

JIGS & FIXTURES**JIGS & FIXTURES:****6.1 Introduction**

Jigs and fixtures are essential to working holding and tool holding devices in industries. These devices facilitate clamping of the workpiece on the machine tool in correct relationship with the cutting tool.

Jigs and fixtures are often used interchangeably and sometimes in pairs, but there is a difference between two terms jigs and fixtures .

Jig:

Jig(tool) is defined as a device which holds and positions the work, locates or guides the cutting tool about the workpiece and usually is not fixed to the machine table. Jigs are used for performing the operations of drilling, reaming, tapping and counter boring.



Jig



Fixture(Pincer grip for material testing in tensile tests.)

Fixture:

Fixture(tool) is a work holding device which only holds and positions the work but does it in itself guide locate or position the cutting tool. The setting of the device is done by machine is done by machine adjustment and a setting block or by using slip gauges. A fixture is bolted or clamped to the machine table and is usually heavy in construction.

Fixtures are designed for specific purposes of machining operations, such as turning, milling, grinding, shaping, planning, and boring operations.

The purpose of using jigs and fixtures:

The basic purposes of developing and using suitable jigs and fixtures for batch production in machine shops are:

- To eliminate marking, punching, positioning, alignments etc.
- easy, quick and consistently accurate locating, supporting and clamping the blank in alignment of the cutting tool
- Guidance to the cutting tool like drill, reamer etc.

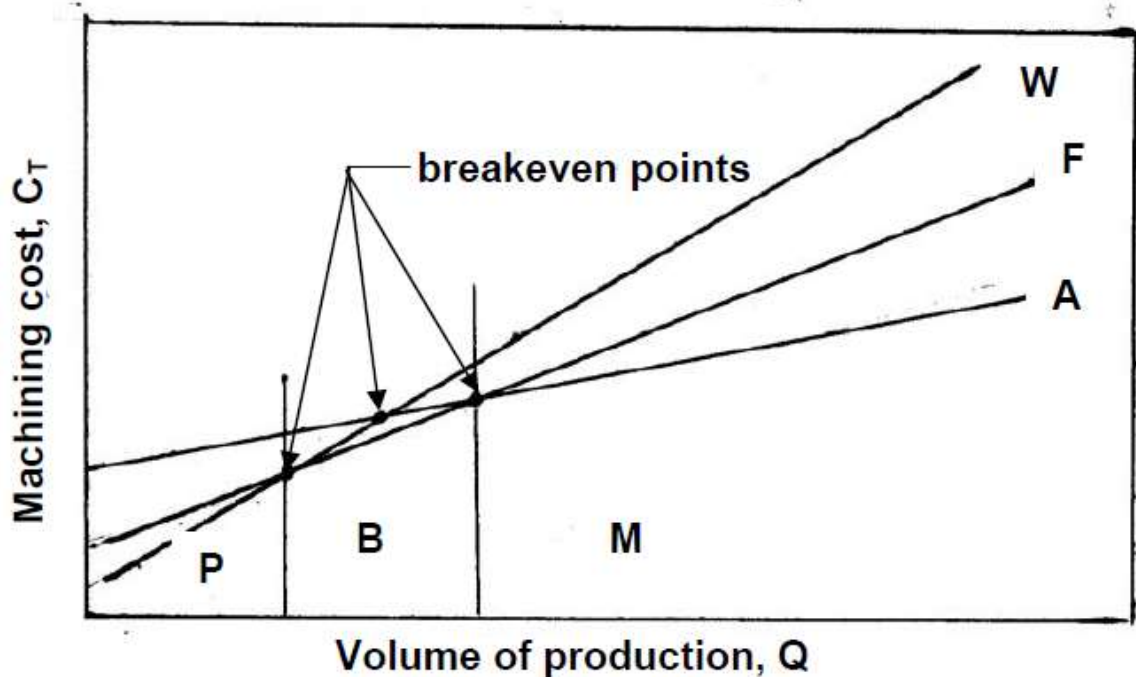
- increase in productivity and maintain product quality consistently
- to reduce operator's labour and skill – requirement
- to reduce measurement and its cost
- enhancing technological capacity of the machine tools
- Reduction of overall machining cost and also increases in inter changeability.
- To reduce the cost of production, by using them, they eliminate the laying out of work and setting up of the tools.
- To increase the production rate.
- To ensure high accuracy of parts produced without any manufacturing defects.
- To provide for inter changeability.
- To ensure heavy and complicated shaped parts are to be machined easily.
- Reduce quality control expenses.
- Increased versatility of the machine tool.
- Their use partially automates the machine tool.
- To provide safety at the work point.

ADVANTAGES OF JIGS & FIXTURES The use of jigs and fixtures provides the followings:

- Eliminates the laborious marking out of each work-piece before machining. The cost of setting up of the work piece according to the marking lines on machine tool bed is reduced.
- Increases machining accuracy and ensures inter change ability because the work-piece is located properly and the cutting tool is guided.
- Increases productivity due to increase in the speeds, feeds and depth of cut. This becomes possible in a jig or fixture due to high clamping rigidity.
- Increases productivity due to increase in number of work-pieces which are simultaneously machined or the number of cutting tools used subsequently, due to the reduction in handling time associated with set up and aligning the work-piece on the machine tool.
- Reduces Job handling. • Allows unskilled labour to on it. • Decreases the cost on quality control.
- Broadens the technological capacity of the machine tools, i.e.; increases the versatility of the machine. • Either fully or partly automates the machine tool.
- Facilitates the assembly due to accuracy of manufactured part and promotes interchangeability.
- JOMY AND COST cost of the tool (Jig and Fixture) and the number of parts to be produced factors in determining the design.. If a small quantity of parts is to be a simple, low-cost tool may be satisfactory. The necessity of keeping the iring cost of a new article as low as possible, or reducing the present cost ting article, usually determines the type of jig or fixture that is to be made. 'stances, the cost of an operation can be reduced by using a more efficient h expensive. ased accuracy and interchangeability secured through the use of a more '01 design , warrants a greater cost. The use of a jig or a fixture must be nly after justifying the cost of the component by using jig or fixture in In to other of other process of making the component.

Difference between Jigs and Fixtures:

S. No	Jigs	Fixtures
1	Jig is a work holding device that holds, supports and locates the workpiece and guides the cutting tool for a specific operation.	Fixture 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.	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.	Fixtures are specific tools used particularly in milling machine, shapers and slotting machine.
4	Gauge blocks are not necessary.	Gauge blocks may be provided for effective handling.
5	Jigs are lighter in construction.	Fixtures are heavier in construction.



W – without using jig & fixture

F – using jig and fixture

A – automatic (special purpose) machine

P – piece production
B – batch production
M – mass production

Fig. 8.1.2 Role of Jigs and Fixtures on machining cost

6.2 Principles of design of jigs and fixtures and uses

Jigs and fixtures are manually or partially power operated devices. To fulfil their basic purposes, jigs and fixtures are comprised of several elements (as indicated in Fig. 8.1.3) :

- base and body or frame with clamping features
- locating elements for proper positioning and orientation of the blank
- supporting surfaces and base
- clamping elements
- tool guiding frame and bushes (for jig)
- indexing plates or systems, if necessary
- auxiliary elements
- fastening parts

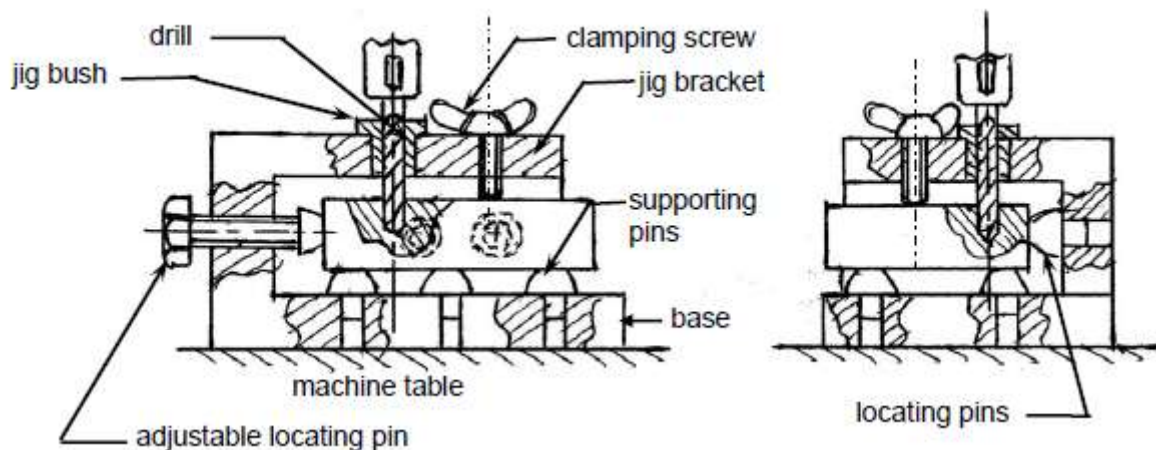


Fig. 8.1.3 Major elements of jig and fixtures.

Therefore keeping in view increase in productivity, product quality, repeatability i.e. interchangeability and overall economy in batch production by machining, the following factors are essentially considered during design, fabrication and assembly of jigs and fixtures :

- Easy, quick and consistently accurate locating of the blank in the jig or fixture in reference to the cutting tool
- providing strong, rigid and stable support to the blank
- Quick, strong and rigid clamping of the blank in the jig or fixture without interrupting any other operations
- Tool guidance for slender cutting tools like drills and reamers
- Easy and quick loading and unloading the job to and from the jig or fixture
- Use of minimum number of parts for making the jig or fixture

- Use of standard parts as much as possible
- Reasonable amount of flexibility or adjustability, if feasible, to accommodate slight variation in the job - dimensions.
- Prevention of jamming of chips, i.e. wide chips-space and easy chip disposal
- Easy, quick and accurate indexing system if required.
- Easy and safe handling and moving the jig or fixture on the machine table, i.e., their shape, size, weight and sharp edges and corners
- Easy and quick removal and replacement of small parts
- Manufacturability i.e. ease of manufacture
- Durability and maintainability
- Service life and overall expenses

6.3 Classification of jigs & fixtures

TYPES OF JIGS

There are many types of drill jigs. There is no hard and fast criterion for classifying the drill jigs. However, the drill jigs may be divided into two types.

1. Open.
2. Closed.

Open jigs are used when the operation is to be done only on one side of the piece. Closed jigs (Box Jig) are used when the operations are to be done on more than one side of the piece.

Jigs are classified according to the design. Most commonly used jigs are:

- | | |
|------------------------------|--------------------------|
| 1. Template Jig. | 9. Leaf Jig or Latch Jig |
| 2. Plate Jig | 10. Indexing Jig |
| 3. Table / Turn over Jig. | 11. Trunnions Jig |
| 4. Sandwich Jig | 12. Local jig |
| 5. Angle plate Jig. | 13. Solid jig |
| 6. Modified angle plate Jig. | 14. Post jig |
| 7. Box Jig | 15. Pot jig |
| 8. Channel jig | |

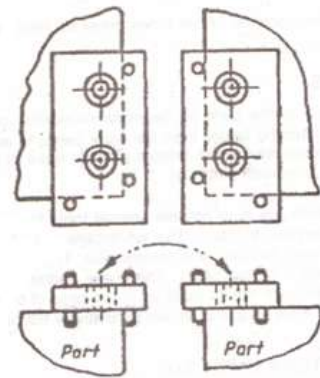
TEMPLATE JIG

A template jig is a simple, open-type of drill jig. It consists mainly of a flat plate containing the drill-guiding holes. The plate may be shaped to match the outline of the surface of the work piece in which the holes are to be drilled, or it may be made to match only a portion of the same outline; It may be a plate with projecting pins which fit over the contour of the locating surface, or the plate may be recessed to fit over parts which are finished to uniform size and shape.

Drill templates are used on large work because the holes can be located more accurately and uniformly if each hole were laid out separately on each piece. They are also used on small work when an inexpensive drill jig is desired.

A template jig has several advantages. They are simple in design and construction, low in cost, easy to handle and locate to on the work. However, al template jig is foolproof and a careless operation can lead to high percentage rejection of work.

The drilling operation is slow because locking pins must be inserted in the first drilled hole and, for some jobs in the second drilled hole. In addition, template jig is not preferred, when location of the holes, must be held to close tolerances. (Refer Fig. -5.1)



TEMPLATE JIG
Fig.-5.1

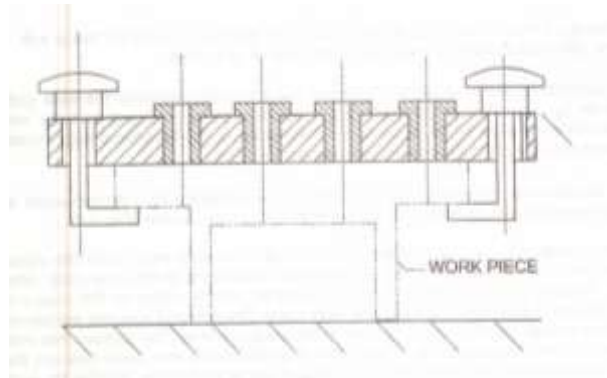


PLATE JIG
Fig.-5.2

PLATE JIGS

The general shape of the plate jig depends somewhat on the shape of the work piece. The plate must be larger than the work piece to accommodate the locating features and clamping devices. A bottom plate or base to provide clearance for the drill point may be used with plate jigs.

The purpose of plate jigs is to provide special tools for drilling which are simple in design and inexpensive to build. The advantages of plate jigs are that they are simple in design, easy to build, and inexpensive. They can also be depended upon to produce accurately drilled holes. There are certain disadvantages. Unloading, cleaning, and loading are not as rapid as in the case of other type of jigs, with quick clamping features. Plate jig use is limited to relatively flat pieces. (Refer Fig.-5.2)

TABLE JIG/TURN OVER JIG

A plate jig with legs is called a table jig. These jigs are used for large work pieces.

SANDWICH JIG

These are a form of plate jig with back plate. This type of jig is ideal for thin or soft parts, which could bend or warp if any other type of jig is used.

In sandwich jig, the work piece is clamped like a sandwich between the base plate and the jig plate. The clamping can be accomplished by two swinging eyebolts, with open clamping slots in the jig plate. The tightening of the hexagonal nuts shown, clamps the jig against the work piece and the base plate.

For unclamping, the hexagonal nuts need to be loosened by only half-a-turn to permit eyebolts swung aside through the open slots in the jig plate

The jig plate can now be removed from the pillars and kept aside while the drilled work piece is removed and a new one is loaded and located on the base plate. After that, the pillar guide bushes in jig plate are aligned with the pillars on the base and the jig plate is slide down, to touch the work piece. The swinging eyebolts are swung vertical through the slots in the jig plate to the position shown. The operator has only to tighten the hexagonal nuts by half-a-turn to sandwich the work piece between the jig plate and the base plate. Sandwich type of jigs is particularly suitable for work pieces, which have parallel-machined Surface Square to the axis of drilling. If the work piece has got only one machined surface, that face should be rested on the base plate. The jig plate should be fitted with a spherical-ended pad or an equalizer clamp to facilitate clamping on the unmachined top surface of the work piece.0

ANGLE PLATE JIG:

These jigs are used to hold work, which are to be drilled at right angles to their mounting locators. In angle plate jigs,, locators are generally fixed to the vertical wall of the angular body. The work piece is located by a central locator and a diamond pin for angular position...0 washer is used for quick clamping of the work piece. The central locator must have relief hole/a groove for passage of the drill after passing through the work piece.

MODIFIED ANGLE PLATE JIG: These jigs are used for drilling at angles other than 90.

BOX TYPE JIG

Work pieces having holes on a number of sides can be drilled economically with box jigs. The jig body is generally shaped like a box with one side kept open for loading and unloading of the work piece. The open side is provided with a hinged latch, which often houses bushes and clamping screws. The jig is fitted with bushes on various sides with suitable jig fits on the opposite sides. Shows a box jig for the work piece shown in the diagram. The work piece rests on the machined base of the jig plate. The box is closed and clamped by the latch and it should be positively located because it carries drill bushes. Four feet are provided to give good seating when drilling all faces and suitable swarf clearance are incorporated.

CHANNEL JIG

These are the simplest form of box jigs. The work piece is held between two sides and machined from the third.

LEAF JIG or LATCH JIG

These generally have a hinged jig (bush) plate. The jig plate can be swung aside as shown by the chain dotted lines to provide clear path for loading and unloading the work piece from the top. The jig plate must have positive resting face to ensure that the axis of bushes is vertical during drilling. The jig plate must be clamped against the resting face by an eyebolt. The open slot in the jig plate and swinging eyebolt facilitate quick clamping and unclamping of the jig plate. The hand knob needs to be loosened by only half-a-turn and the eyebolt swung to the position as shown by the chain dotted line, in order to permit swinging of the jig plate aside for loading and unloading of the work piece from top. Leaf-type jigs are particularly suitable for workpiece having location surfaces and holes to be drilled on opposite sides are shown in the figure. The jig plate is often used to house the clamping screw. It is also same as open type Jig in which the top plate is arranged, to swing about a fulcrum so that it completely clears the jig for easy loading and unloading of the work piece. The drill bushes are fitted into the plate that is also known as leaf, latch or lid.

INDEXING JIG

Indexing jigs are often used when holes are to be drilled at various angles. A jig of this kind may partially or wholly enclose the work. By means of locators, clamps, and other supports, the work may be positioned on a rotating or swiveling drum so that correct hole locations may be indexed to a vertical position in line with stationary drill bushings. This type of jig can be simple or complicated, depending upon the work and the volume of production. Such a jig may be designed to hold several identical parts. The jig can be manually or automatically operated to index the work to the drilling position.

TRUNNION JIGS

When large, heavy workpieces are to be drilled or number of sides, the jig is constructed like a box with jig bushes on various sides. Due to the large size and weight of the work piece and the jig, it is impossible to rotate the jig assembly manually for drilling the holes on the various-sides.

To ease this operation, the jig body is provided with pivots at both ends. The pivots are supported with ball bearings in the supporting brackets at both ends. This reduces friction and consequently,

the force required to turn the jig around the pivots. On one side of the jig is attached an indexing plate with location bushes for indexing.

When the indexing plunger is engaged with one of the indexing bushes/ the work piece and jig is held in position for drilling holes on one side. For drilling holes on the other side, the indexing plunger is withdrawn from the bush and the jig is rotated to drill holes on the other side. When the indexing plunger enters the indexing bush in the indexing plate, we can be sure that the drill jig is held accurately for drilling holes on one side.

Thus, trunnion facilitates moving and positioning of heavy workpieces and jigs for drilling holes on various sides. The heavy jig and trunnion remain stationary during drilling. The drilling machine spindle must be moved to align with the drill bushes in the jig. Consequently, trunnion-type jigs can be used only on moveable spindle machines such as a radial drilling machine.

LOCAL, SOLID, POST, POT JIGS

The local jig is a plate jig that is bolted to the facing to be machined; the workpiece is located and clamped to a base that is suitable for a number of operations

Fig 5.13 shows a solid jig that is made from a block of steel in the example shown, the workpiece is clamped by a button clamp, and burr grooves are provided so that the workpiece can be easily removed. (Two grooves are required because one burr will be produced at the point of drill entry, and a second burr is produced at the point of drill break-through.)

Pot jig in which the workpiece is located from its outside in a bush, and the drill bush is located on a post. The workpiece is supported at the point of drilling, and swarf clearances are provided; the drill plate is located to line up with the swarf clearance grooves. The pot jig shown in fig. 5.16 is a similar type, but the workpiece is only placed in the pot to support the flange, and the drill plate is located directly in the workpiece bore.

TYPES OF FIXTURES

A fixture is a device in which a component is held for a specific operation but the cutting tools are not guided. Fixture usually locates the work also. Fixtures may be classified according to the kinds of operations in which they are used. Some of the common types of fixtures are: Turning fixtures. Milling fixtures. (P-Th Grinding fixtures. Inspection fixtures. 7-, Assembly fixtures.

TURNING FIXTURES Holding the work pieces for the lathe operations is successfully achieved with the help of numerous type of equipment available commercially. Such equipment can be classified into chucks, mandrels and collets, faceplate and milling vise. Three jaw chucks are used to hold round or hexagonal bar stock or other symmetrical work. Four jaw chucks are used for rough castings and square or octagonal work.

When irregular shaped castings and forgings are to be machined, special chuck jaws may be used to suit the component. Collets are used primarily for bar stock, some types of jobs can be mounted and supported on a faceplate. Standard equipment such as angle brackets and flat plates may be screwed or bolted to the faceplate and the work clamped to these. For example, jobs, which are hard to hold such as pipe may be bolted to an angle plate, which in turn is bolted to the faceplate.

Hollow jobs such as gear blanks and pulleys can be supported on a mandrel between centers and rotated by a dog. A Mandrel is a hardened bar held between centers. It has flats on each end for clamping a lathe dog. A milling vise can be mounted on the lathe bed in place of the compound rest, to hold the work and the cutter is inserted in the lathe spindle. If the job can be held easily and quickly in the above-mentioned standard devices, then there is no need of a special work holding device. However, many jobs, particularly castings and forgings, because of their shape, cannot be conveniently held by any of the standard devices. It then becomes necessary to build a special work holding device for the job. Such a device is called a lathe fixture. A base, location and fastening the

fixture securely and accurately in the lathe. A lathe fixture can be fixed to the lathe either by holding the chuck jaws or fixing to a face plate.

G CHUCKS A chuck is a device mounted on a spindle nose of a lathe. It has jaws for holding workpiece or cutting tool, usually the former. Chucks are used in boring as well as turning operations. Short component such as castings, forgings and billets that are readily mounted on chucks.

Much of these class of work need facing and boring in addition to turning operation: so that the tail stock center cannot be used. Rigidity is a vital factor and the chuck selected for a vital job, whatever its type must be of adequate size. Jaws, which are opened so far that they project beyond the chuck body diameter, cannot be expected to grip properly. Moreover they become danger to the operator. Accuracy is another important factor. Care should be taken to oil the moving parts to reduce the wear and cleaning of dirt and scarf.

TYPES OF CHUCKS

- **INDEPENDENT CHUCK:** In independent chucks, Jaws are operated independently by inserting the chuck key in the appropriate socket of the jaw screw by direct rotation of a screw.

- **SELF-CENTERING CHUCK:** The self-centering chuck jaws close concentrically upon the rotation of a key inserted in any one of a number of sockets in the body.

- **COMBINATION CHUCK:** In combination chucks, the jaws may be operated simultaneously by a master socket, while means for individual adjustment of each jaw is also provided. In using the combination chuck, the first component of a run is adjusted into position by the independent jaw screws. Subsequent components of the batch are then easily and quickly gripped by the operation of the self-centering mechanism.

- **WRENCH OPERATED CHUCK:** Wrench operated chuck is a chuck in which jaws are opened or closed with a wrench which may be either hand or power operated, this chuck is available in independent self centering or combination designs. The wrench chuck is opened and closed by hand.

- **DRAW-BAR OPERATED CHUCK:** This is one in which the jaws are opened or closed by an operating bar or type located on the central axis of the center and extending through the spindle of the machine in which chuck is mounted. The operating lever is actuated by a pneumatic cylinder, a hydraulic cylinder or by mounting a motor at the ends of head stock. A mechanism is usually incorporated so that the torque can be adjusted to suit the gripping power required.

C COLLET: Components turned from bar stock are frequently gripped in collet chucks, which are quick acting but have a small range of movements. Hardened spring collet or collet pads which will accept various sizes up to the limit of spindle bore are fitted to the chuck. The hand or pneumatic actuated mechanism causes the collet to close on bar with sufficient force to take all normal cutting loads and can be operated while spindle is revolving.

The spring collets are the simplest device developed for holding work in lathes and screw machine. It is the universal chucking device used in both hand and automatic machines when parts are turned from stock.

MANDRELS:

Some components require an operation that is both combination of bar and chuck work e.g. a pulley which is first bored while it is gripped in chuck on the outside diameter and is then machined externally so that the diameters are concentric. The easiest way is to use mandrel, which is supported between centres to mount the pulley on it.

A mandrel is a very slightly tapered bar, the diameter being suited to the workpiece to be carried on it and short enough to be rigid under the heaviest loads likely to be imposed. If the mandrel is to be used more than once it is made normally from case hardened steel and after heat

treatment is ground with a taper of about 0.5mm per meter, the smaller end being slightly below normal size. This enables it to be forced into the work until a holding force powerful enough to drive the workpiece against the cutting load is obtained. Expanding mandrels are most satisfactorily used for the production work since the workpiece in most cases is easier to remove, also there is less wear on the mandrel as well as less damage on the bore of the workpiece.

There are many special mandrels available, ranging from those with a self-contained hydraulic system which causes the mandrels to expand to those containing a roller actuated expanding sleeve.

FACE PLATE:

A face plate is an accurately turned casting or a forging machined to a suitable dimension to fit the spindle nose or adaptor and having number of slots and holes on its face. The work is bolted or clamped to the face so that required operations can be performed. Short components such as castings, forging and billets that are rigid enough to require no other support are mounted on chucks or face plates.

Work fitted to a face plate frequently takes longer time to set up than similar component set up by chuck, but the jobbing work under versatility is more important than speed, many different types of components can be handled. A small bearing housing is faced and bored. The previously machined surface base is bolted to an angle bracket attached to the faceplate, while one end is faced and centre hole bored.

USE OF TURNING FIXTURE

It is used for complicated work pieces, and is, in effect a simplification of the technique of bolting the workpiece to a faceplate. the fixture body is located on the machine spindle, and bolted in position; it carries the workpiece location and clamping systems.

complicated fixture; here the workpiece is located and clamped to a shelf that projects from the fixture body.

The fixture illustrated incorporates a balance weight (the fixture would otherwise be out of balance) and a pilot bush to guide the boring bar. A setting face, machined relative to the location system, and a typical hardened setting piece is also shown.

GENERAL POINTS FOR A LATHE FIXTURE

- ❖ Grip the rotating workpiece securely to the fixture to resist torsional forces. * The fixture should be rigid and overhang should be minimum possible
- ❖ Locate the workpiece on critical surfaces from where all or major dimensional and angular tolerances are taken.
- ❖ Provide adequate support for frail section or sections under pressure from lathe tools.
- ❖ Fixture should be accurately balanced to avoid vibrations at high spindle speeds.
- ❖ Fixture should be free from projections likely to cause injury to the operator.
- ❖ A pilot bush for supporting tools should be provided where extreme accuracy is required in boring operations.
- ❖ Reduce time required for loading and unloading to justify reduced total cost per component, for the quantity to be produced.

MILLING FIXTURES

A fixture is a device for holding and locating a workpiece during a machining operations. The name is derived from the fact that a fixture is always fixed to a machine or bench in a fixed position. It does not contain special arrangements for guiding the tool. As drill jigs do. Many machining operations can be performed by clamping the workpiece to the machine table without using a

fixture, when the parts to be machined are bigger in size like machine tool bed. However when number of parts, are more then use of a fixture for holding and locating the work is economical.

A milling fixture is a work holding device, which is firmly clamped to the table of the milling machine. It holds the work piece in correct position as the table movement carries it past the cutter or cutters. A milling fixture is usually a good solid casting, since cast iron has the important characteristic of absorbing and damping out the vibrations resulting from the cutting action of the milling cutters. The essential features of a milling fixture are: A heavy base, locating and clamping elements and setting blocks.

TYPES OF MILLING FIXTURES

Milling fixtures are classified in a variety of ways and there. seems to be standard method of classification. This is because each fixture is different and must be designed to meet certain specific requirements. However according to the method of milling used, the following are main types of milling fixture.

Vice or clamp for single piece milling.

String milling fixture.

Gang milling fixture,

Continuous milling fixture.

Index milling fixture'

Air operated or Pneumatic milling fixture.

Duplex milling fixture.

Milling fixtures can be classified in the following ways also.

ACCORDING TO THE TYPE OF OPERATIONS PERFORMED ON THE WORK:

- Slotting fixtures.
- Straddle milling fixtures.
- Face milling or form milling fixtures.

ACCORDING TO THE METHOD OF MILLING :

- Single piece milling fixtures.
 - String milling fixtures.
 - Abreast milling fixtures.
 - Reciprocal milling fixtures.
 - Progressive milling fixtures.
 - Index milling fixtures.

ACCORDING TO THE METHOD OF CLAMPING THE WORKPIECES:

- Hand clamping fixtures.
- Power clamping or automatic clamping fixtures.

VICE OR CLAMP FOR SINGLE PLACE MILLING: When numbers of pieces to be milled are very few then one of the most used and adaptable fixture is vice. The vice can be adapted for different jobs by using special jaws made to suit special characteristics of the component. It consists of a fixed jaw and a movable jaw. The movable jaw is cam operated to secure proper holding of job.

STRING MILLING FIXTURE: When a number of components are located behind each other in a line, in a fixture, the fixture may be called string or line milling fixture. The fixture moves relative to the cutters hence two factors are to be considered, firstly it has to be decided that how many components shall be accommodated in the row. Secondly what means can be adopted to bring components as close as

possible to avoid cutting air during the machining operation. When the components are to be string milled, the question of an adequate clamping scheme must be considered.

GANG MILLING FIXTURE: If more than two cutters are used on the arbor for milling, the operation is called 'Gang Milling'. Therefore any fixture, which is used with a set of gang milling cutters, can be referred to as a gang-milling fixture. The heavy cutting load which is generally associated with gang milling makes it necessary to design very rigid fixtures to absorb the forces set up by cutting tools. A gang-milling fixture arranged for milling a pin. It is not necessary to keep the components as close together as possible. A single setting piece is required for setting the gang of cutters.

CONTINUOUS MILLING FIXTURE: When very high rates of production are necessary a continuous milling fixture may be used. The number of stations used will depend upon the machine used and

Components are fed continuously through the cutters. There is a specific work loading station. For clamping, the ideal method is to employ automatic clamping. To take full advantage of method of operation, power feed is essential.

INDEX MILLING FIXTURE

Workpiece which involve machining of slots to some specific relationship may be dealt with using fixtures incorporating specially designed devices. The fixture is provided with a mechanism to ensure the relation between the two machining being kept uniform.

PNEUMATIC MILLING FIXTURE

Use of pneumatic fixture results in reduction of operating time. The main difference between an ordinary fixture and pneumatic fixture is that the usual clamps or other gripping arrangements are omitted and replaced by toggles and wedges operated by a compressed air cylinder.

DUPLEX MILLING FIXTURES

When machining on a component is required in two planes then a duplex type fixture is recommended. Milling fixture for a component calling for machining in two planes.

GRINDING FIXTURE

Surface grinding is used widely in industry to finish lengths and thickness of the workpieces within precise tolerances. The standard magnetic tables furnished with surface grinding machines can be used satisfactorily for workpieces having resting surface parallel to the surface to be ground. Solid plates can be ground under magnetic clamping alone and no other fixtures are necessary.

However, light workpieces having smaller resting area tend to tilt and fly off the magnetic table due to the high speed of the grinding wheel and the high feed used in grinders with reciprocating or rotating tables. As the magnetic clamping force is not sufficient to secure the workpiece during the grinding operation, it is necessary to provide additional supports by nesting the workpiece. Placing solid plates around the workpiece can do this.

With more weight and resting area, the nest plates are held firmly by the magnetic force of the table. The nest plates siege the workpiece from outside and arrest its movement in the horizontal plane, thus, preventing it from flying off or tilting due to high speed and feed inherent in the grinding operation.

In mass production, the capacities of the machines should be utilized to the maximum possible extent. Consequently, the maximum possible area of the magnetic table should be utilized to grind as many workpieces as possible in a single batch.

To achieve this, the jig and tool design office should furnish a layout of the workpieces on the magnetic table. For round spacers the work pieces are arranged in rows with common

supporting nest plates around. The thickness of the nest plates should be lesser than the finish height of the workpiece to prevent obstruction of the grinding wheel

For odd-shaped workpieces with little variation in size, an epoxy resin nest can be used. The nest prevents the tilting and sliding of the workpieces during grinding operation.

For workpieces unsuitable for magnetic clamping, special fixtures must be designed. Surface grinding fixtures are generally similar to face milling fixtures in design. However, generally face milling is the first operation whereas grinding is done at a much later stage when a number of machined portions of the workpiece are available for location and clamping.

CYLINDRICAL GRINDING

Fixtures for cylindrical grinding are similar to fixtures used for turning and boring. A variety of mandrels can be used for grinding the outside diameters of the bushes concentric with the inside diameter. Fixtures used for internal grinding are similar to face plate fixtures used for boring workpieces on turning machines.

The design features for location and clamping of the workpiece are similar to those of turning fixtures. Only the arrangement for securing fixtures to the machine spindle should be made suitable for the spindle of the grinding machine.

INSPECTION AND ASSEMBLY FIXTURES;

These are used for process and final inspections of work pieces in machining operations and in assembling the components after machining and also to test the work pieces and assembled units.

Inspections are used for process and final inspection of components during and after completion of machining process.

Assembly fixtures are used to check, inspect the total assembly of a unit.

6.4 Principles of location and clamping

Principles and Methods of Locating, Supporting and Clamping Blanks and Tool Guidance in Jigs and Fixtures

It is already emphasized that the main functions of the jigs and fixtures are :

(a) easily, quickly, firmly and consistently accurately

- locating
- supporting and
- clamping

the blank (in the jig or fixture) in respect to the cutting tool(s)

(b) providing guidance to the slender cutting tools using proper bushes There are and can be several methods of locating, supporting and clamping depending upon the size, shape and material of the job, cutting tool and the machining work required. But some basic principles or rules are usually followed while designing for locating, supporting and clamping of blank in fixtures.

(a) Locating, Supporting and Clamping of jobs in jigs and fixtures

Locating - principles and methods

• Principles or rules of locating in jigs and fixtures

For accurate machining, the workpiece is to be placed and held in correct position and orientation in the fixture (or jig) which is again appropriately located and fixed with respect to the cutting tool and the machine tool. It has to be assured that the blank, once fixed or clamped, does not move at all. Any solid body may have maximum twelve degrees of freedom as indicated in Fig.

8.1.4. By properly locating, supporting and clamping the blank its all degrees of freedom are to be arrested as typically shown in Fig. 8.1.5.

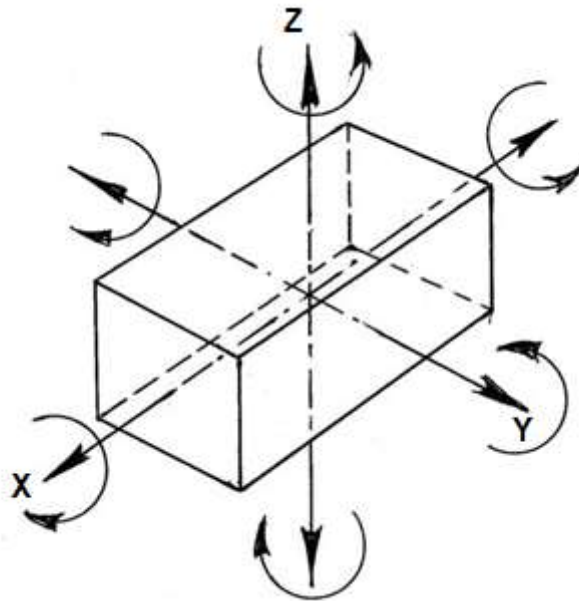


Fig. 8.1.4 Possible degrees of freedom of a solid body

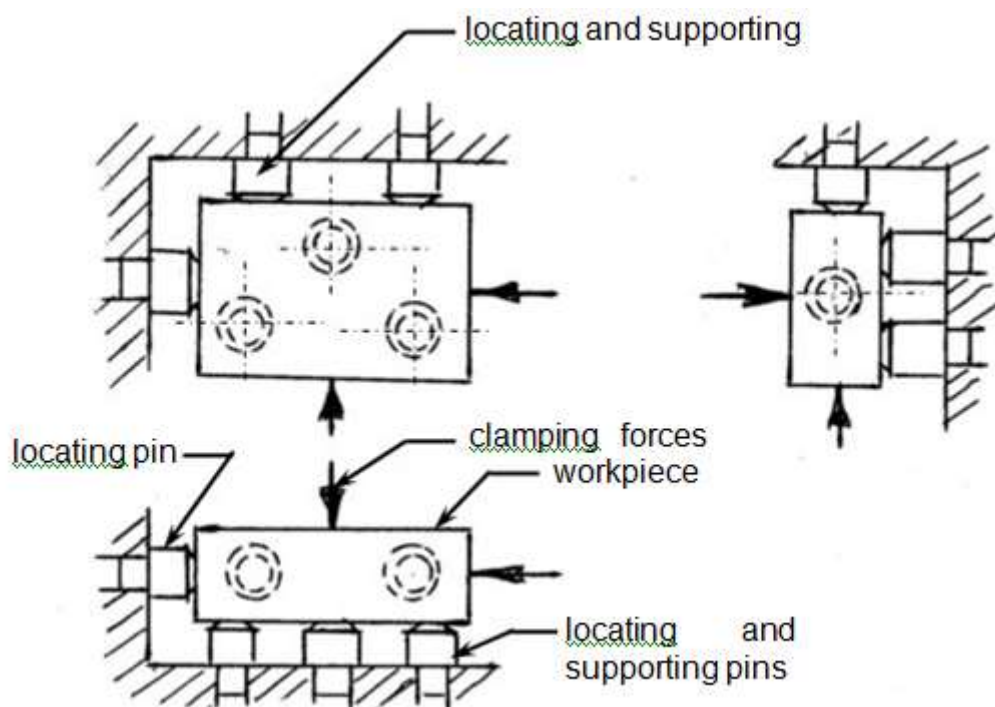


Fig. 8.1.5 Arresting all degrees of freedom of a blank in a fixture.

The three adjacent locating surfaces of the blank (workpiece) are resting against 3, 2 and 1 pins respectively, which prevent 9 degrees of freedom. The rest three degrees of freedom are arrested by three external forces usually provided directly by clamping. Some of such forces may be attained by friction.

Some basic principles or rules need to be followed while planning for locating blanks in fixtures, such as

- One or more surfaces (preferably machined) and / or drilled / bored hole(s) are to be taken for reference
- The reference surfaces should be significant and important feature(s) based on which most of the dimensions are laid down
- Locating should be easy, quick and accurate
- In case of locating by pin, the pins and their mounting and contact points should be strong, rigid and hard
- A minimum of three point must be used to locate a horizontal flat surface
- The locating pins should be as far apart as feasible
- Vee block and cones should be used for self-locating solid and hollow cylindrical jobs as typically shown in Fig. 8.1.6
- Sight location is applicable to first - operation location of blank with irregular surfaces produced by casting, forging etc. as indicated in Fig. 8.1.7
- When the bracket is first located on two edges to machine the bottom surface which will be used for subsequent locating.
- Adjustable locating pin(s) as indicated in Fig. 8.1.3 is to be used to accommodate limited part size variation
- For locating large jobs by rough bottom surface one of the three pins may be replaced by a pivoted arm as indicated in Fig. 8.1.7. The pivoted arm provides two contact points

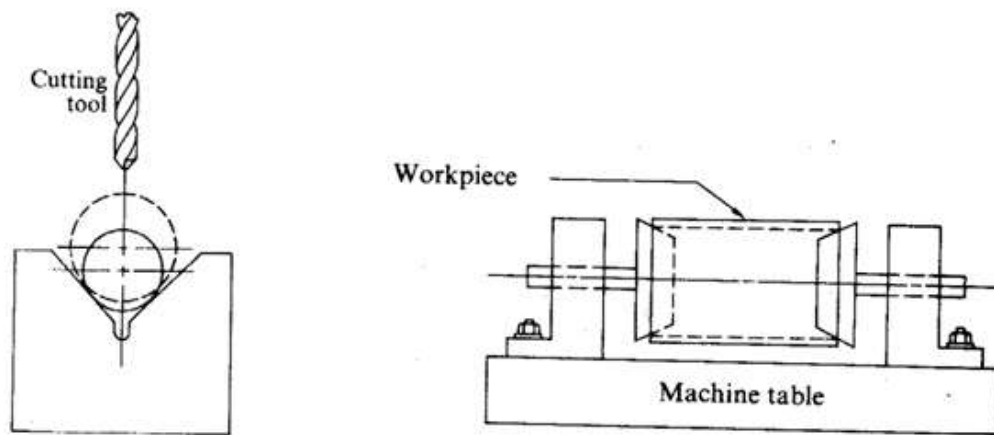


Fig. 8.1.6 Locating by Vee block and cone

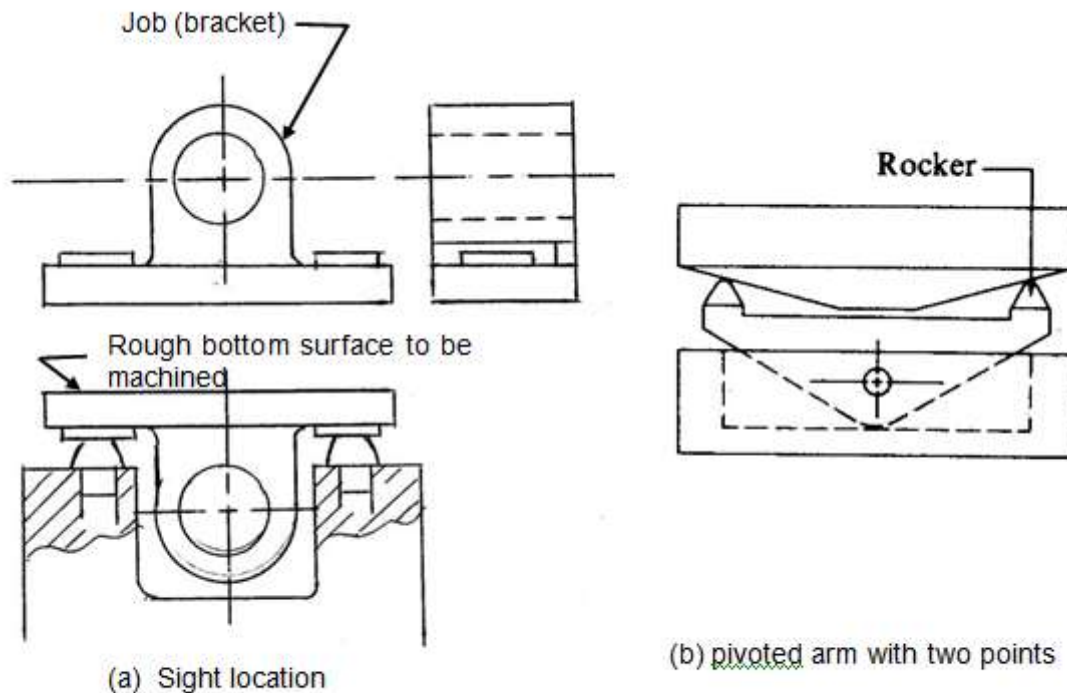


Fig. 8.1.7 (a) Sight location and (b) location by pivoted points (equalizer)

General methods of locating

Locating blanks for machining in lathes

In lathes, where the job rotates, the blanks are located by

- Fitting into self centering chuck
- Fitting into 4 - independent jaw chuck and dead centre oin self - centering collets
- in between live and dead centres by using mandrel fitted into the head stock - spindle
- Fitting in a separate fixture which is properly clamped on a driving plate which is coaxially fitted into the lathe spindle.

Locating for machining in other than lathes

In machine tools like drilling machine, boring machine, milling machine, planing machine, broaching machine and surface grinding machine the job remains fixed on the bed or work table of those machine tools.

Fixtures are mostly used in the aforesaid machine tools and jig specially for drilling, reaming etc. for batch production.

For machining in those jigs and fixtures, the blank is located in several ways which include the followings:

Locating by flat surfaces

Fig. 8.1.8 typically shows locating jobs by their flat surfaces using various types of flat ended pins and buttons.

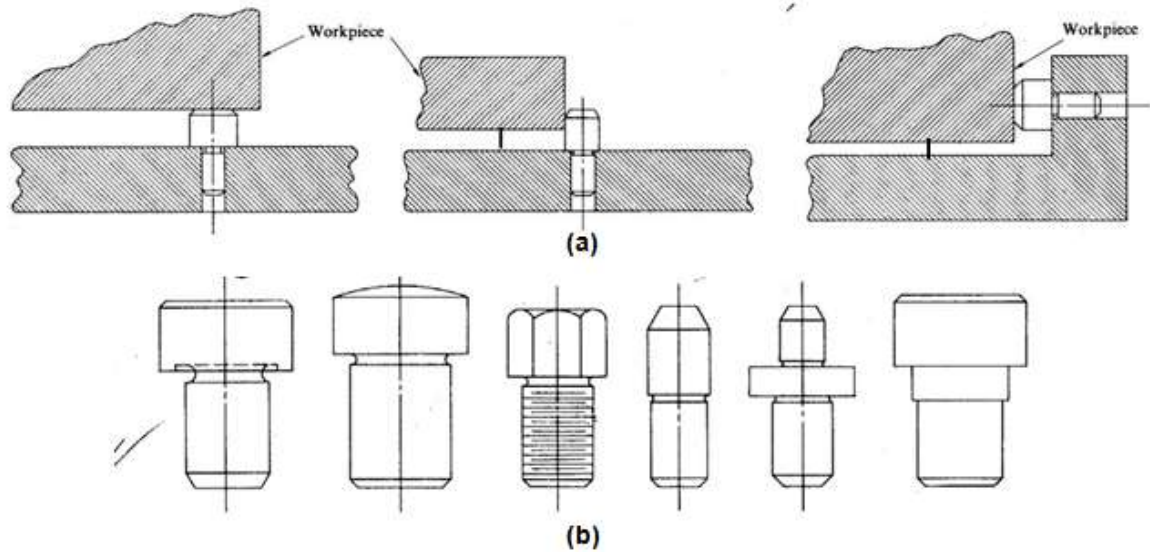


Fig. 8.1.8 Locating by (a) flat surfaces and (b) types of pins used for that.

Locating by holes

In several cases, workpieces are located by premachined (drilled, bored or pierced) holes, such as;

*Locating by two holes as shown in Fig. 8.1.9 (a) where one of the pins has to be diamond shaped to accommodate tolerance on the distance between the holes and their diameters

*Locating by one hole and an external pin which presents rotation of the blank around the inner pin as indicated in Fig. 8.1.9 (b) *Locating by one hole and one Vee-block as shown in Fig. 8.1.10

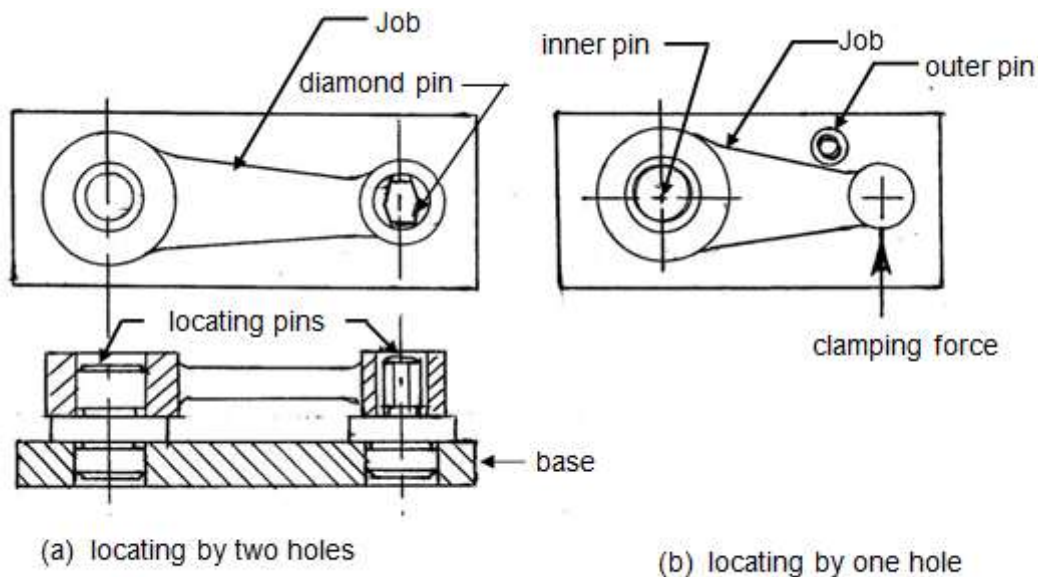


Fig. 8.1.9 Locating by holes.

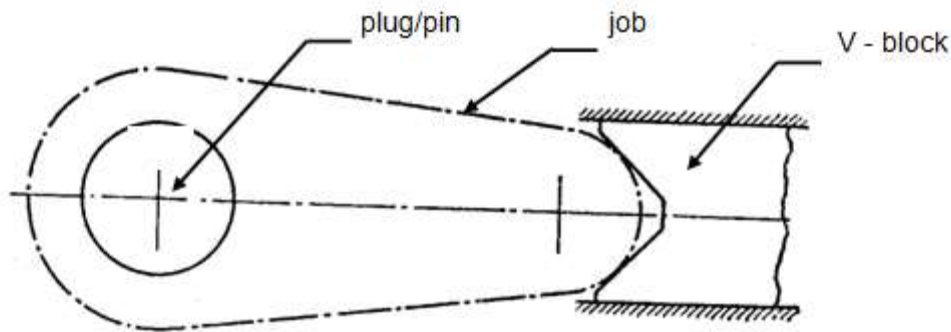


Fig. 8.1.10 Locating by a pin and Vee block.

Locating on mandrel or plug

Ring or disc type workpieces are conveniently located on mandrel or single plug as shown in Fig. 8.1.11.

However, there may be several other ways of locating depending upon the machining conditions and requirements.

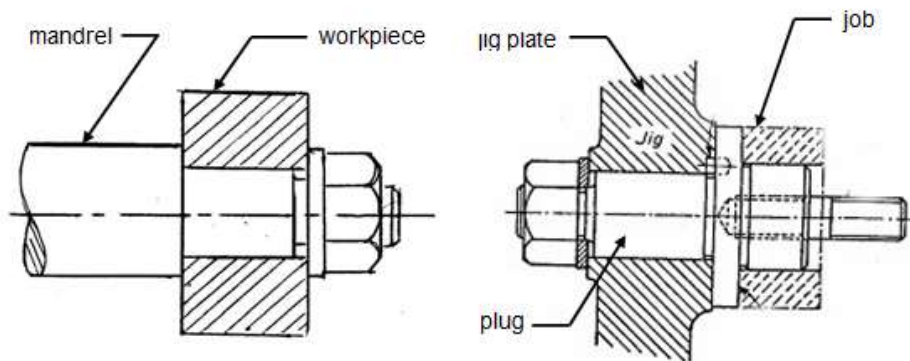


Fig. 8.1.11 Locating by mandrel or plug.

Supporting - principles and methods

A workpiece has to be properly placed in the jig or fixture not only for desired positioning and orientation but also on strong and rigid support such that the blank does not elastically deflect or deform under the actions of the clamping forces, cutting forces and even its own weight.

Basic principles or rules to be followed while designing or planning for supporting

- supporting should be provided at least at three points
- supporting elements and system have to be enough strong and rigid to prevent deformation due to clamping and cutting forces
- unsupported span should not be large to cause sagging as indicated in fig. 8.1.12
- supporting should keep the blank in stable condition under the forces as indicated in fig. 8.1.13
- For supporting large flat area proper recess is to be provided, as indicated in fig. 8.1.14, for better and stable support.
- Round or cylindrical work pieces should be supported (along with locating) on strong vee block of suitable size
- Heavy work pieces with pre-machined bottom surface should be supported on wide flat areas, otherwise on flat ended strong pins or plugs.

- If more than three pins are required for supporting large workpieces then the additional supporting pins are to be spring loaded or adjustable
- Additional adjustable supporting pins need to be provided
 - to compensate part size variation
 - when the supporting surface is large and irregular *when clamping and cutting forces are large
- ring or disc type jobs, specially requiring indexing should be supported (and located) in mandrel

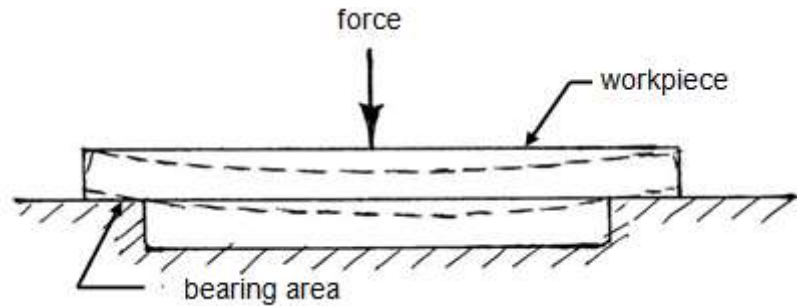


Fig. 8.1.12 Deflection due to force(s) for wide gap in between supports

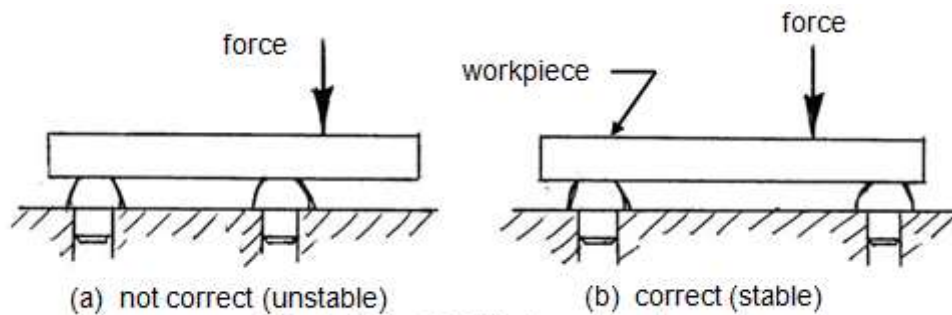


Fig. 8.1.13 Stability in supporting.

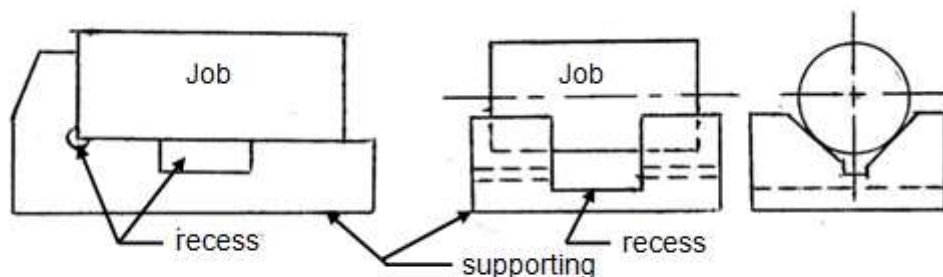


Fig. 8.1.14 Recess in long span supporting.

Common methods of supporting job in fixtures

- supporting on vices
- supporting on flat surfaces / blocks (fig. 8.1.15 (a))
- supporting by fixed pins (fig. 8.1.15 (b))
- additional supporting by adjustable pins and plugs or jack screws as shown in fig. 8.1.16
- supporting (and locating) on vee blocks and mandrels (fig.8.1.11)

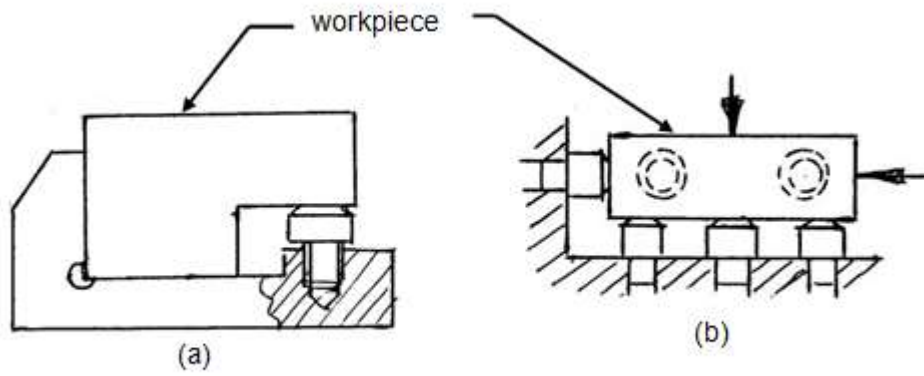


Fig. 8.1.15 Supporting (a) by flat surface and (b) by pins

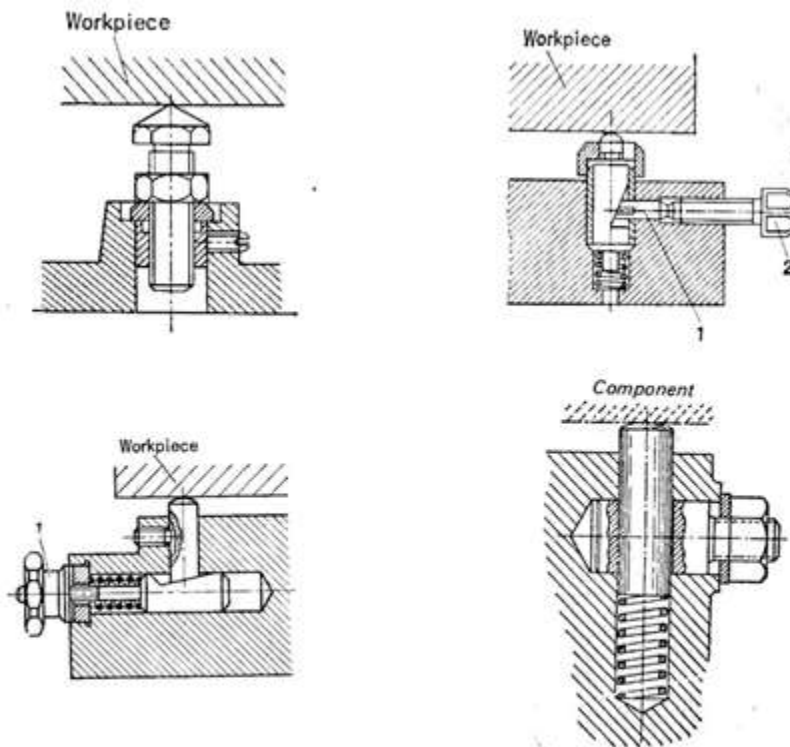


Fig. 8.1.16 Adjustable supporting pins.

17.19. CLAMPING

In most cases, it is not possible to restrain a workpiece completely by means of locating elements alone in jigs and fixtures. As such, clamping becomes an essential feature of almost all types of jigs and fixtures. (A clamping device holds the workpiece securely in a jig or fixture against the cutting forces. It has a direct bearing on the operating time of a jig or fixture and should, therefore, be carefully designed and incorporated in the latter. For efficient operation, firm clamping of the workpiece is a must. Inadequate clamping may always prove dangerous.)

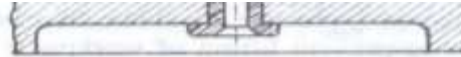


Fig. 17.21. Bush location.

17.20. BASIC REQUIREMENTS OF CLAMPING DEVICES

Irrespective of whether it is simple or complicated, a good clamping device must meet the following basic requirements :

1. It should be able to rigidly hold the workpiece in a jig or fixture against all the forces acting on the latter.
2. It should not damage the workpiece it holds.
3. It should force the workpiece to remain in firm contact with the locating pins or surfaces.
4. It should exert just sufficient pressure on the workpiece.
5. It should neither distort nor become loose under heavy pressures or vibrations.
6. Its operation time, i.e., releasing and reclamping, should be minimum.

17.21. IMPORTANT CONSIDERATIONS IN CLAMP DESIGN

There are some basic principles involved in designing the clamping devices for jigs and fixtures, so that these devices operate efficiently, meet the desired operational requirements and serve the desired purpose effectively. For this, the following factors need to be considered while designing a clamping device :

1. It should be simple, quick operating and fool-proof.
2. It should be able to exert the required clamping pressure on the workpiece upon being operated by a small force only.

3. However, the clamping pressure should be kept just enough to hold the work against the external forces. Too high clamping pressure will spoil the work.
4. The clamping pressure on the workpiece should be so directed that it will counteract the cutting forces.
5. As far as possible, endeavour should be made to direct the clamping pressure along the direction of cutting.
6. Both, the clamping pressure and the cutting forces, should be directed towards the locating surfaces or pins to prevent bending and distortion of the workpiece.
7. The clamping pressure should be directed towards the support surfaces and/or points to prevent lifting of workpiece from its support.
8. The clamp should be of robust construction so that it will not bend under pressure.
9. The clamp movement, while releasing and clamping should be limited and positively guided to make it quick acting and accurate.
10. The clamping faces should always be arranged directly above the work supports to avoid distortion of work.
11. As far as possible, a suitable device like spring should always be incorporated to avoid lifting of the clamp by hand.
12. Also, the design should facilitate complete separation of the clamp from over the work to enable unrestricted and quick unloading and loading.
13. A suitable heat treatment, like case hardening, should always be prescribed for the clamp to prevent the clamping faces from wearing out.
14. When soft and fragile workpieces are to be handled, the clamping faces should be provided with fibre pads to prevent damage to the work.
15. The position of the clamp should be so arranged on the workpiece that several different operations can be performed on the workpiece without disturbing the setting of the clamp.

Clamping of workpiece in fixtures

In jigs and fixtures the workpiece or blank has to be strongly and rigidly clamped against the supporting surfaces and also the locating features so that the blank does not get displaced at all under the cutting forces during machining.

- While designing for clamping the following factors essentially need to be considered :
- clamping need to be strong and rigid enough to hold the blank firmly during machining
- clamping should be easy, quick and consistently adequate
- clamping should be such that it is not affected by vibration, chatter or heavy pressure
- the way of clamping and unclamping should not hinder loading and unloading the blank in the jig or fixture
- the clamp and clamping force must not damage or deform the workpiece
- clamping operation should be very simple and quick acting when the jig or fixture is to be used more frequently and for large volume of work
- clamps, which move by slide or slip or tend to do so during applying clamping forces, should be avoided
- clamping system should comprise of less number of parts for ease of design, operation and maintenance
- the wearing parts should be hard or hardened and also be easily replaceable
- clamping force should act on heavy part(s) and against supporting and locating surfaces

- clamping force should be away from the machining thrust forces clamping method should be fool proof and safe
- clamping must be reliable but also inexpensive

Various methods of clamping

Clamping method and system are basically of two categories:

- (a) General type without much consideration on speed of clamping operations
- (b) Quick acting types

(a) General clamping methods of common use :

•Screw operated strap clamps as typically shown in Fig. 8.1.17. The clamping end of the strap is pressed against a spring which enables quick unclamping

•Clamping by swing plates

Such clamping, typically shown in Fig. 8.1.19, are simple and relatively quick in operation but is suitable for jobs of relatively smaller size, simpler shape and requiring lesser clamping forces

•Other conventional clamping methods include:

- Vices like drilling and milling vices
- Magnetic chucks
- Chucks and collets for lathe work

Cam clamping

Quick clamping by cam is very effective and very simple in operation. Some popular methods and systems of clamping by cam are shown in Fig. 8.1.21

The cam and screw type clamping system is used for clamping through some interior parts where other simple system will not have access

•Quick multiple clamping by pivoted clamps in series and parallel. This method shown in Fig. 8.1.22 is capable to simultaneously clamp number of rods even with slight diameter variation

•Quick clamping by hydraulic and pneumatic force for strong and light clamping respectively

(b) Drill - jig bushing

Slender and cantilever type cutting tools, mainly drills, usually suffer from run - out due to possible errors in the drill, sockets and drilling machine spindle and finally in the overall alignment. Such run out causes over sizing, out of roundness and surface roughening of the drilled holes. Such run out aggravates further with the increase in drill speed (rpm) and the thrust force, especially if the drill is not geometrically symmetrical. This often leads to, in addition to poor product quality, breakage of the drill by bending and / or buckling. To reduce such problems, bushes are used in the jigs to guide the drill bits

The factors to be considered while designing for jig - bushing, are:

- The bushes, used to guide and properly locate drills, reamers etc. are generally made of carbon or alloy steel and made wear resistive by hardening to RC 60 and above. Often bushes are also made from grey cast iron for antifricition and protection of the tools.
- The hardened jig bushes are finished outside by grinding and inside by grinding and lapping if high precision is insisted.
- The bush's length should be sufficient ($\geq$ twice drill diameter) and its diameter should be slightly larger than the drill diameter
- Design and construction should enable easy and quick proper fitting and removal or replacement of the bushes

- Bushes should not come out from its seat along with the drill during its return.

Types of jig bushes

Depending upon nature of fitting, quick mounting and replacement, job requirement etc. jig bushes are classified into several types.

- Bushes may be
 - Press fitted type – Slip type
 - Screwed type

Press fitted thin sleeve type bushes are generally used for shorter runs and are not renewable. Renewable type slip bushes are used with liner. But screw bushes, though renewable may be used without or with liner.

- Bushes may be
 - Without head
 - With head
 - With a flange being screwed on the bracket

6.5 Typical examples of jigs and fixtures

Example - 1 In a pre-machined hollow metallic disc six equispaced blind holes have to be drilled radially as indicated in Fig. 8.2.4.

Design the configuration and working method of the fixture or jig for such drilling work in a batch production.

Design - The proposed design is schematically shown in Fig. 8.2.4

- Since the machining requirement is drilling where the tool will essentially need guidance, a jig has to be designed
- Since it is required to produce equi-angular spaced holes by drilling an indexing system has to be considered
- The indexing work can be accomplished by indexing the jig, holding the job clamped inside, manually by bringing the desired hole axis aligned with the fixed drill axis by manual adjustment. Six bushes are fitted equispaced in the jig. The design of the jig is schematically shown in Fig. 8.2.4. The same work could be done by indexing the workpiece only within the fixed jig having only one bush (example 2).

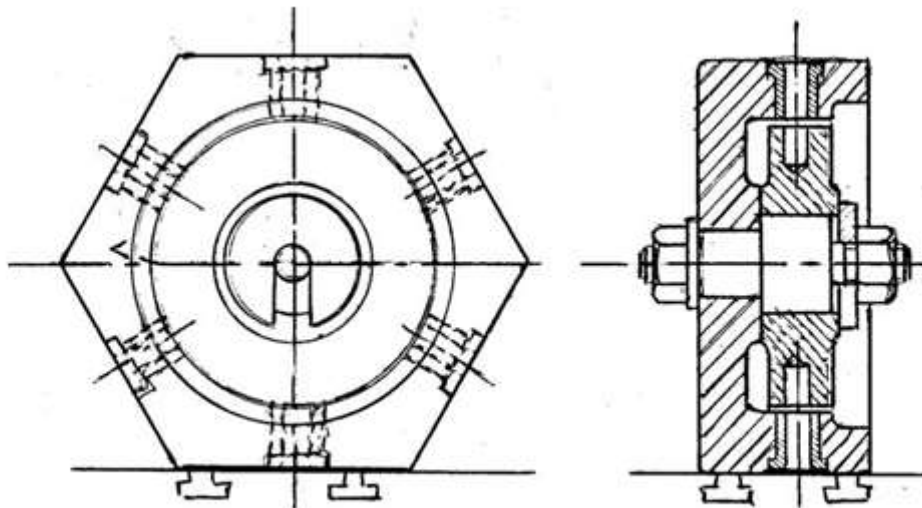


Fig. 8.2.4 Jig for drilling six equispaced radial blind holes in a disc.

Example - 2 Four equispaced through holes have to be drilled radially in a disc, (like rotor of radial piston pump) as shown in Fig. 8.2.5 (a). A jig is to be designed for batch production of such discs.

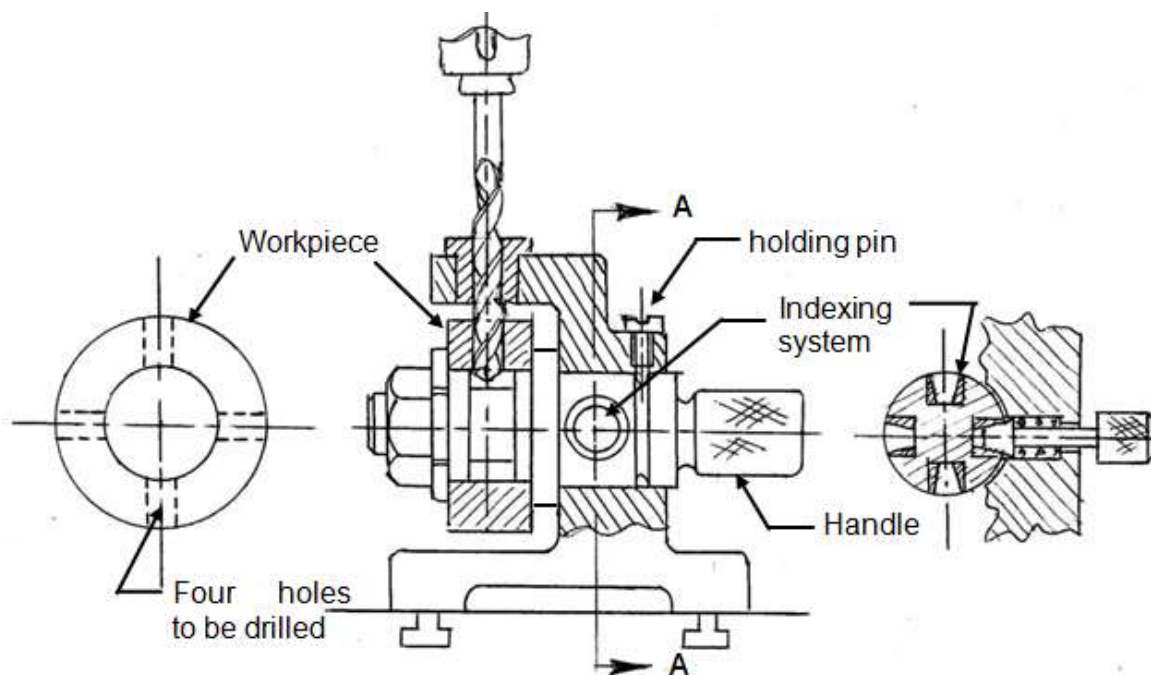


Fig. 8.2.5 Jig for drilling four equispaced through radial holes in a ring.

Design: The proposed design is schematically shown in Fig. 8.2.5

- Drilling four equispaced through radial holes will need indexing in the jig to be designed.
- The jig possesses a rotatable mandrill on which the pre-machined blank (hollow disc) will be mounted as shown
- The axial location of the blank with respect to the axis of the desired hole i.e. drill is provided by the step in the mandrill
- The blank gets desirably strong support from the mandrill both radially and axially
- Only one bush is mounted coaxially with the drill for necessary tool guidance

- The blank will be strongly and rigidly clamped by the front nut. A quick acting nut could also be used.
 - A suitable indexing system has been incorporated which will enable 90° - rotation of the blank, within the fixed jig, by unlocking the indexing pin and rotating the mandrill with the help of the handle shown. The small fixed (screwed) pin will prevent any axial shift of the mandrill during its rotation under unlocked condition. This jig will remain clamped on the drilling machine bed (table) with the axis of the bush aligned with that of the drill i.e., spindle

Example - 3A through rectangular section slot has to be cut on a rod as shown in Fig. 8.2.6 (a). A fixture or jig is to be designed for cutting the slot in batch production

Design: The proposed design is schematically shown in Fig. 8.2.6 (b)

- It will be a fixture, not jig, since there is no need of making holes
- A slot milling cutter of width equal to the width of the slot desired has to be used as shown
- Since the blank is a cylindrical piece, V - block type system has been used for locating and supporting
- The axial location (and supporting) will be accomplished by the axial pin and the contact will be assured by the swing type spring loaded pusher as shown.
- Clamping will be done quickly by the cam pressing the strap as shown
- The fixture holding the workpiece will be properly fixed on the table of the milling machine and will move along that table
- After completion of the work, i.e. cutting of the slot, the fixture will be removed. A spring loaded ejector (cum locator) can also be used as shown in the Fig. 8.2.6 (b)

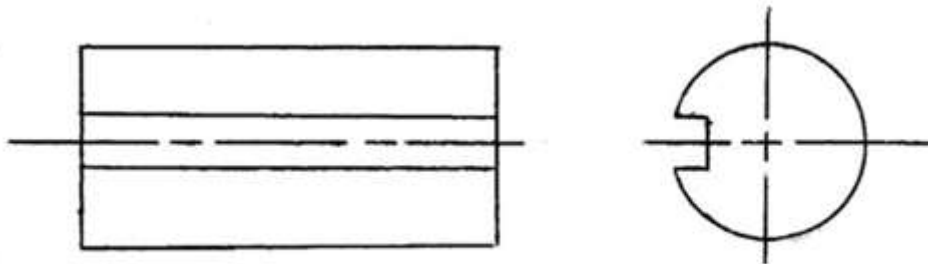


Fig. 8.2.6 (a) A through slot to be produced on a rod

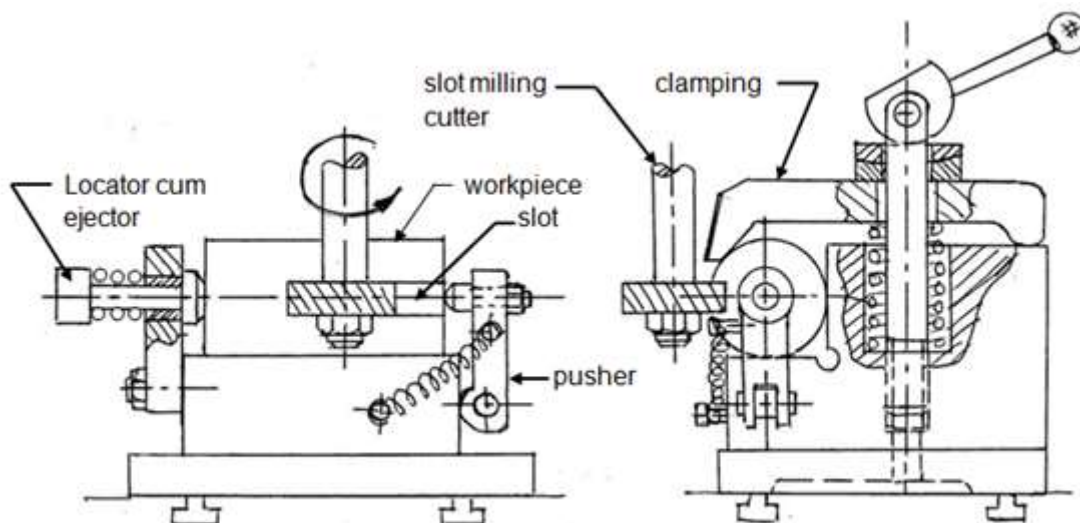


Fig. 8.2.6 (b) Fixture for milling the slots on the rod.

It is to be noted; jigs and fixtures are not standard items and are as such not available in the market. It has to be designed and built as and when required based on the exact requirements.

6.6 CNC MACHINE TOOLS

6.7 CNC Machines

Some of the dominant advantages of the CNC machines are:

- CNC machines can be used continuously and only need to be switched off for occasional maintenance.
- These machines require less skilled people to operate unlike manual lathes / milling machines etc.
- CNC machines can be updated by improving the software used to drive the machines.
- Training for the use of CNC machines can be done through the use of 'virtual software'.
- The manufacturing process can be simulated virtually and no need to make a prototype or a model. This saves time and money.
- Once programmed, these machines can be left and do not require any human intervention, except for work loading and unloading.
- These machines can manufacture several components to the required accuracy without any fatigue as in the case of manually operated machines.
- Savings in time that could be achieved with the CNC machines are quite significant.

Some of the disadvantages of the CNC machines are:

- CNC machines are generally more expensive than manually operated machines.
- The CNC machine operator only needs basic training and skills, enough to supervise several machines.
- Increase in electrical maintenance, high initial investment and high per hour operating costs than the traditional systems.
- Fewer workers are required to operate CNC machines compared to manually operated machines. Investment in CNC machines can lead to unemployment.

6.8 Working principle

6.9 Classification

6.10 Constructional features of CNC machines

6.11 CNC controller

6.12 Types of motion controls in CNC machines

6.13 Applications of NC/CNC machine tools

CNC was initially applied to metal working machinery: Mills, Drills, boring machines, punch presses etc and now expanded to robotics, grinders, welding machinery, EDM's, flame cutters and also for inspection equipment etc. The machines controlled by CNC can be classified into the following categories: CNC mills and machining centres.

- CNC lathes and turning centers
- CNC EDM
- CNC grinding machines
- CNC cutting machines (laser, plasma, electron, or flame)

- CNC fabrication machines (sheet metal punch press, bending machine, or press brake)
- CNC welding machines
- CNC coordinate measuring machines