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Global Engineering Solutions presents,

introduction to :

"JIGS & FIXTURES"

Purposes of jigs and fixtures and their Design principles :

✓ This lesson will enable the students

(i) Define Fixture and Jig that aid machining

(ii) Conceive the purposes of use of jigs and fixtures

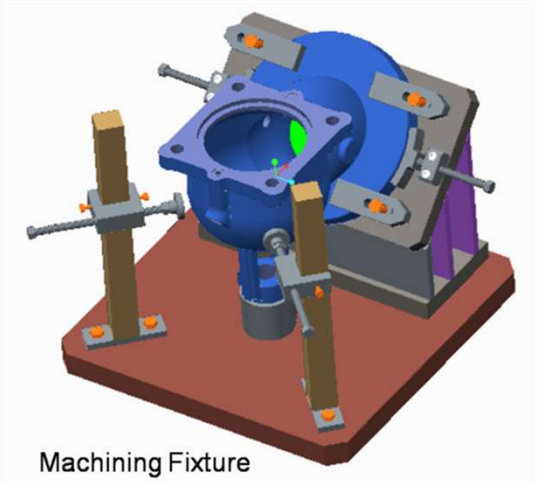
(iii) State the design considerations for jigs and fixtures

(iv) 3-2-1 Principle And Methods Of Locating, Supporting And Clamping Blanks And Tool Guidance In Jigs And Fixtures.

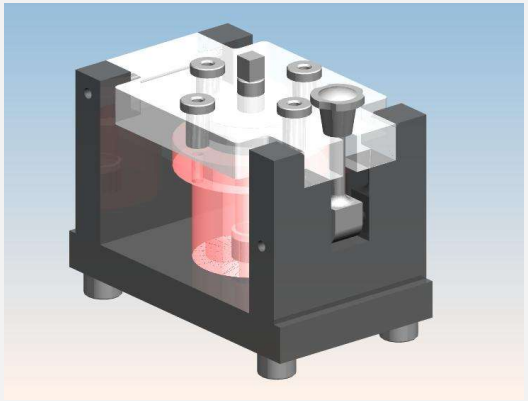
(i) Definition Of Fixture And Jig :

Fixtures, being used in machine shop, are strong and rigid mechanical devices which enable easy, quick and consistently accurate locating, supporting and clamping, blanks against cutting tool(s) and result faster and accurate machining with consistent quality, functional ability and interchangeability.

Jig is a fixture with an additional feature of tool guidance.



Machining Fixture



Drill Jig

(ii) Purpose Of Using Fixtures And Jigs

For a machining work, like drilling a through hole of given diameter eccentrically in a pre-machined mild steel disk as shown in Fig. 8.1.1 in a

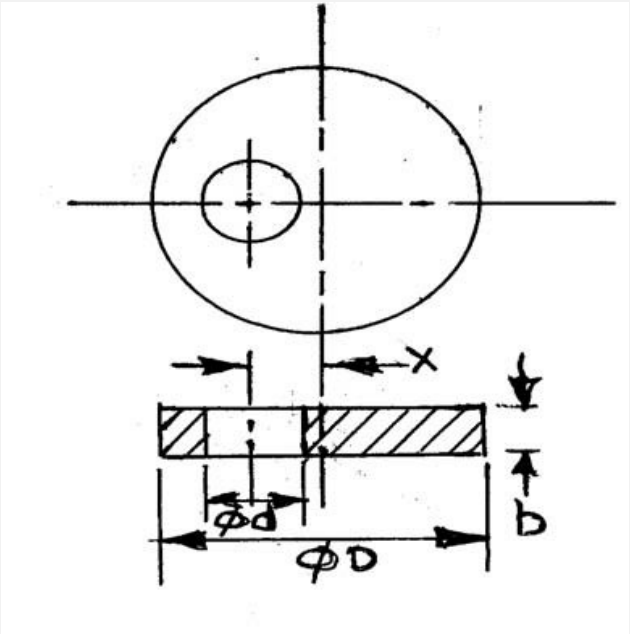


Fig. 8.1.1 A through hole has to be drilled in a pre-machined mild steel disc.

(ii) Purpose Of Using Fixtures And Jigs :

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Conventional drilling machine without using any fixture or jig, the following elementary steps are to be sequentially followed

- ✓ cleaning and de-burring the blank (disc)
- ✓ marking on the blank showing the location of the hole and its axis on the blank
- ✓ punch the centre at the desired location and prick punch the periphery of the hole to be made in the disc
- ✓ mount the blank in a drilling vice using parallel block, a small 'V' block etc. to provide support and clamp the blank firmly
- ✓ position the vice along with the marked blank to bring the hole axis in alignment with the drill axis by
  - Δ either adjusting the vise position w.r.t. the fixed drill axis
  - Δ or moving the drilling machine table and then locking the table position
  - Δ or moving the radial arm and the drilling head, if it is a radial drilling machine
- • after fixing the blank, vise and the table, alignment is checked again
- • if error, like eccentricity, is found to occur then readjustment of location of the hole – axis is to be done before and even after starting drilling
- • drilling is accomplished.

(ii) Purpose Of Using Fixtures And Jigs :

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•Therefore, it appears that so many operations are needed to be carried out carefully and skillfully by the machinist or operator for such a simple job.

• Even after that there may be inaccuracies in machining.

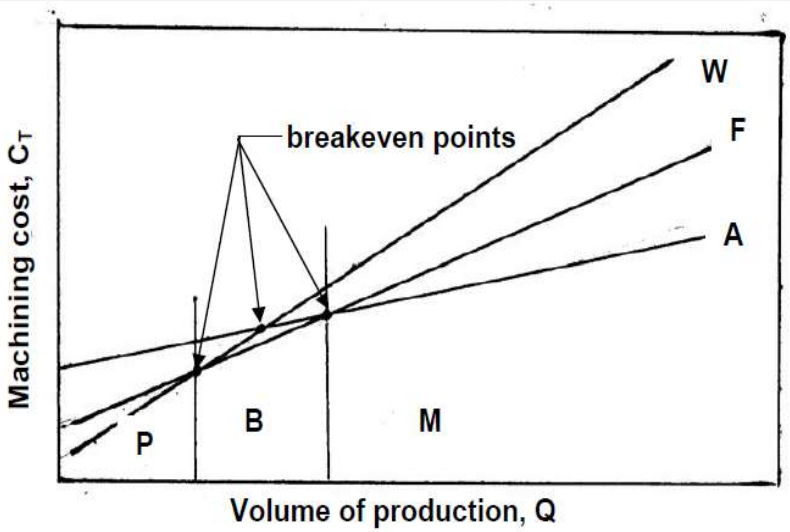
• Such tedious and time-consuming manual work are eliminated or drastically reduced in mass production by automatic or special purpose machine tools.

• But such machine tools are quite expensive and hence

• are economically justified for only huge or mass production and not viable for small lot or batch production.

•For batch production proper design and use of simple but effective jigs and fixtures are appropriate and economically justified.

•This is schematically illustrated in Fig. 8.1.2.



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*

(ii) Purpose Of Using Fixtures And Jigs :

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 increase in interchangeability.*

(iii) Design Considerations For Jigs And Fixtures :

Jigs and fixtures are manually or partially power operated devices.

To fulfill 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

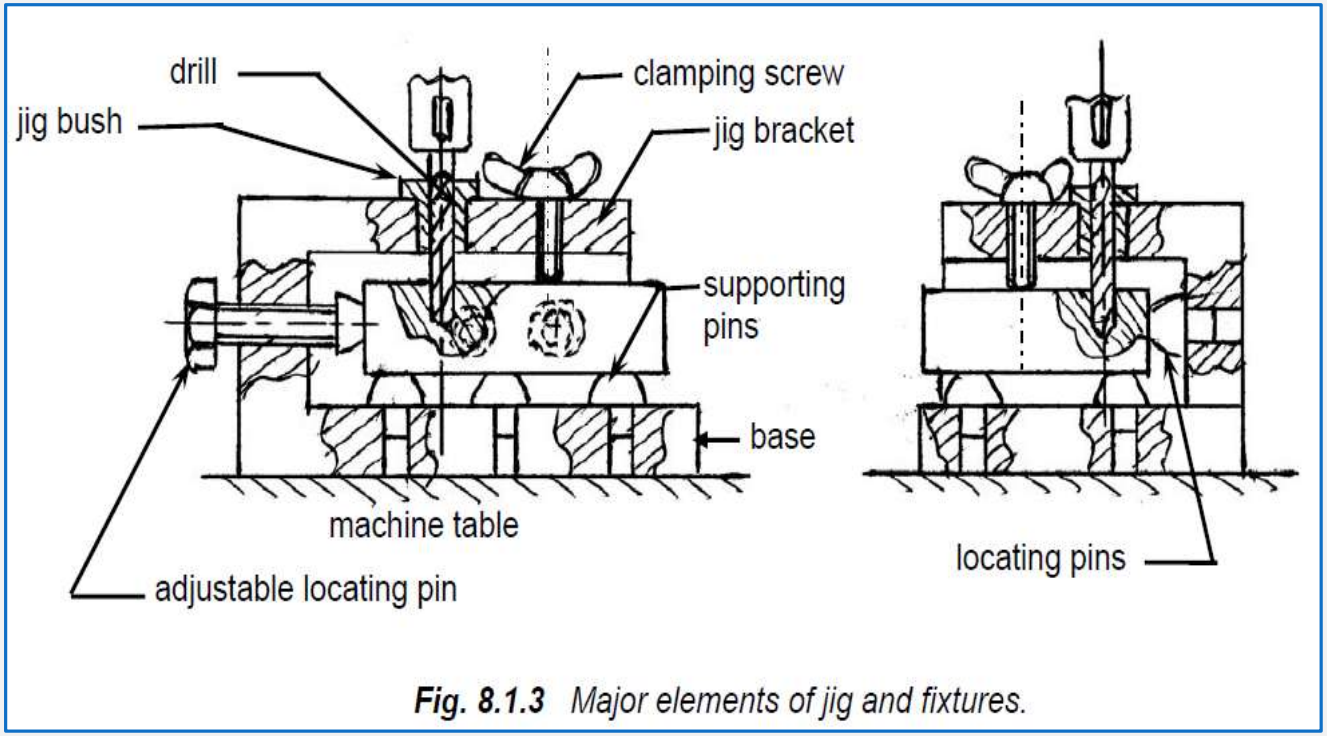


Fig. 8.1.3 *Major elements of jig and fixtures.*

(iii) Design Considerations For Jigs 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*

(iv) 3-2-1 Principle And Methods Of Locating, Supporting And Clamping Blanks And Tool Guidance In Jigs And Fixtures :

- **Locating, Supporting and Clamping of jobs in jigs and fixtures**

1) 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.

✓ 6 translational degrees of freedom : +x, -x, +y, -y, +z, -z

✓ 6 rotational degrees of freedom :
- Clockwise around x axis , y axis & z axis
- Anti-clockwise around x axis , y axis & z axis

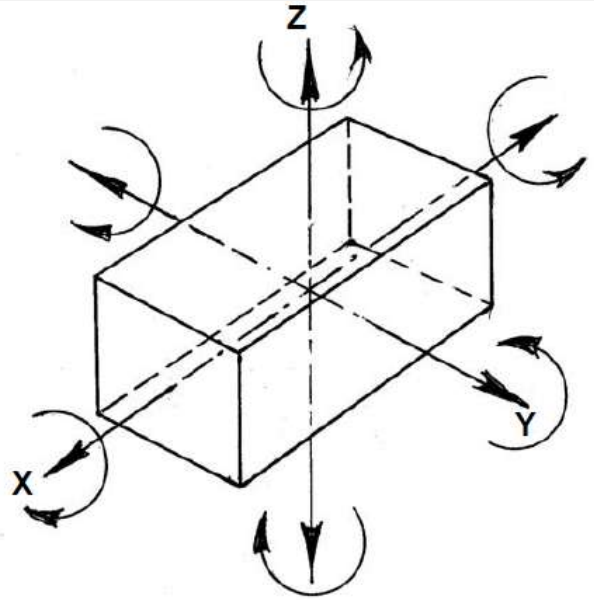


Fig. 8.1.4 *Possible degrees of freedom of a solid body.*

3-2-1 Principle And Methods Of Locating, Supporting And Clamping :

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.

3-2-1 Principle :

- *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.*

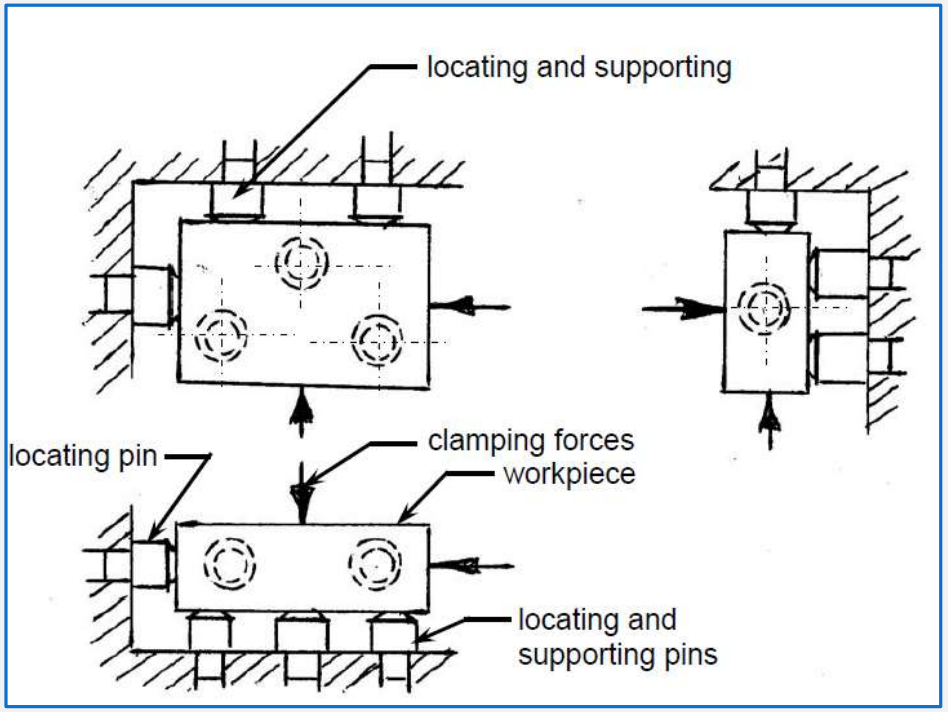


Fig. 8.1.5 Arresting all degrees of freedom of a blank in a fixture.

1) Locating – principles and methods:

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
- 'V' 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

1) Locating – principles and methods:

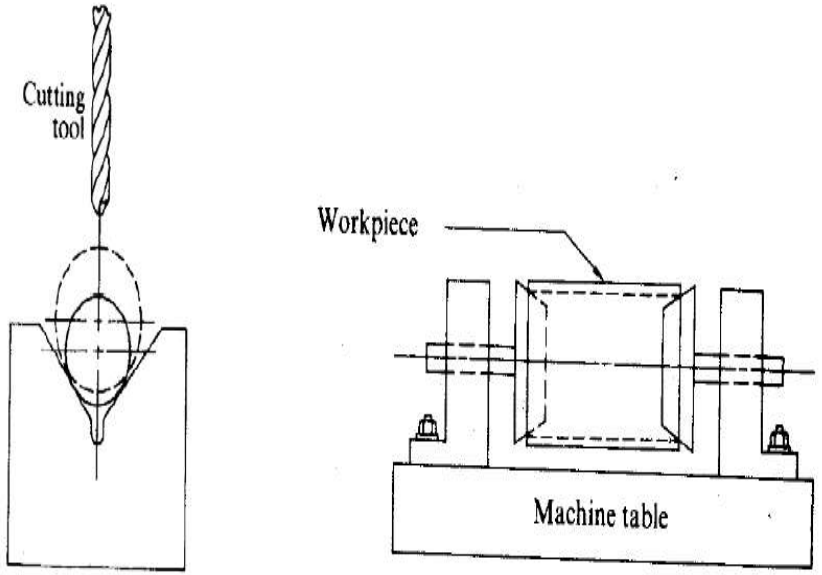


Fig. 8.1.6 Locating by Vee block and cone.

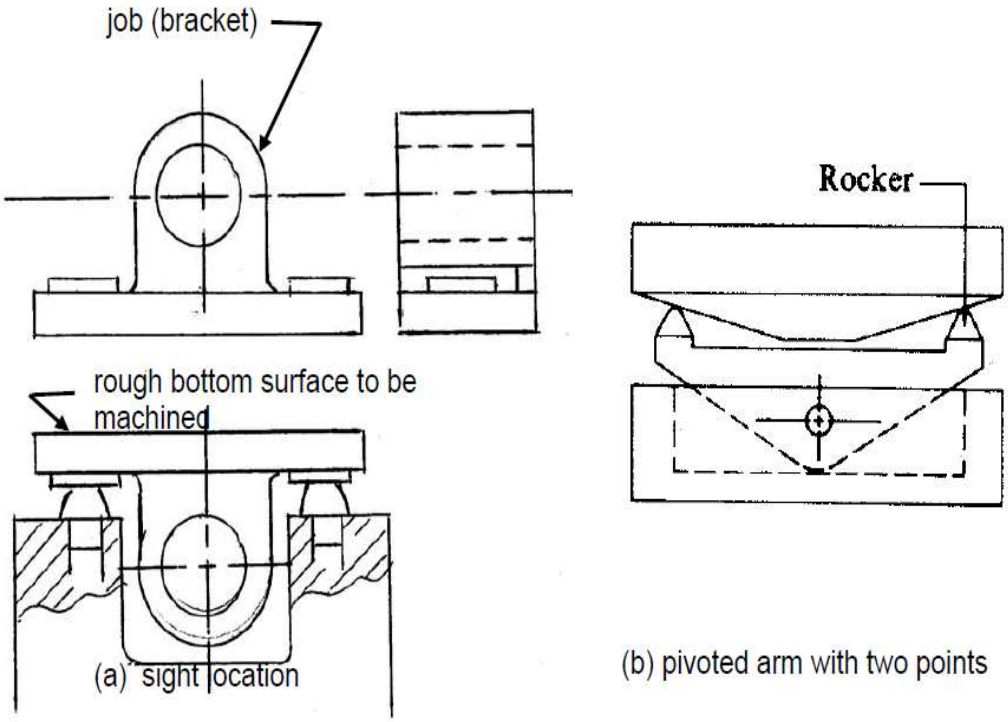


Fig. 8.1.7 (a) Sight location and (b) location by pivoted points (equalizer)

General methods of Locating:

- **Locating by flat surfaces**

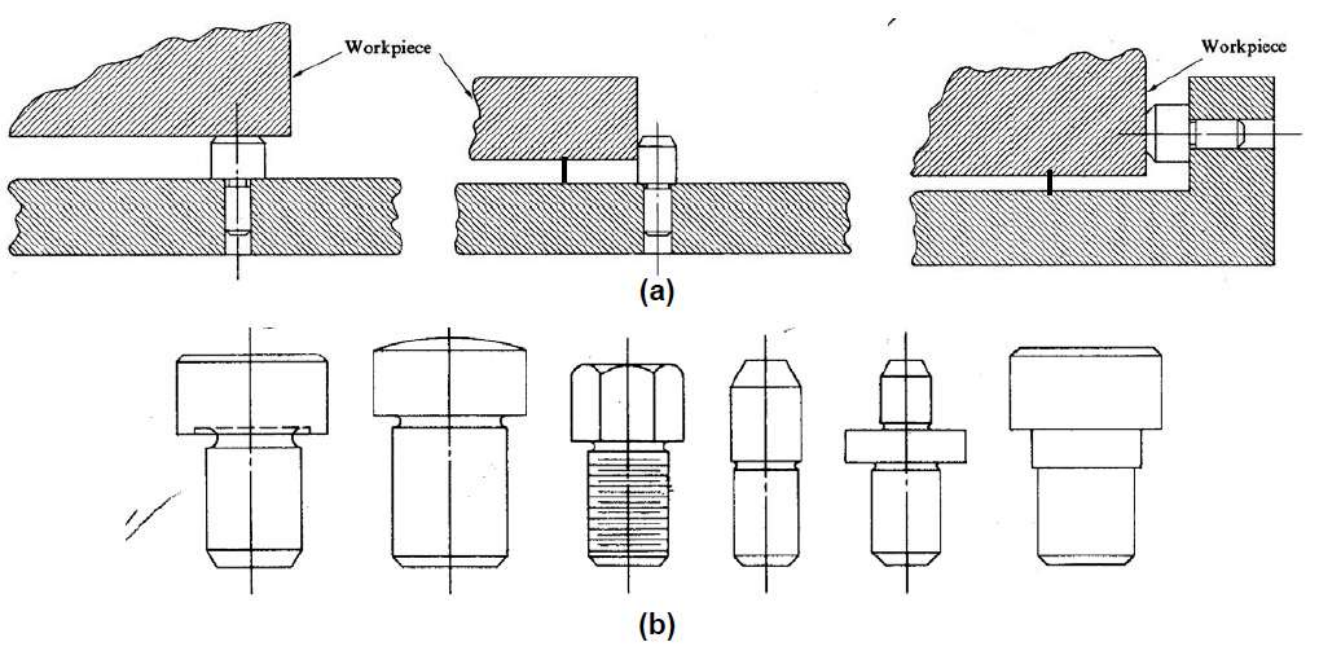


Fig. 8.1.8 *Locating by (a) flat surfaces and (b) types of pins used for that.*

General methods of Locating:

- **Locating by holes**

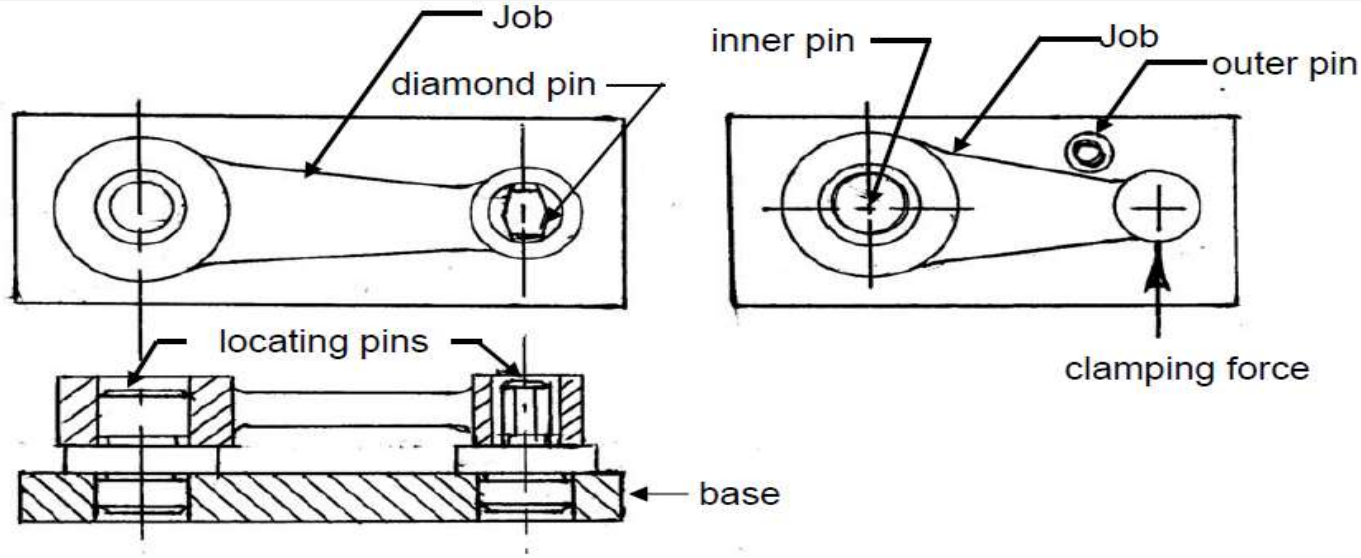


Fig. 8.1.9 *Locating by holes.*

General methods of Locating:

- **Locating by a Pin and Vee Block :**

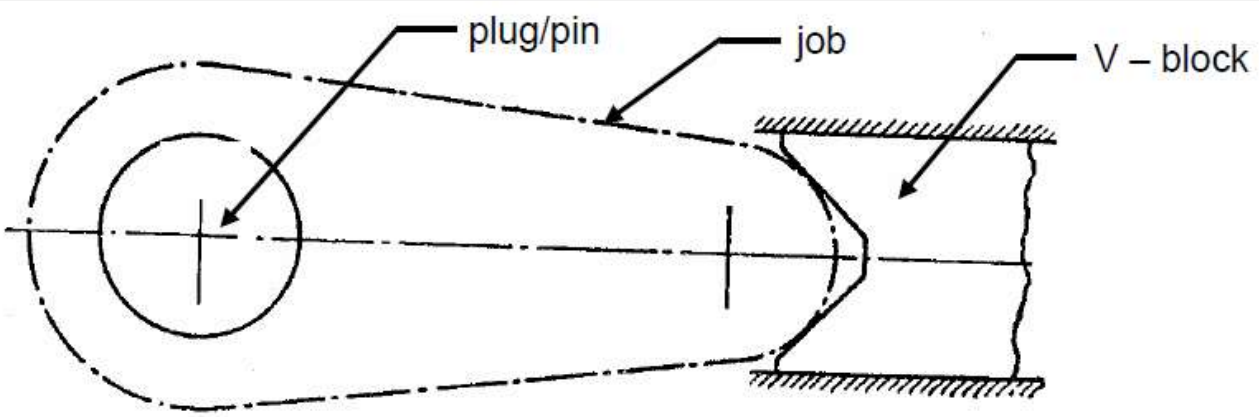


Fig. 8.1.10 *Locating by a pin and Vee block.*

General methods of Locating:

•**Locating on mandrel or plug :**

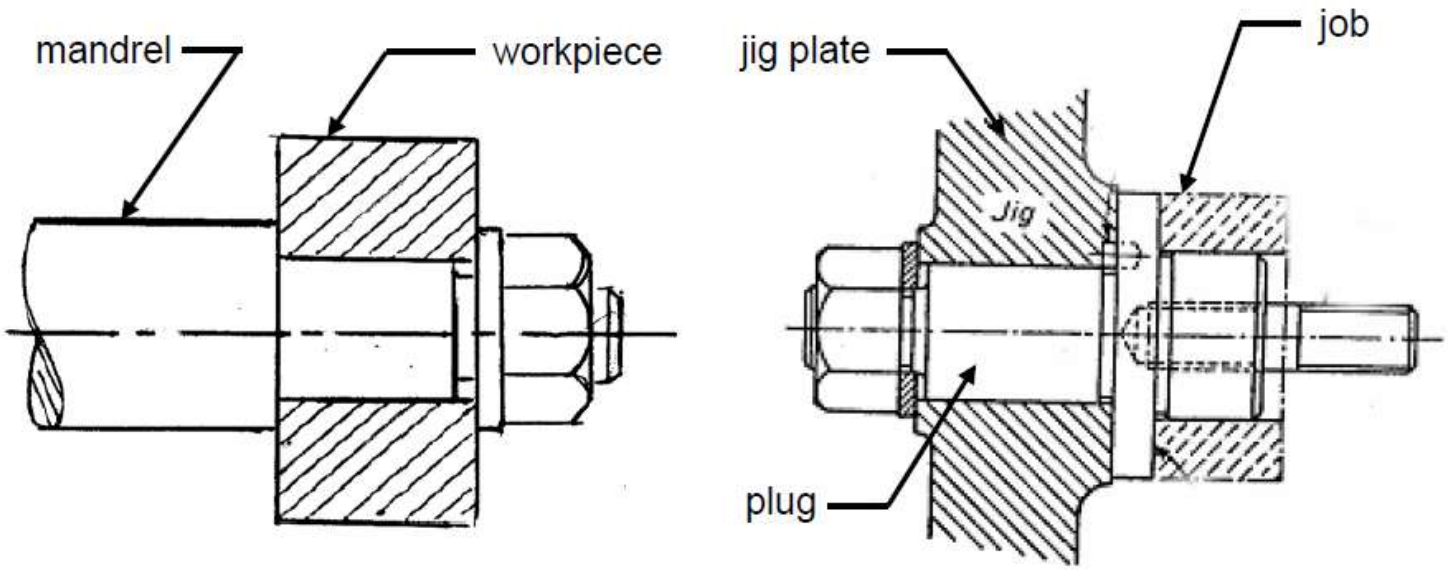


Fig. 8.1.11 *Locating by mandrel or plug.*

2) Supporting – principles and methods

• **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 workpieces should be supported (along with locating) on strong vee block of suitable size

✓ heavy workpieces 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, especially requiring indexing should be supported (and located) in mandrel

2) Supporting – principles and methods

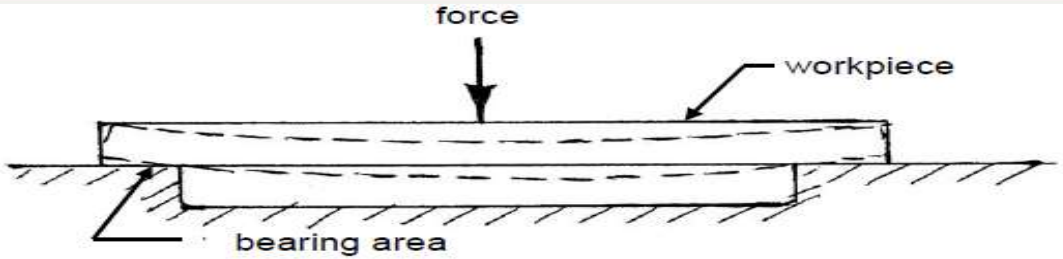


Fig. 8.1.12 Deflection due to force(s) for wide gap in between supports.

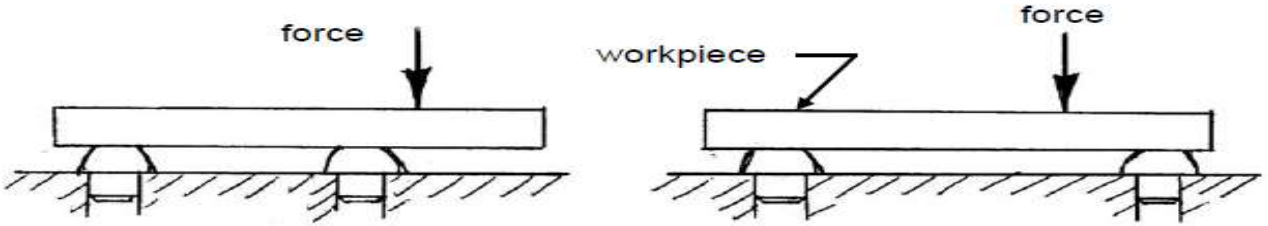


Fig. 8.1.13 Stability in supporting.

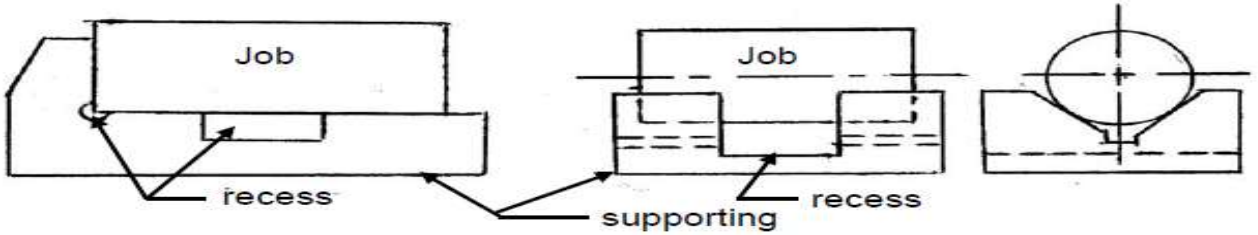


Fig. 8.1.14 Recess in long span supporting.

Common methods of supporting job in fixtures

Some Common methods of supporting job in fixtures are as below:

- ✓ 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)

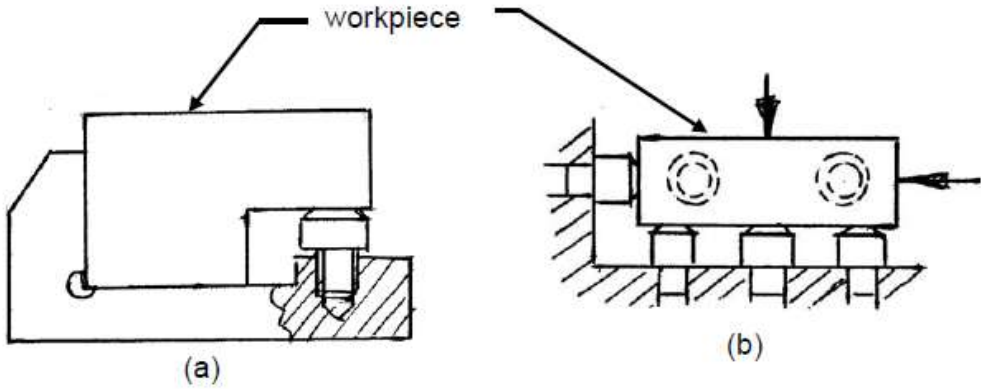


Fig. 8.1.15 *Supporting (a) by flat surface and (b) by pins*

Common methods of supporting job in fixtures

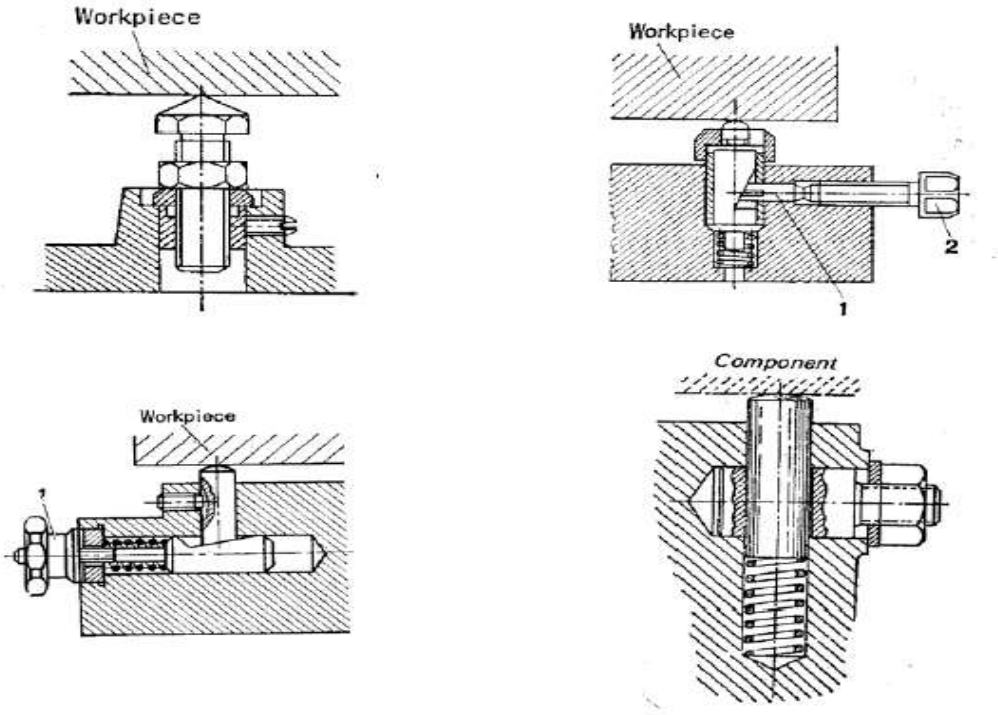


Fig. 8.1.16 Adjustable supporting pins.

3) Clamping of workpiece in fixtures:

- **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 :

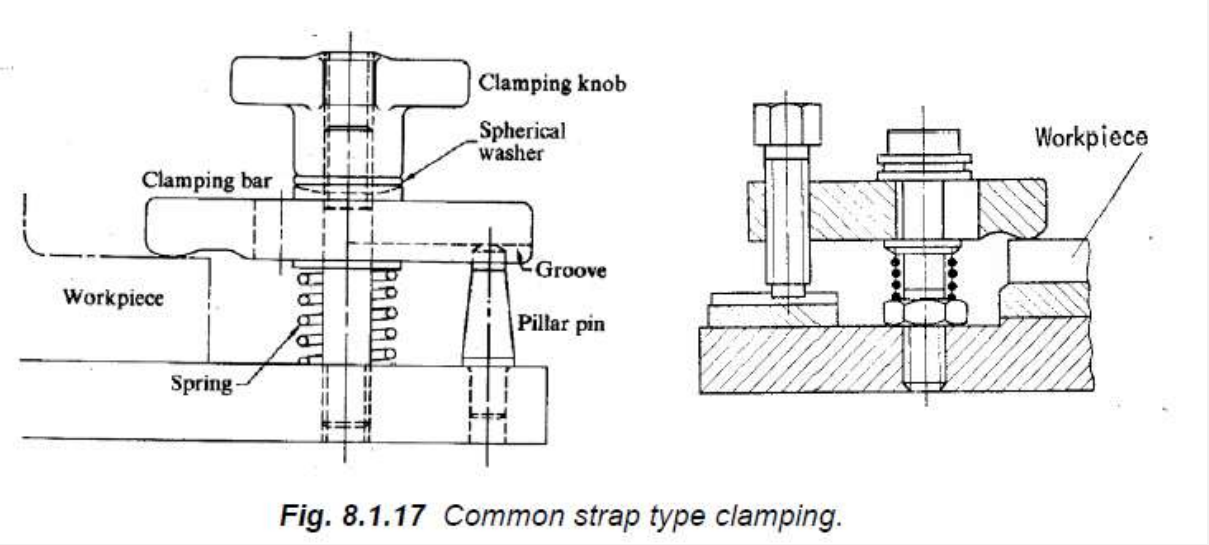


Fig. 8.1.17 Common strap type clamping.

Various methods of clamping :

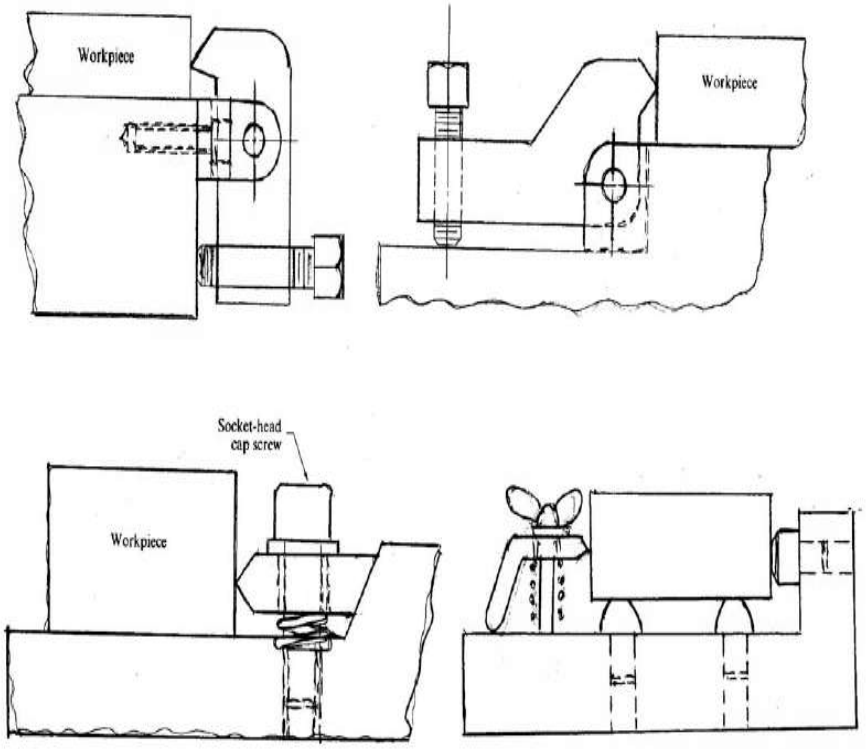


Fig. 8.1.18 Clamping from side for free machining of the top surface.

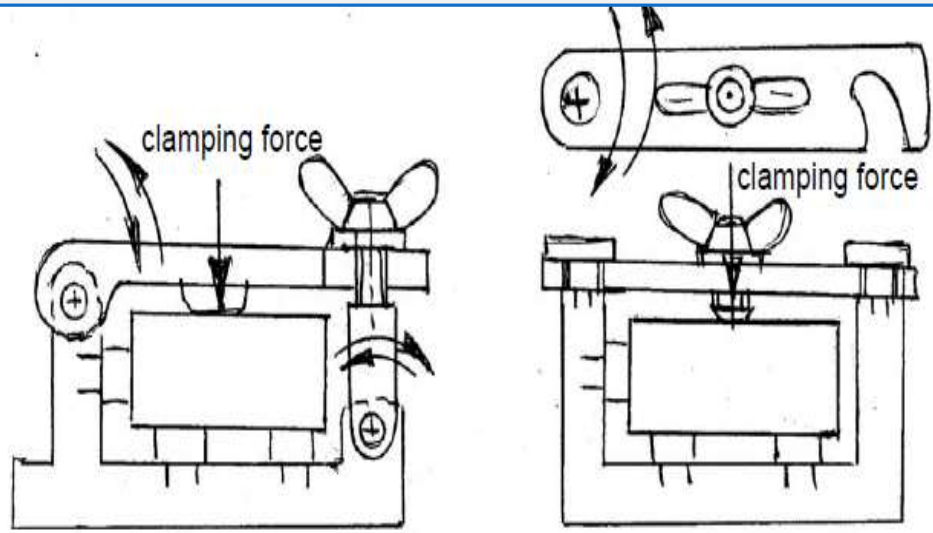


Fig. 8.1.19 Clamping by swing plates.

Various methods of clamping :

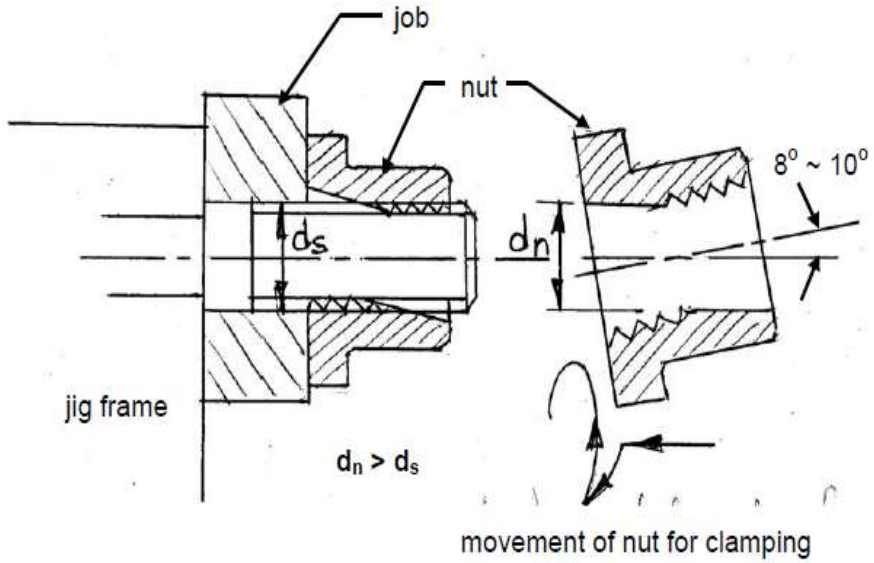
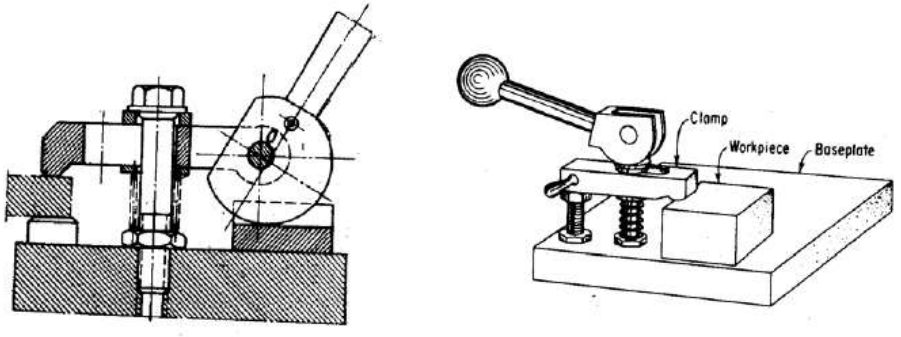
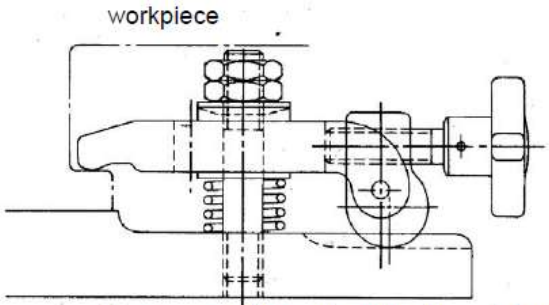


Fig. 8.1.20 Quick acting nut for rapid clamping.



(a) clamping by cam



(b) screw and cam clamping from distance

Fig. 8.1.21 Quick clamping by cams.

Various methods of clamping :

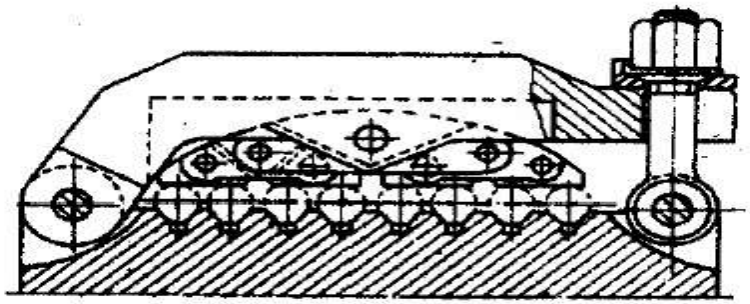


Fig. 8.1.22 *Quick multiple locating and clamping of cylindrical jobs.*

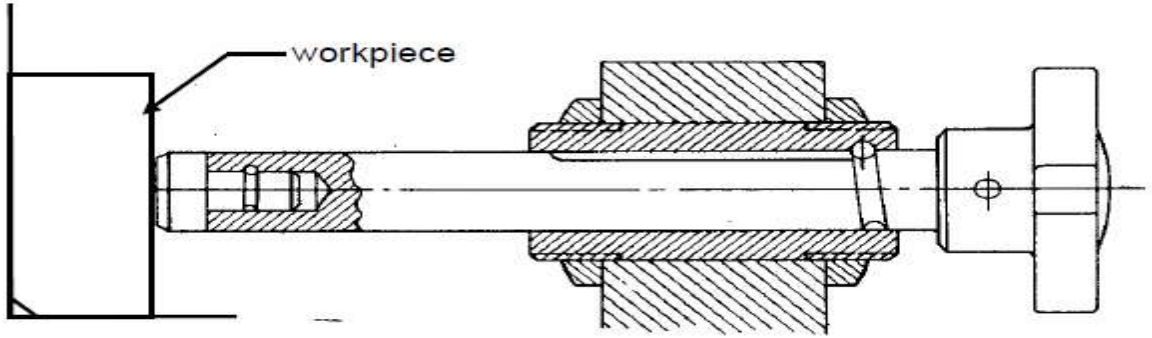


Fig. 8.1.23 *Quick acting screw (bayonet type) clamping.*

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