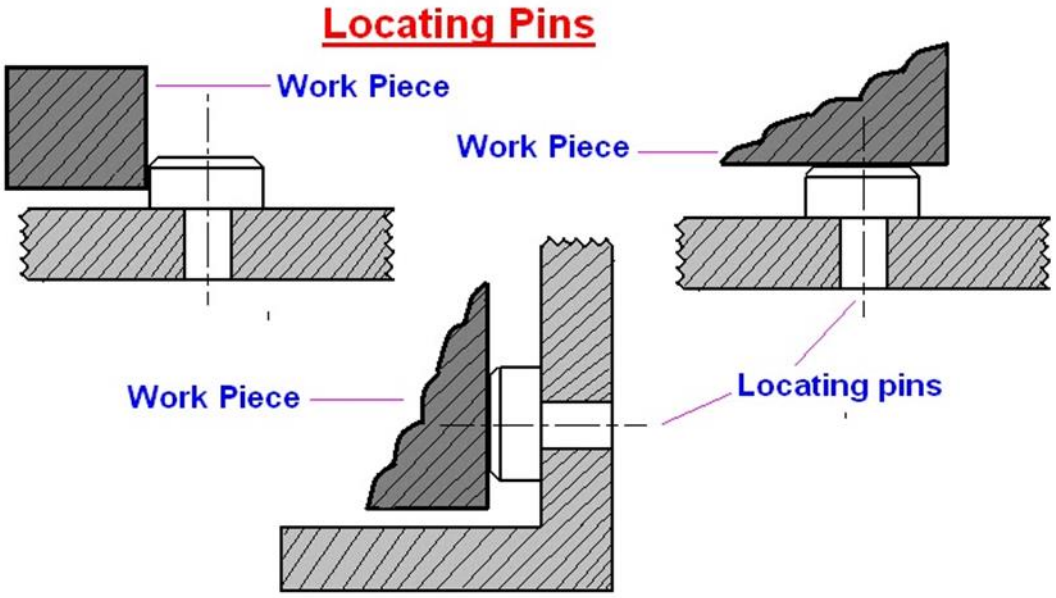
The pins of various design and made of hardened steel are the most common locating devices used to locate a work piece in a jig or fixture. The shank of the

pin is press fitted or driven into the body of jig or fixture. The locating diameter of the pin is made larger than the shank to prevent it from being forced into the jig or fixture body due to the weight of the work piece or cutting forces. Depending upon the mutual relation between the work piece and the pin.

The pin may be classified as follows:

(A): Locating Pins:

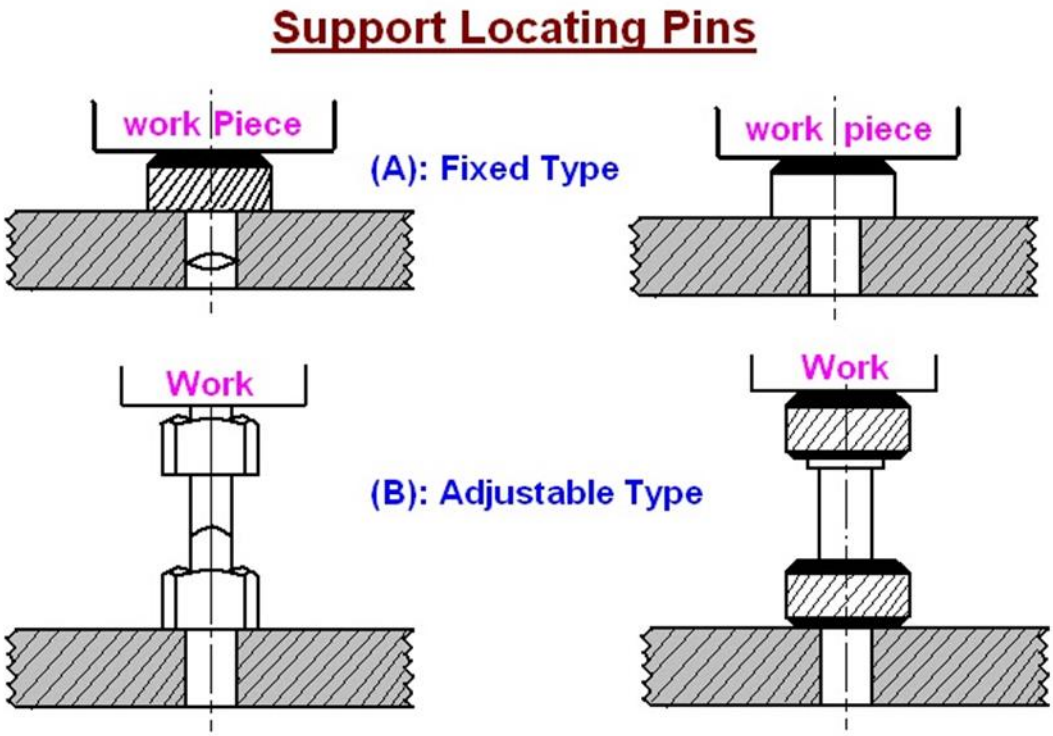
When reamed or finally finished holes are available in work piece, these can be used for locating purpose of the manner as shown, these are two types of locating pins:



1. Conical locating pins
2. Cylindrical locating pins

(B): Support Locating Pins:

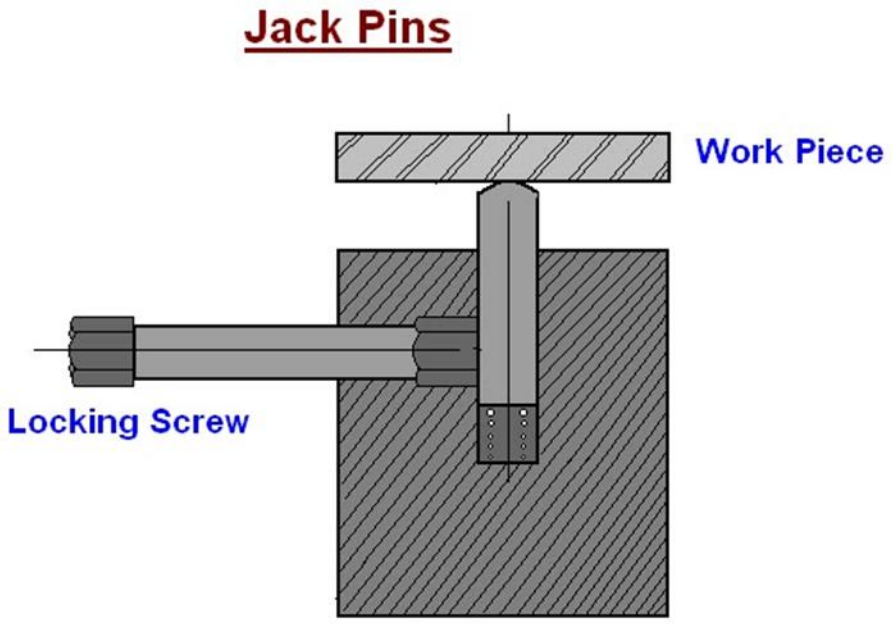
With these pins (also known as rest pins) buttons or pads the work piece with flat surfaces supported at convenient. In the fixed support pins the locating face is either ground flat or curved. Support pins with flat head are usually employed and provided location and support to machine surface, because more contact area is available during location. It would insure accurate and stable location. The spherical head or round head rest buttons are used for supporting rough surfaces (un machined and cast surfaces) because they provide a point support which may be stable under these circumstances. Adjustable type support pins are used for work piece whose dimension can vary. For example, sand casting, forging or unmachined faces.



(C): Jack Pins:

Jack pins or spring pins are also used to locate the work piece whose dimension are subjected to variation. The pin is allow to come up under spring pressure or

conversely is pressed down by the work piece. When the location of the work piece is secured the pin is locked in this position by means of locking screw.



3: Clamping devices:

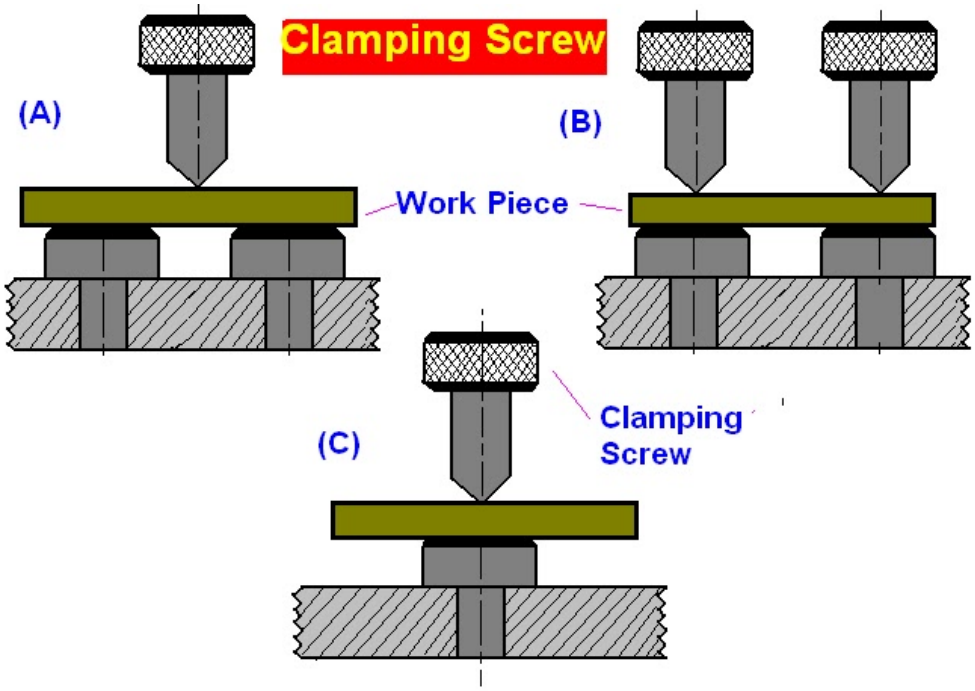
If the work piece cannot be restrained by the locating devices or elements, it become necessary to clamp the work piece in jig or fixture body. The most common example of clamping devices is bench vice. The purpose of the clamping is to exert a pressure to press a work piece against the locating surfaces and hold it there in a position to the cutting forces. In bench vice the movable

jaw of the vice exert force on the work piece, there by holding it in correct position of location in the fixed jaw of the vice.

The commonly used clamping devices are follows:

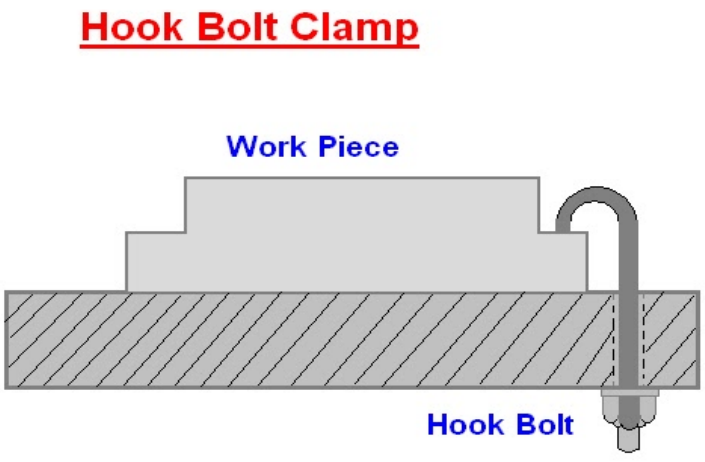
(A): Clamping Screws:

Clamping screws are used for light clamping. Clamping screws are shown in fig.



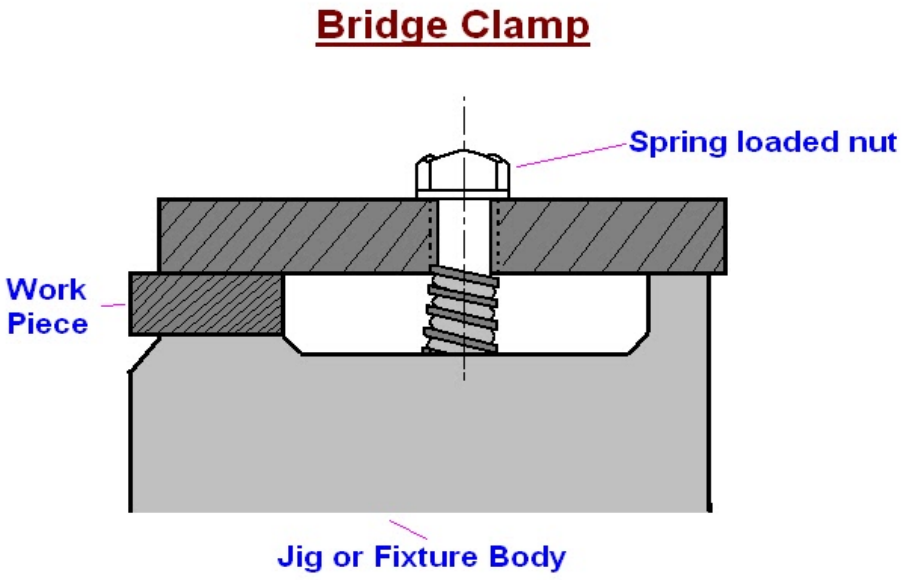
(B): Hook Bolt Clamp:

This is very simple clamping device and is only suitable for light work and where usual tip of the clamp is inconvenient. The typical hook bolt clamp is shown.



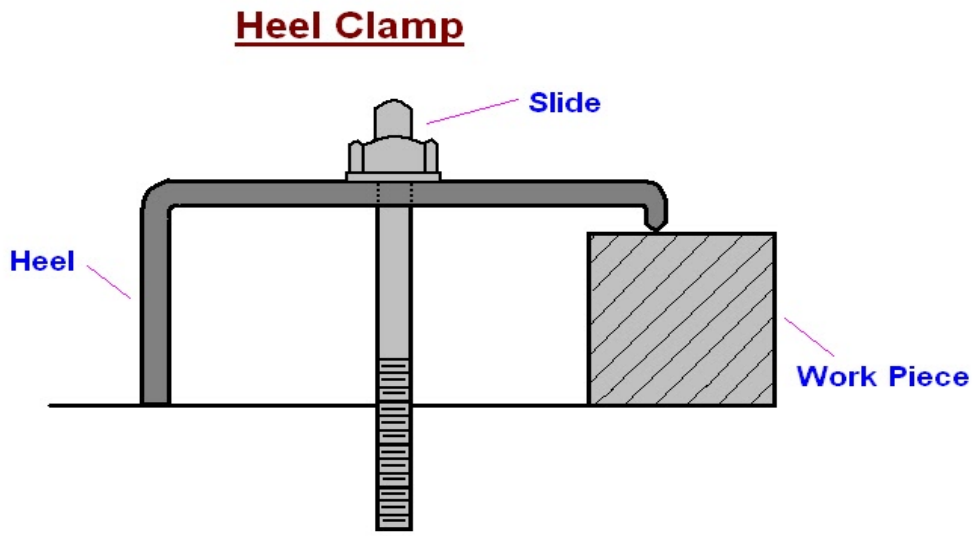
(C): Bridge Clamp:

It is very simple and reliable clamping device. The clamping force is applied by spring loaded nut.



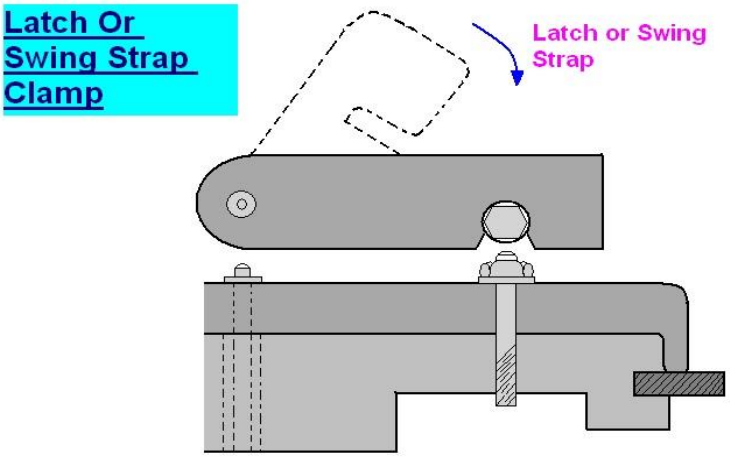
(D): Heel Clamp:

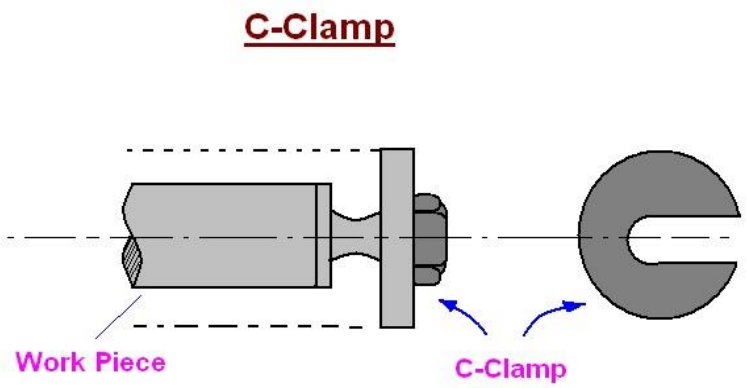
These consists of a rusted plate, center stud and heel. This trap should be strengthening at the point where the hole for the stud is cut out, by increasing the thickness around the hole. The design differ from simple bridge clamp in that a heel is provided at the outer end of the clamp to guide its sliding motion for loading and unloading the work piece.



(E): Swinging Strap (Latch Clamp):

This is a special type of clamp which provides a means of entry for loading and unloading the work piece. For this the strap (latch or lid) can be swing out from the work piece. The typical swing strap or latch clamp is shown in figure.





(F): C-Clamp:

To unload the work piece, the locking nut is unscrewed by giving it about one turn and this releases the c- clamp. When the clamp is removed or swing away the work piece can freely pass over the nut. To reverse procedure is adopted for loading the work piece.

How do jigs and fixtures differ

JIG	FIXTURES
1. It is a work holding device that holds, supports and locates the workpiece and guides the cutting tool for a specific operation	1. It is a work holding device that holds, supports and locates the workpiece for a specific operation but does not guide the cutting tool
2. Jigs are not clamped to the drill press table unless large diameters to be drilled and there is a necessity to move the jig to bring one each bush directly under the drill.	2. Fixtures should be securely clamped to the table of the machine upon which the work is done.
3. The jigs are special tools particularly in drilling, reaming, tapping and boring operation.	3. Fixtures are specific tools used particularly in milling machine, shapers and slotting machine.
4. Gauge blocks are not necessary.	4. Gauge blocks may be provided for effective handling.
5. Lighter in construction.	5. Heavier in construction.

Advantages of Jigs and Fixtures

PRODUCTIVITY:

Jigs and fixtures increase the productivity by eliminating the individual marking, positioning and frequent checking. The operation time is also reduced due to increase in speed, feed and depth of cut because of high clamping rigidity.

INTERCHANGEABILITY AND QUALITY:

Jigs and fixtures facilitate the production of articles in large quantities with high degree of accuracy, uniform quality and interchangeability at a competitive cost.

➢ SKILL REDUCTION:

There is no need for skillful setting of work on tool. Jigs and fixtures make possible to employ unskilled or semi-skilled machine operator to make savings in labour cost.

➢ COST REDUCTION:

Higher production, reduction in scrap, easy assembly and savings in labour cost results in ultimate reduction in unit cost.

Fundamental principles of Jigs and Fixtures design

LOCATING POINTS: Good facilities should be provided for locating the work. The article to be machined must be easily inserted and quickly taken out from the jig so that no time is wasted in placing the workpiece in position to perform operations. The position of workpiece should be accurate with respect to tool guiding in the jig or setting elements in fixture.

FOOL PROOF: The design of jigs and fixtures should be such that it would not permit the workpiece or the tool to inserted in any position other than the correct one.

- **REDUCTION OF IDLE TIME:** Design of Jigs and Fixtures should be such that the process, loading, clamping and unloading time of the workpiece takes minimum as far as possible.
- **WEIGHT OF JIGS AND FIXTURES:** It should be easy to handle, smaller in size and low cost in regard to amount of material used without sacrificing rigidity and stiffness.
- **JIGS PROVIDED WITH FEET:** Jigs sometimes are provided with feet so that it can be placed on the table of the machine.
- **MATERIALS FOR JIGS AND FIXTURES:**

  Usually made of hardened materials to avoid frequent damage and to resist wear. Example- MS, cast iron, Die steel, CS, HSS.
- **CLAMPING DEVICE:**

  It should be as simple as possible without sacrificing effectiveness.
  The strength of clamp should be such that not only to hold the workpiece firmly in place but also to take the strain of the cutting tool without springing when designing the jigs and fixtures.

Essential features of Jigs and Fixtures

- **Reduction of idle time** – Should enable easy clamping and unloading such that idle time is minimum

- **Cleanliness of machining process** – Design must be such that not much time is wasted in cleaning of scarfs, burrs, chips etc.

- **Replaceable part or standardization** – The locating and supporting surfaces as far as possible should be replaceable, should be standardized so that their interchangeable manufacture is possible

- **Provision for coolant –** Provision should be there so that the tool is cooled and the swarf's and chips are washed away

- **Hardened surfaces** – All locating and supporting surfaces should be hardened materials as far as conditions permit so that they are not quickly worn out and accuracy is retained for a long time

- **Inserts and pads** – Should always be riveted to those faces of the clamps which will come in contact with finished surfaces of the workpiece so that they are not spoilt

- **Fool-proofing** – Pins and other devices of simple nature incorporated in such a position that they will always spoil the placement of the component or hinder the fitting of the cutting tool until the latter are in correct pos

- **Economic soundness** – Equipment should be economically sound, cost of design and manufacture should be in proportion to the quantity and price of producer

- **Easy manipulation** – It should be as light in weight as possible and easy to handle so that workman is not subjected to fatigue, should be provided with adequate lift aids

- **Initial location** – Should be ensured that workpiece is not located on more than 3 points in anyone plane test to avoid rocking, spring loading should be done

- **Position of clamps** – Clamping should occur directly above the points supporting the workpiece to avoid distortion and springing

- **Clearance** – Sufficient amount of clearance should be provided around the work so that operator's hands can easily enter the body for placing the workpiece and any variations of work can be accommodated

- **Ejecting devices** – Proper ejecting devices should be incorporated in the body to push the workpiece out after operation

- **Rigidity and stability** – It should remain perfectly rigid and stable During operation. Provision should be made for proper positioning and rigidly holding the jigs and fixtures

- **Safety –** The design should assure perfect safety of the operator

General rules for designing

- Compare the cost of production of work with present tools with the expected cost of production, using the tool to be made and see that the cost of buildings is not in excess of expected gain.
- Decide upon locating points and outline clamping arrangement
- Make all clamping and binding devices as quick acting as possible
- Make the jig fool proof
- Make some locating points adjustable
- Avoid complicated clamping arrangements
- Round all corners
- Provide handles wherever these will make handling easy
- Provide abundant clearance
- Provide holes on escapes for chips
- Locate clamps so that they will be in best position to resist the pressure of the cutting tool when at work
- Place all clamps as nearly as possible opposite some bearing point of the work to avoid springing action
- Before using in the shop, test all jigs as soon as made

MATERIALS USED

- Jigs and Fixtures are made of variety of materials, some of which can be hardened to resist wear.

Materials generally used:

- **High speed Steel**: Cutting tools like drills, reamers and milling cutters.
- **Die steels**: Used for press tools, contain 1% carbon, 0.5 to 1% tungsten and less quantities of silicon and manganese.
- **Carbon steels:** Used for standard cutting tools.
- **Collet steels**: Spring steels containing 1% carbon, 0.5% manganese and less of silicon.
- **Non shrinking tool steels:**

  High carbon or high chromium

  Very little distortion during heat treatment. Used widely for fine, intricate press tools.
- **Nickel chrome steels**: Used for gears.
- **High tensile steels:** Used for fasteners like high tensile screws
- **Mild steel:**

  Used in most part of Jigs and Fixtures

  Cheapest material

  Contains less than 0.3% carbon

- **Cast Iron:**

  Used for odd shapes to some machining and laborious fabrication

  CI usage requires a pattern for casting

  Contains more than 2% carbon

  Has self-lubricating properties

  Can withstand vibrations and suitable for base
- **Nylon and Fiber:** Used for soft lining for clamps to damage to workpiece due to clamping pressure

- **Phospher bronze:**

  used for nuts as have high tensile strength

  Used for nuts of the lead screw

Factors to be considered for design of Jigs and Fixtures

1. **Component-**

   Design to be studied carefully

   Ensure work is performed in a proper sequence

   Maximum operations should be performed on a machine in single setting

2. **Capacity of the machine-**

   Careful consideration to be performed on type and capacity of machine.

3. **Production requirements-**

   Design to be made on basis of actual production requirements. Then comes decision on manual and automatic tooling arrangements.

4. Location-

- Location should ensure equal distribution of forces throughout all sequence of oper
- Location should be hard resistant, wear resistant and high degree of accuracy.
- Movement of workpiece should be restricted.
- Should be fool proofed to avoid improper locations of the workpiece.
- Should facilitate easy and quick loading of workpiece.
- Redundant locators should be avoided.
- Sharp corners must be avoided.
- At least one datum surface should be establised**.**

5. Loading and Unloading arrangements-

There should be adequate clearance for loading and unloading. Hence process becomes quick and easy. Size variation must be accepted.

It should be hardened material and non sticky.

6. Clamping arrangements-

Quick acting clamps must be used as far as possible. The clamping should not cause any deformation to the workpiece

It should always be arranged directly above points supporting the work.

Power driven clamps are favoured as they are quick acting, controllable, reliable and operated without causing any fatigue to the operators.

- Features of clamps:

Clamping pressure should be low Should not cause distortion Simple and fool proof

Movement of clamp should be minimum Case hardened to prevent wear

Sufficiently robust to avoid bending

7. Clearance between Jig and Component-

To accommodate various sizes if work

Chips to pass out of the opening between them

8. Ejectors-

To remove work from close fitting locators.

Speeds up unloading of the part from the tool and hence production rate.

9. Base and Body construction-

Methods used: Machining, Forging and machining, Casting, Fabricating, Welding.

10. Tool guiding and cutter setting-

By adjusting the machine or using cutter setting block, the cutter is set relative to the work in a fixture. The drill bushes fitted on jig plates guides the tools.

11. Rigidity and vibration-

Must possess enough rigidity and robustness.

Should not vibrate as it may lead to unwanted movement of workpiece and tools.

12. Safety-

Operation should be assured full safety.

13. Cost-

Should be simple as possible.

Cost incurred should be optimum**.**

14. Materials generally used-

Sl. No	Part Name	Material
1	Jig body	CI
2	Stud	MS
3	Drill/Bush	Gun metal
4	Pin	MS
5	Nut	MS


Oil only!
GREASE!