Introduction to JIGS AND FIXTURES

Introduction

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.

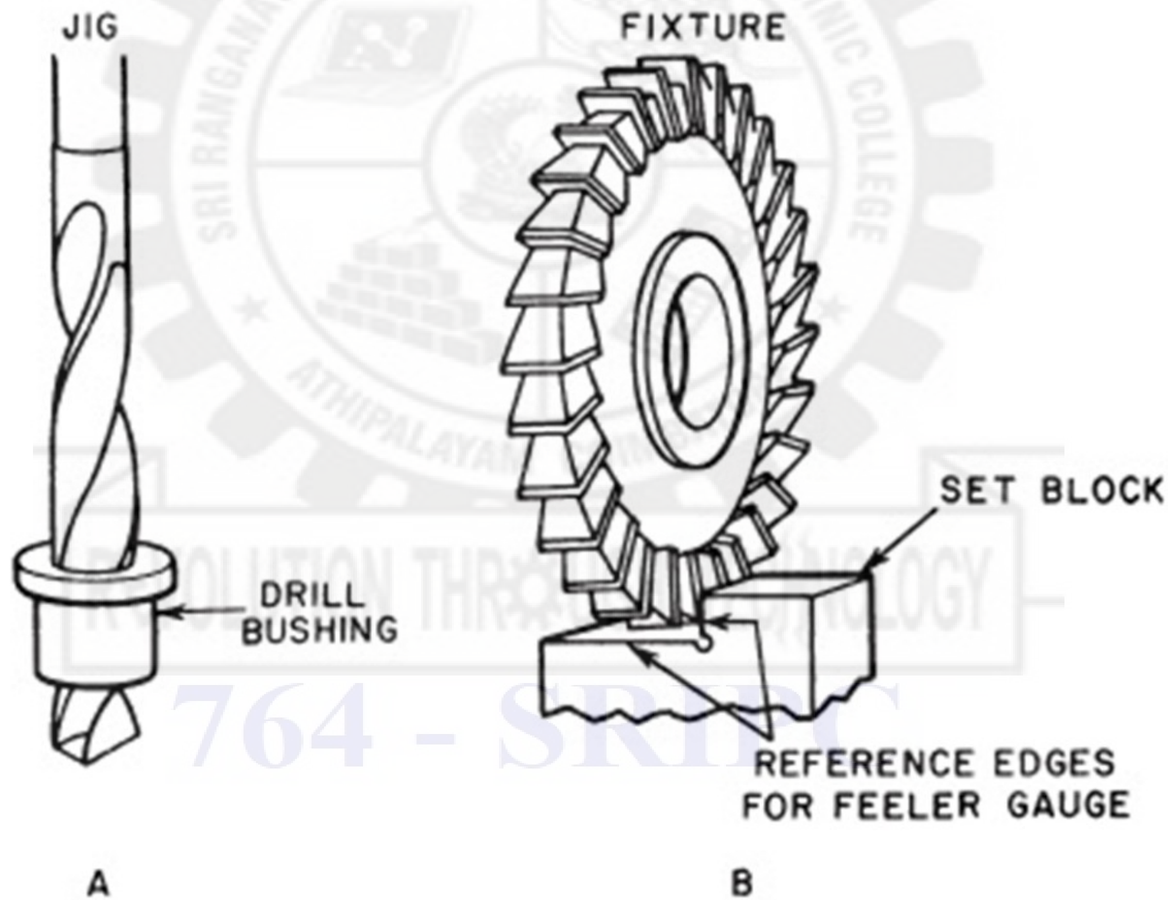


Figure 2–1 Referencing the tool to the work.

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

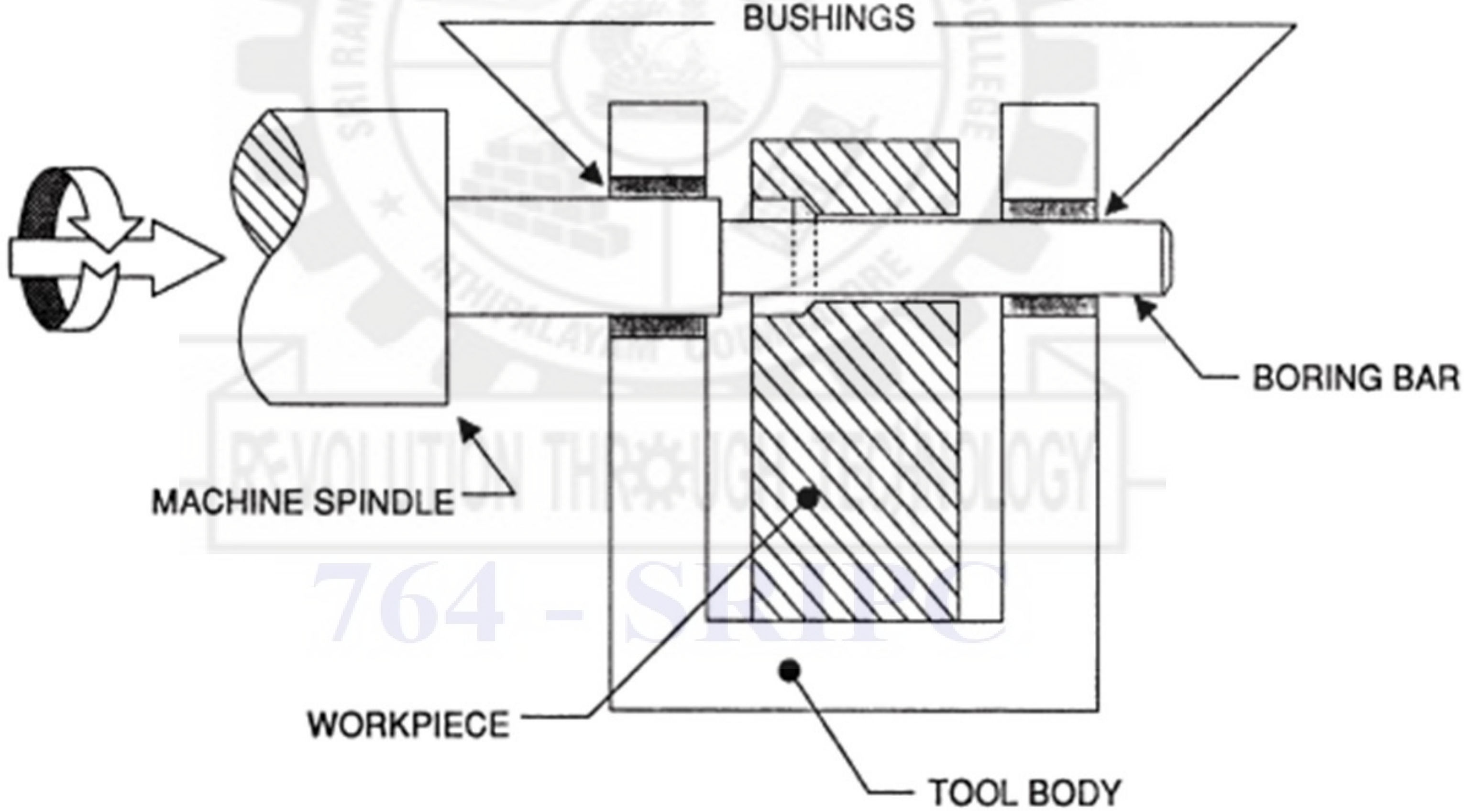


Figure 2–2 Boring jig.

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

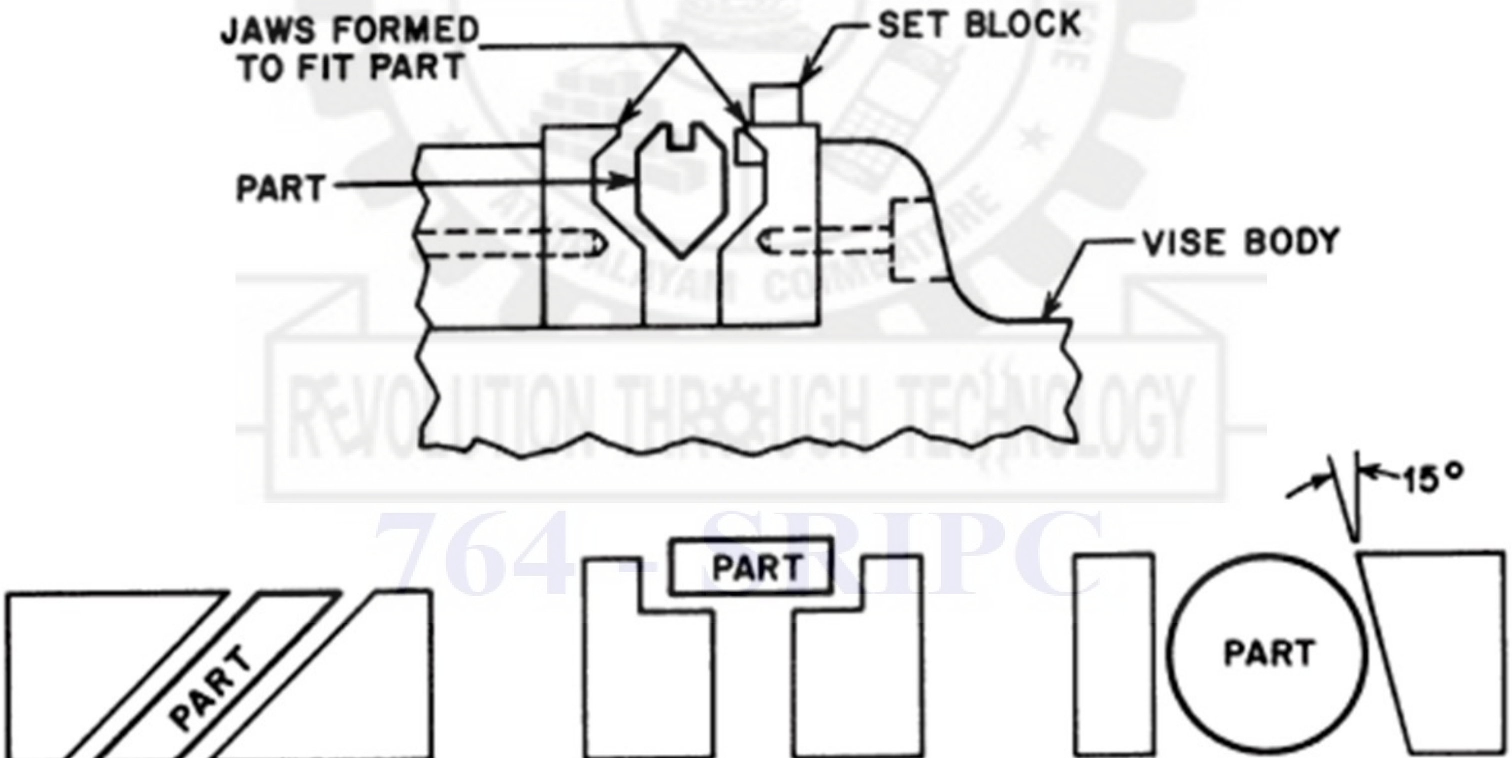


Figure 2–20 Vise-jaw fixture.

How do jigs and fixtures differ

JIGS	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.

JIGS	FIXTURES
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 increases 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 makes 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, Diesteel, 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 swarfs 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.

5. Non shrinking tool steels:

High carbon or high chromium

Very little distortion during heat treatment.

Used widely for fine, intricate press tools.

6. Nickel chrome steels: Used for gears.

7. High tensile steels: Used for fasteners like high tensile screws

8. Mild steel:

Used in most part of Jigs and Fixtures

Cheapest material

Contains less than 0.3% carbon

9. 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

10. Nylon and Fiber: Used for soft lining for clamps to damage to workpiece due to clamping pressure

11. 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 operation.
- 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.

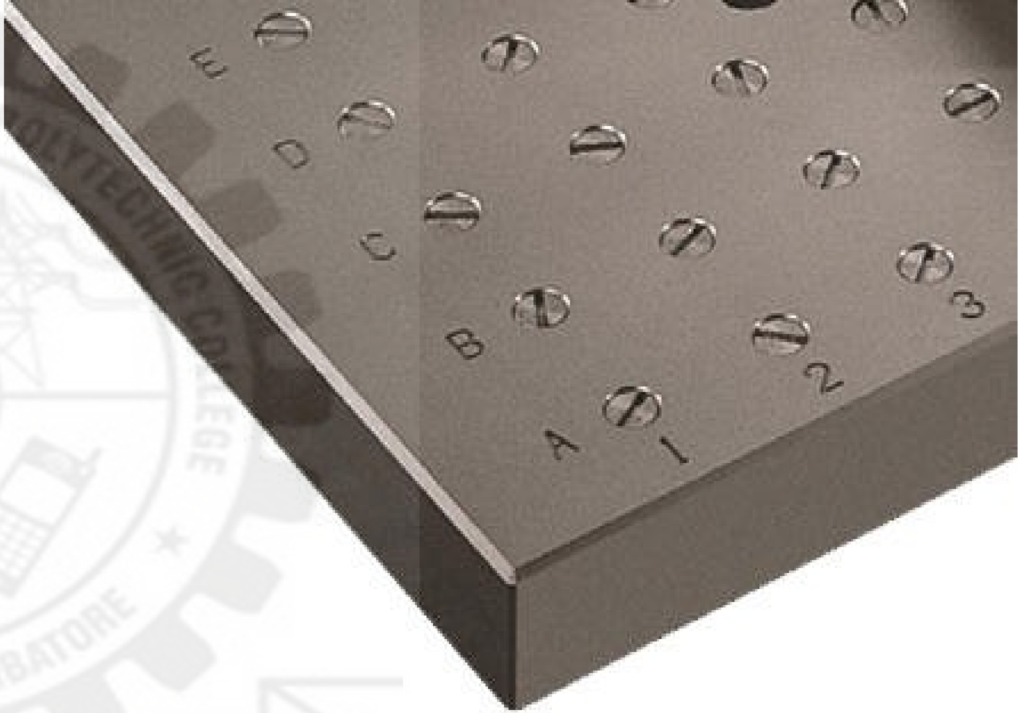
13. Cost-

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



Locating Principles
&
Devices

LOCATING PRINCIPLES

To position the work piece w.r.t. to tool, to ensure precision in machining

Locating: dimensional and positional relation-ship b/w work piece and tool

Locator: device to establish and maintain position of a part in a jig or fixture

BASIC PRINCIPLES

Positioning the locator

Accuracy & tolerances

Fool proofing

Duplicate location

Motion economy

1- Positioning the locators

Locators should contact the work (preferably machines surface) on a solid and stable point:

This permits accurate placement of the part in the tool & ensures the repeatability of the jig and fixture

- They should be placed as far as possible:
  - This permits the use of fewer locators
  - Ensures complete contact over the locating surface

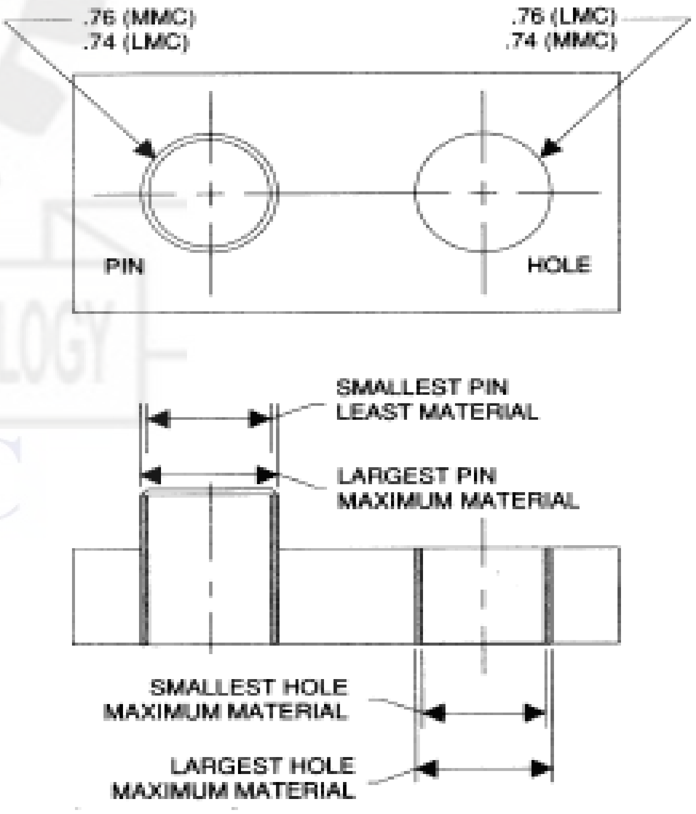
2- Accuracy and Tolerance

The workpiece itself determines the overall size of a locating element.

locators must be made to suit the MMC (<u>Maximum-Material Condition</u>) of the area to be located. (The MMC of a feature is the size c the feature where is has the maximum amount of material).

With external features, like shafts, the MMC is the largest size within the limits.

With internal features, like holes, it is the smallest size within the limits.

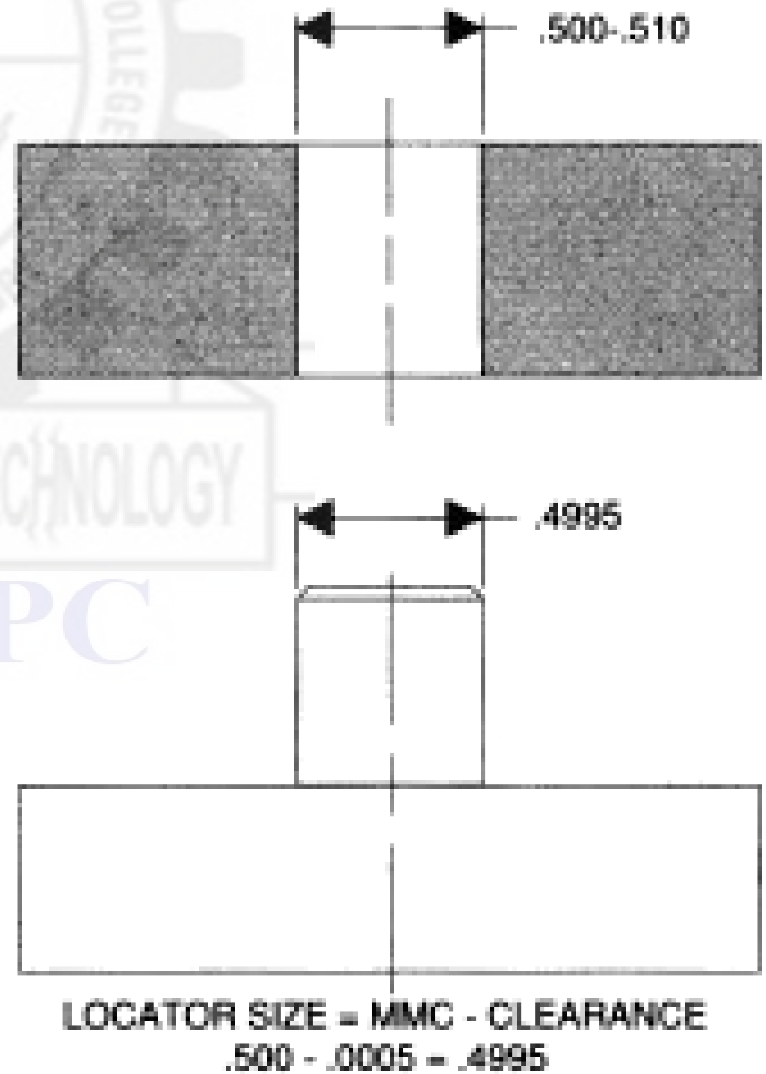


- The main considerations are the size of the area to be located and the required clearance between the locator and the workpiece.

- Make the locating pin slightly smaller than the hole.

- Here, the hole is specified as .500-.510" in diameter. Following the rule of MMC, the locator must fit the hole at its MMC of .500". Allowing for a .0005 clearance between the pin and the hole, desired pin diameter is calculated at .4995".

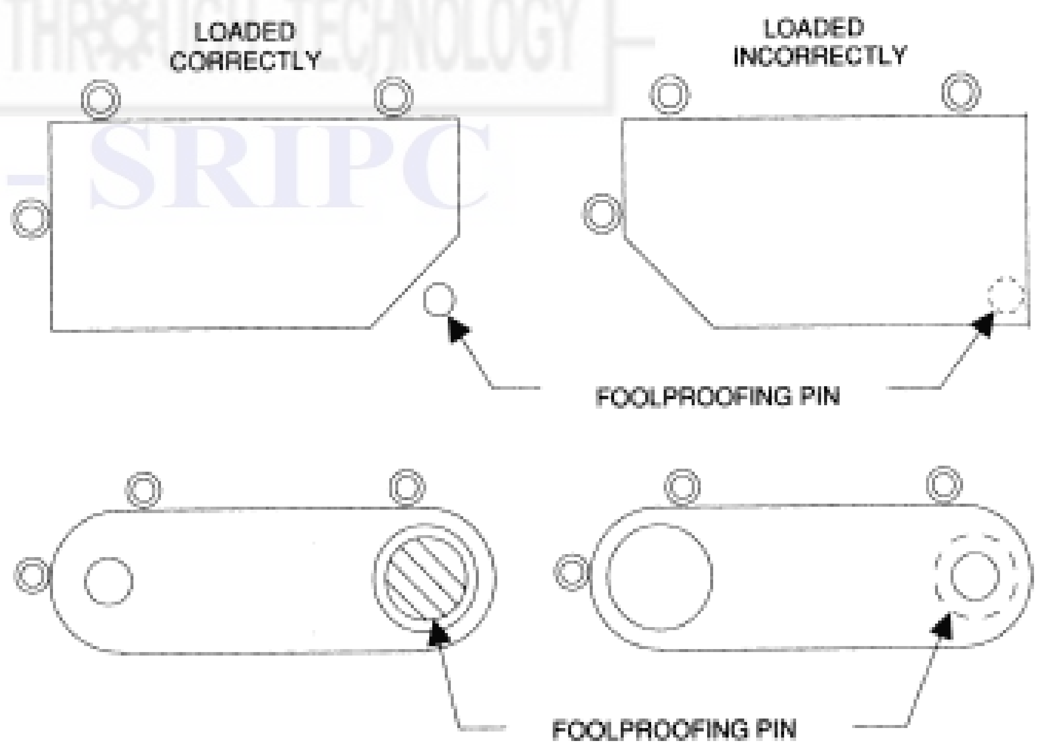
- Tool tolerance should be between 20 and 50 percent of the part tolerance.

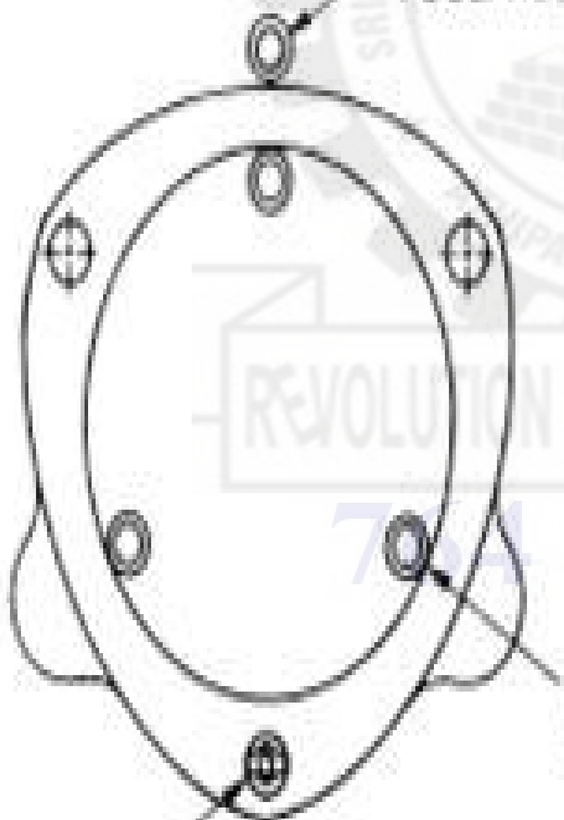


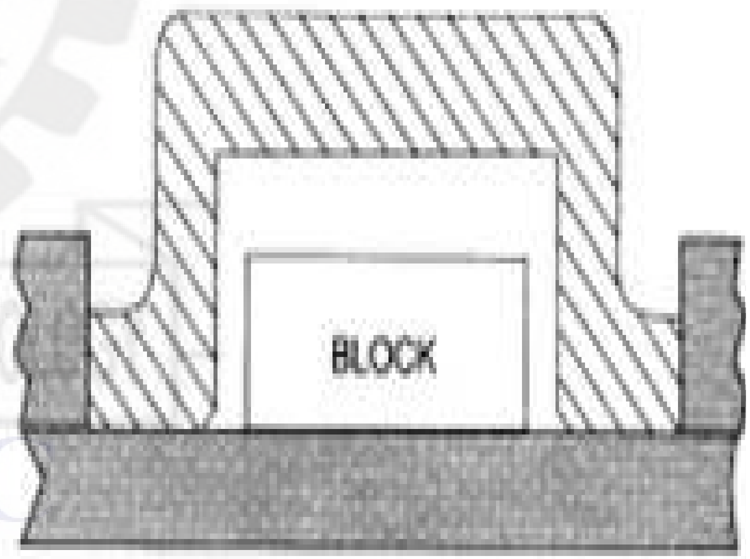
FOOL PROOFING

Ensures that the part fits into the tool in its correct position only

The simplest and most cost effective method is positioning a fool proof pin.







BLOCK USED TO FOOLPROOF THE LOCATION OF THE PART

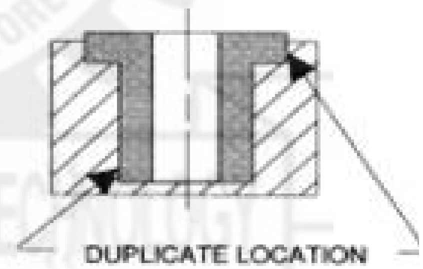
4- Duplicate locators

Redundant, or duplicate, locators should be avoided.

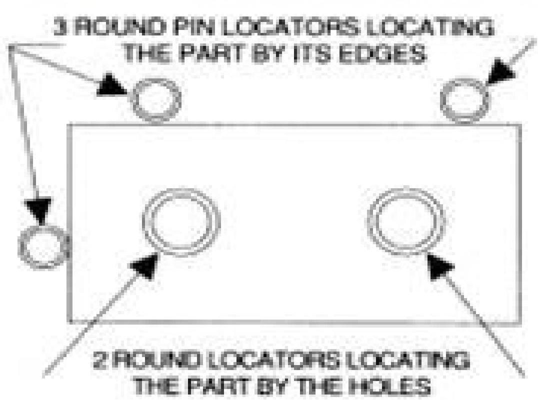
a) Flat surface can be redundantly located. The part should be located on only one, not both, side of surfaces.

(a)

b) Both the hub and the flange locating the same parallal surface



(b)

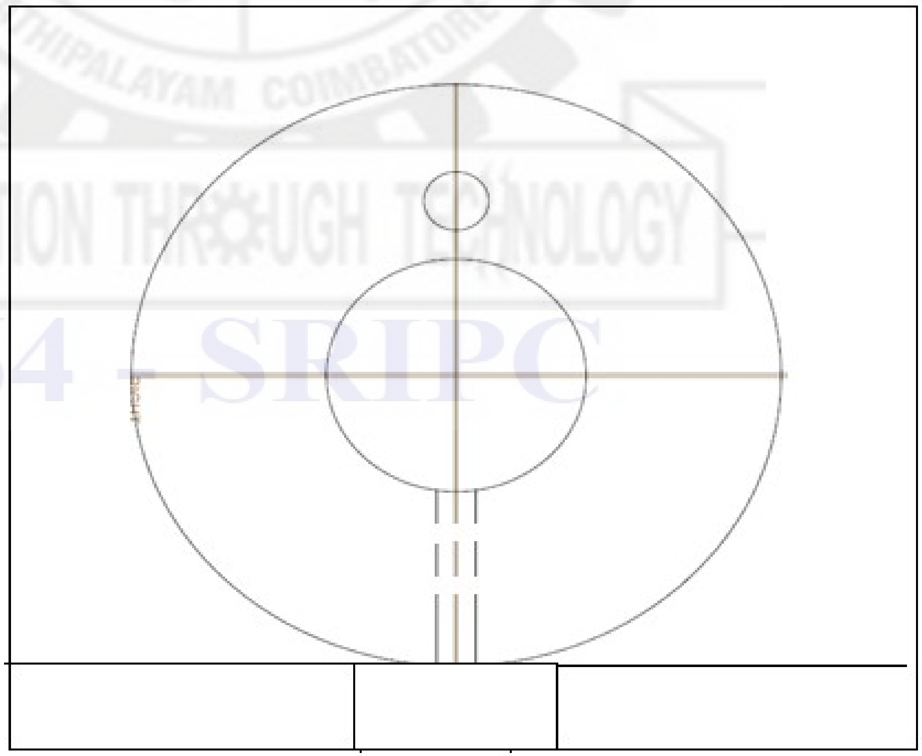


(c)

c) Difficulty with combining hole and surface location: Either locational method (locating from the holes or locating from the edges) works well if used alone.

5. Motion Economy

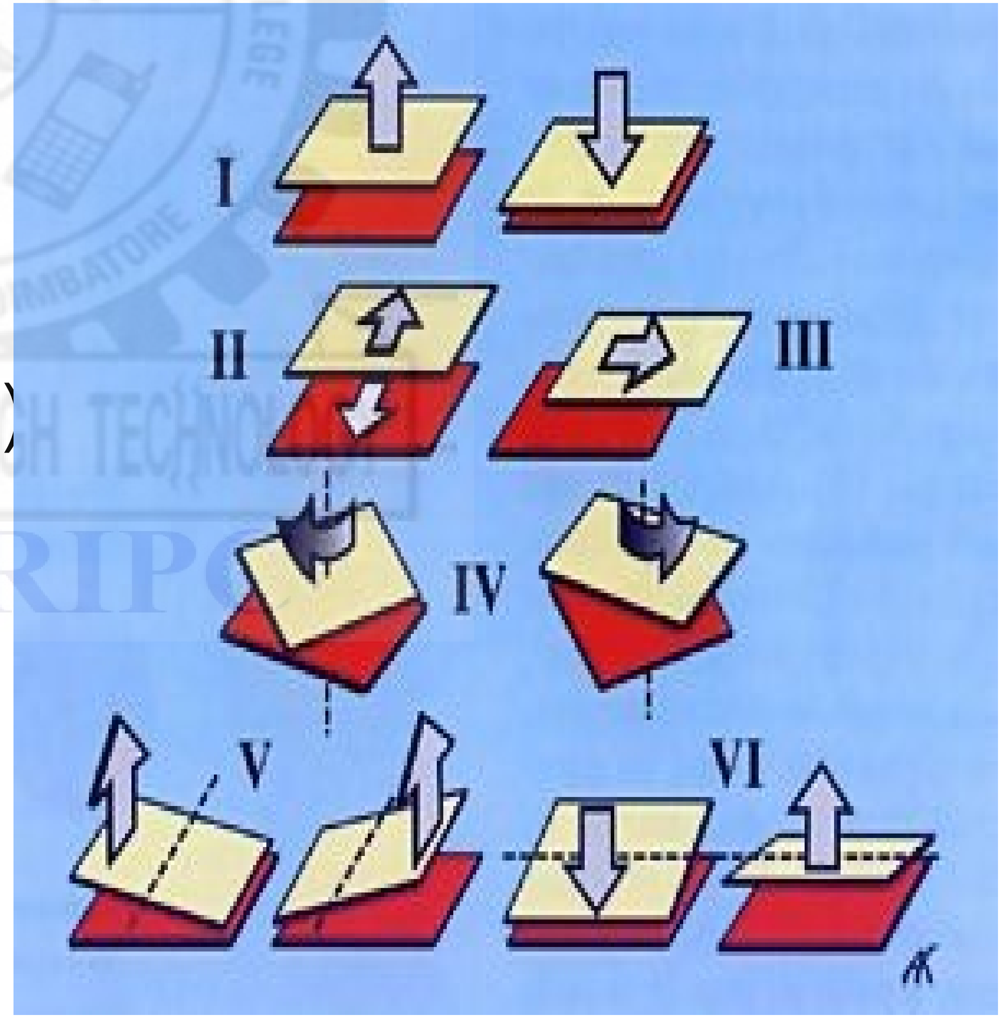
It involves use of easy, quick and economic loading of work pieces.



Degrees of Freedom

- Here we consider 12 degrees of freedom(not 6)

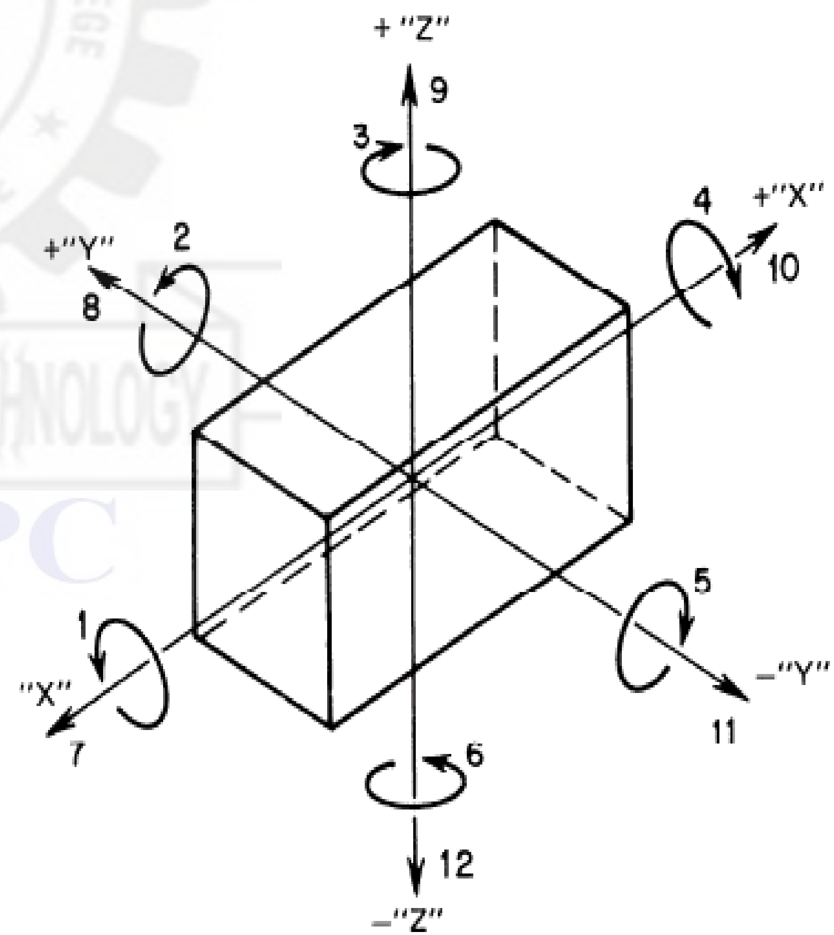
- 4 along each axis;2 translational and two rotational.



Restriction of Movement:

Six-pin method(3-2-1 method):

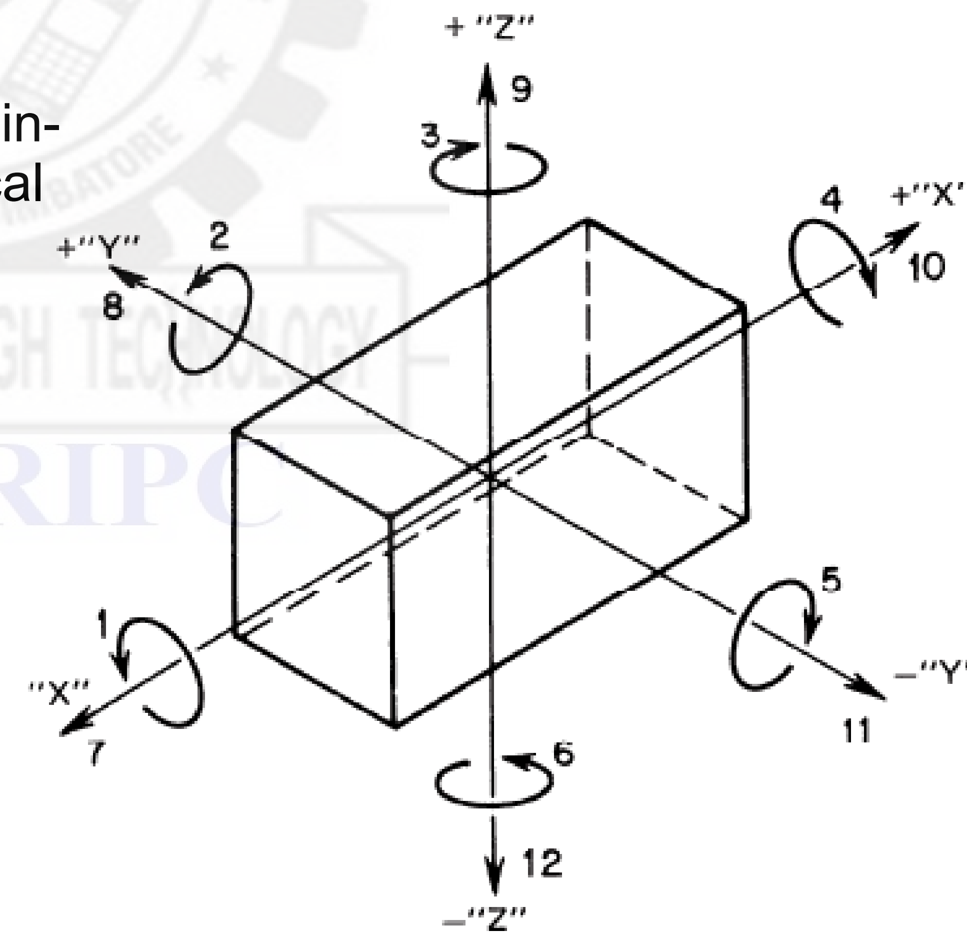
❖ Motion is restricted using clamps and locatoı
A three pin base can restrict five motions.
>Rotation about X,Y axes.(4 motions)
>Translation along -ve z-axis
(1 motion)
Directions nine, ten and eleven are restricted by a clamping device.
(3 motions)

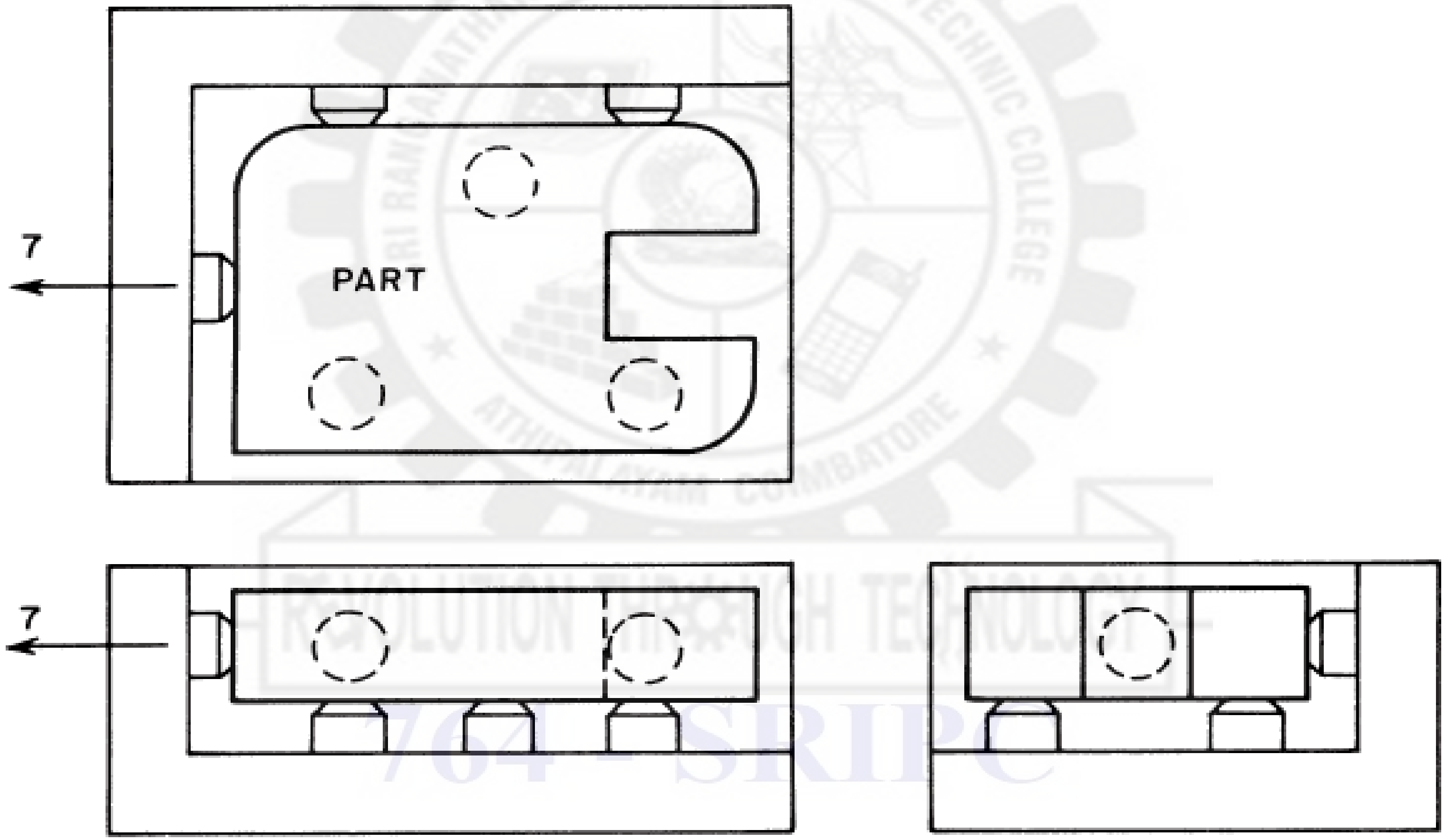


Cont..

- To restrict the movement of the part around the ZZ-
axis and in direction eight, two more pin-type locators are positioned in a vertical plane.(3 motions)

- A single pin locator in vertical plane restricts motion along direction 7.(1 motion)
- So motion in all 12 directions are restricted.





- Six-pins- restrict nine motions.
- Other three are restricted by using a clamp.

>>contd.

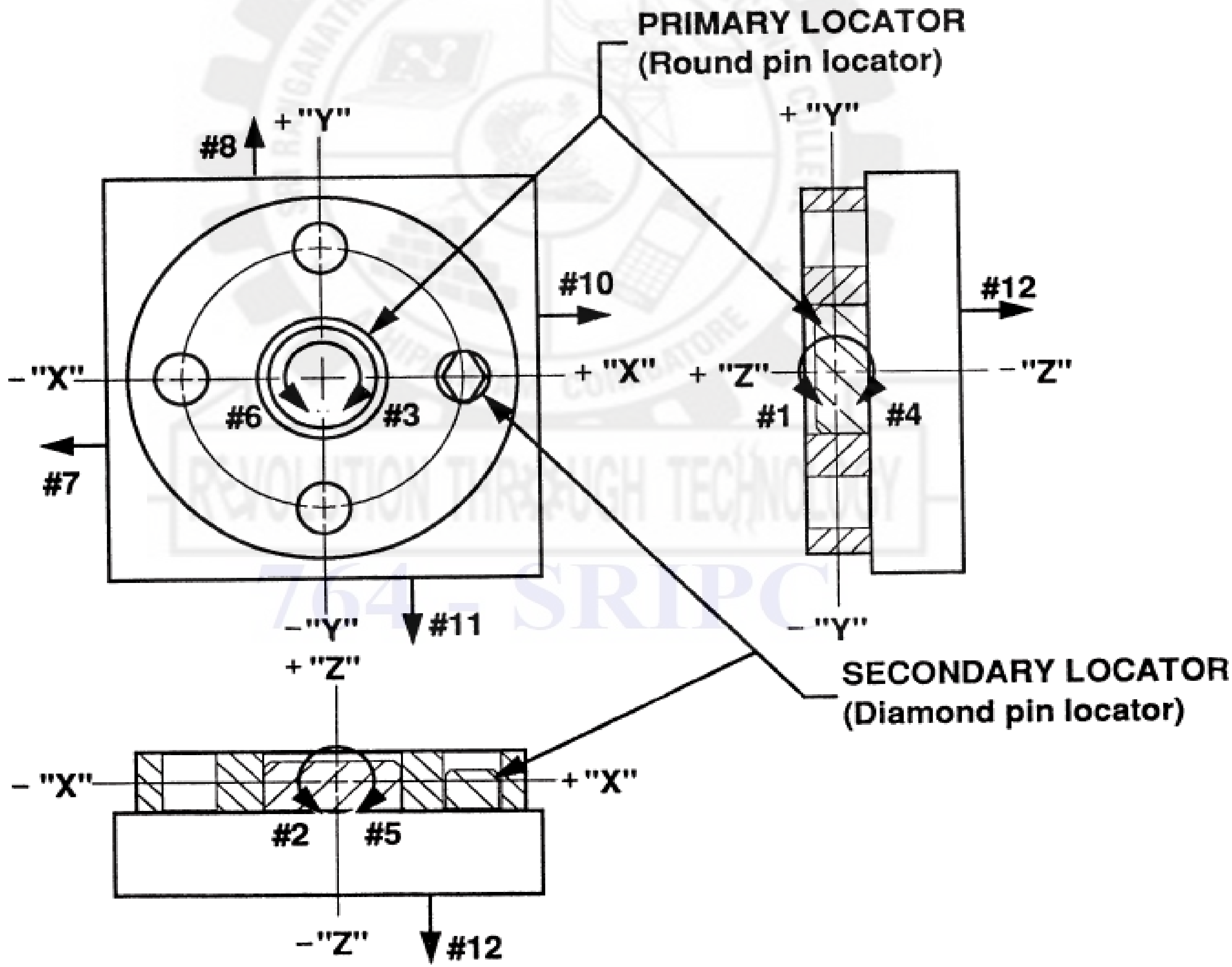
- This is the most common locating method employed for square or rectangular parts.

- Flat bases may also be used, but these should be installed rather than machining into the base.

- But pin/button type locators offers more accuracy as the area of contact is less. Moreover, they raise the work above the base so that chips wont interrupt the operation.

Workpieces with holes:

- Holes provide an excellent method for locating.
- A round pin inside the hole(primary) and a diamond pin(secondary) can restrict 11 motions!



PRIMARY LOCATOR
(Round pin locator)
+ "Y"
#8
#10
#12
– "X"
+ "X"
+ "Z"
– "Z"
#6
#3
#1
#4
#7
– "Y"
#11
+ "Z"
SECONDARY LOCATOR
(Diamond pin locator)
– "X"
+ "X"
#2
#5
–"Z"
#12

Locating Methods:

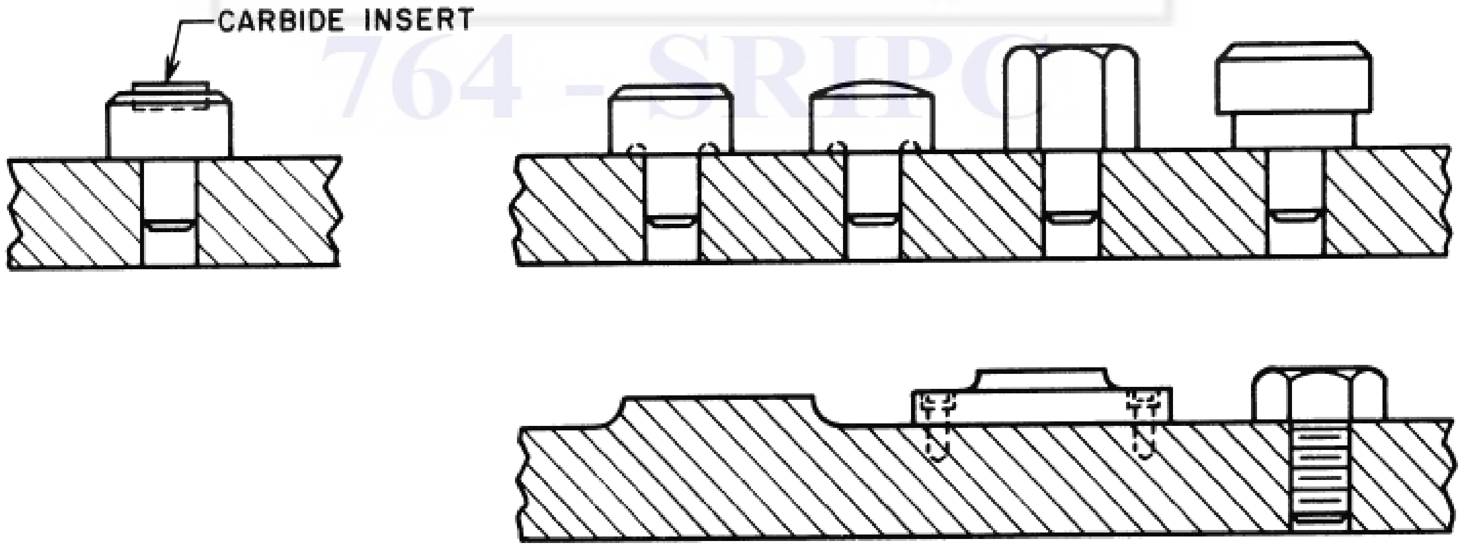
Locating from a Flat Surface:

There are three primary methods of locating work from a flat surface:

- solid supports
- adjustable supports,
- equalizing supports

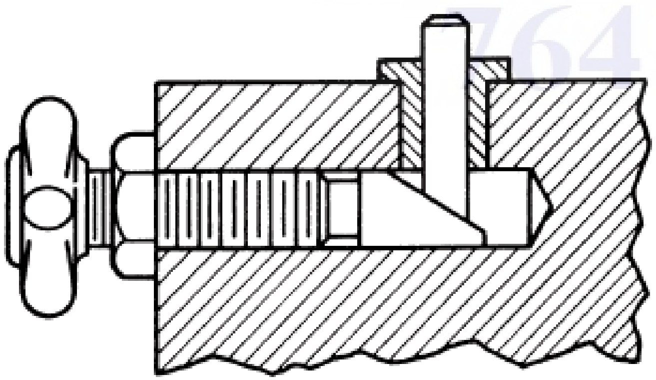
Solid supports:

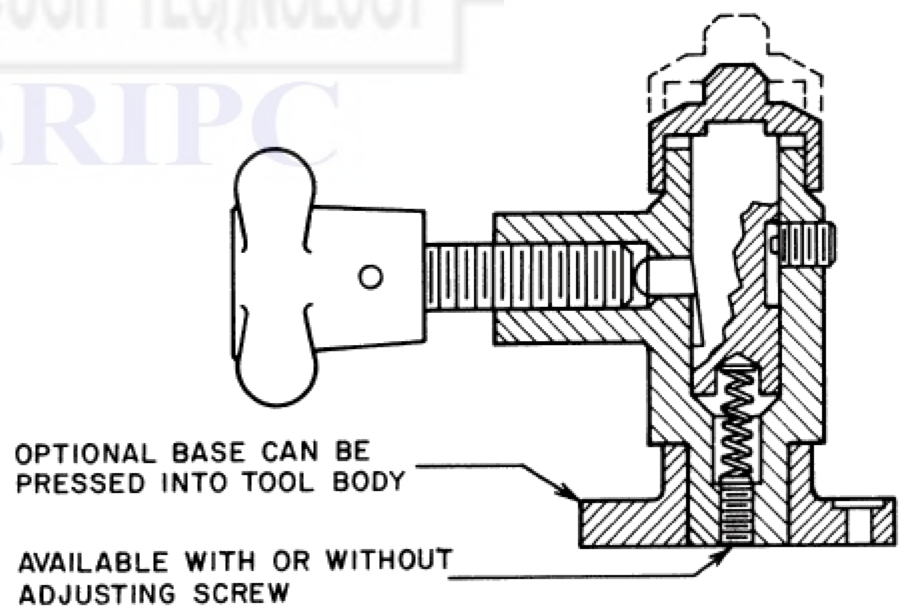
- Easiest and cheapest.
- Less accurate.
- Used where machined surface acts as a locating point.



Adjustable supports:

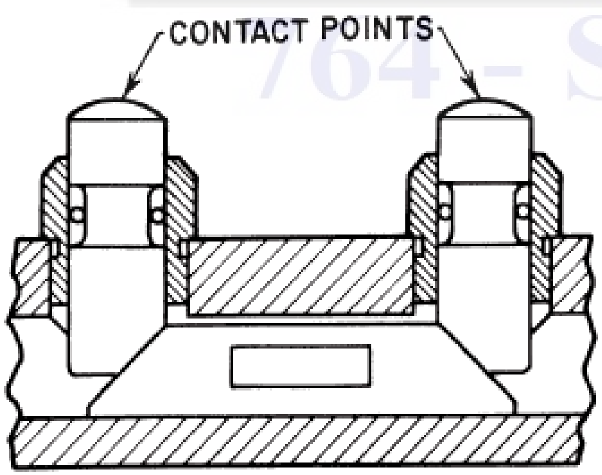
- Used where surfaces are uneven(casting,forging..)
- Threaded style is the easiest and more economical.
- Adjustable locators are normally used with one or more solid locators to allow any adjustment needed to level the work.

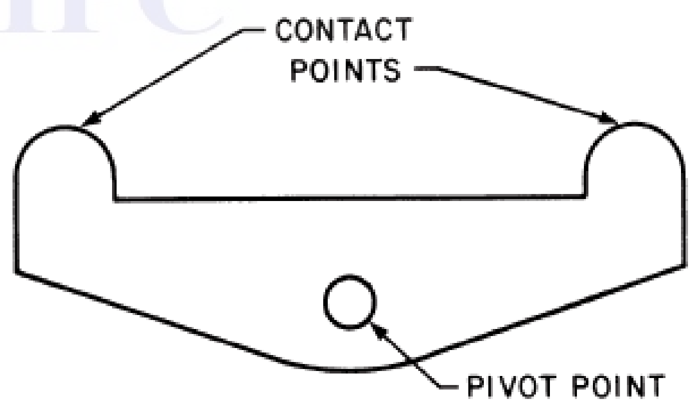




Equalizing supports:

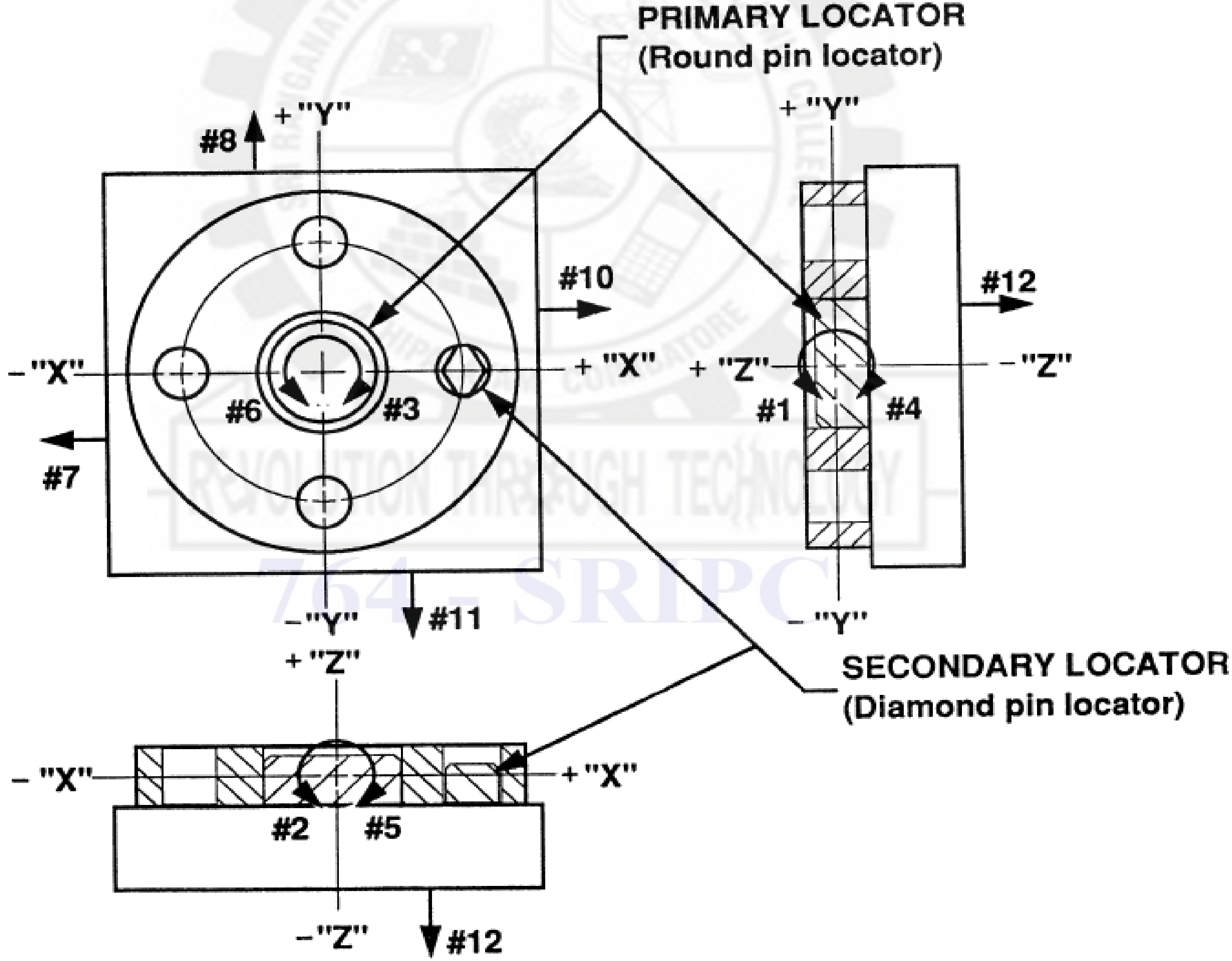
- They provide equal support through two connected contact points.
- As one point is depressed, the other raises and maintains contact with the part.
- This feature is especially necessary on uneven cast surfaces.





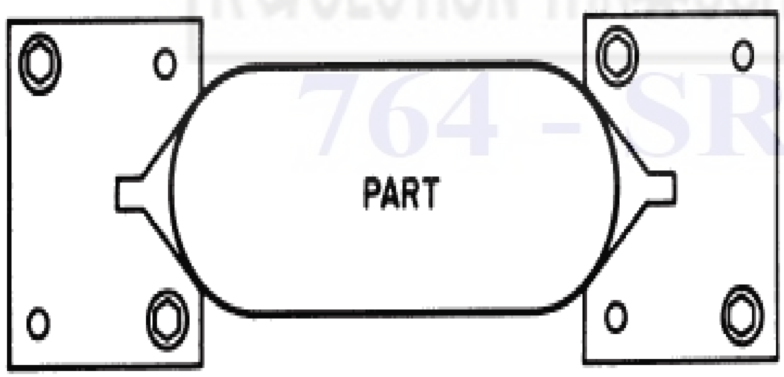
Locating from an Internal Diameter

- Locating a part from a hole or pattern is the most effective way to accurately position work.
- Nine of the twelve directions of movement are restricted by using a single pin, and eleven directions of movement are restricted with two pins.
- When possible, it is logical to use holes as primary part locators.


PRIMARY LOCATOR
(Round pin locator)
+ "Y"
#8
#10
#12
- "X"
+ "X"
+ "Z"
- "Z"
#6
#3
#1
#4
#7
- "Y"
#11
+ "Z"
SECONDARY LOCATOR
(Diamond pin locator)
- "X"
+ "X"
#2
#5
- "Z"
#12

Locating Cylindrical Surfaces(Externally) “V”-locators

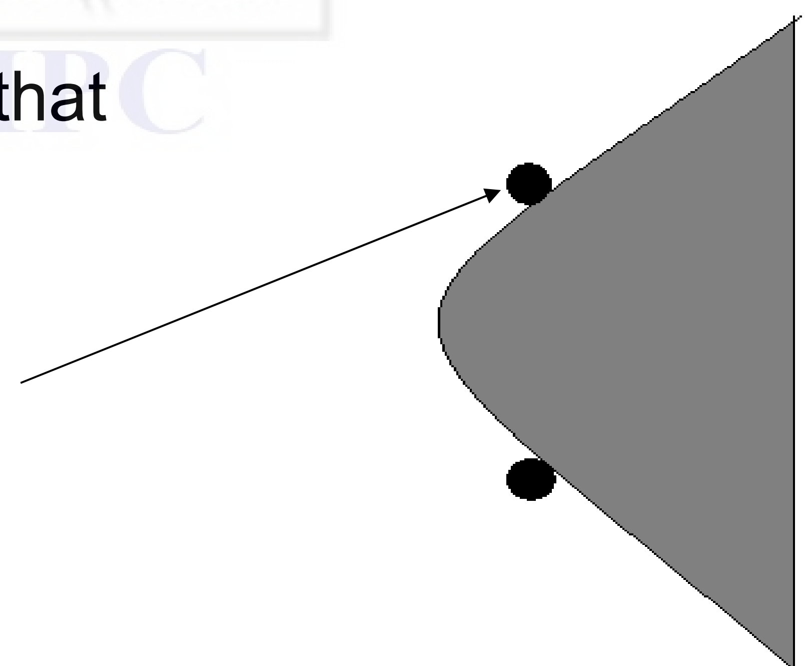
- Vee locators are used mainly for round work.
- They can locate flat work with rounded or angular ends and flat discs.
- Two types:Fixed and Adjustable:



Locating from Irregular Surfaces(External)

Locating work from an external profile, or outside edge, is the most common method of locating work in the early stages of machining.

- For simple components,a sighting plate may be used. Location is done by adjusting the workpiece in such a way that it has equal margins on all sides.
- In large parts cylindrical pins can be used.



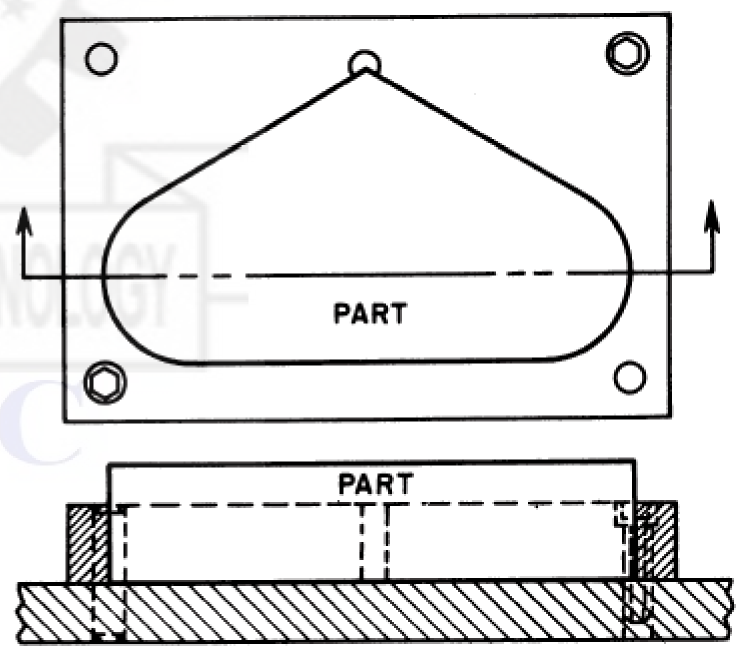
cont..(irregular surfaces)

- If there are large variations from batch to batch, eccentric locators can be used, whose eccentricity can be varied according to the profile.
- Eccentricity is varied just by rotating the locator until it holds the workpiece in position.

(cont; irregular profiles)

Locating from an External Profile

- **Nesting locators** position a part by enclosing it in a depression, or recess, of the same shape as the part.
- Nesting is the most accurate locating device for profile location.
- Obviously, the height of the nest should be lesser than the height of the workpiece.
- In case of sheet-metals or thin workpieces, finger slots or ejector pins should be provided.



Pin and button locator

- locator used to support or hold the workpiece in position.
- Pins locators are longer and for horizontal locations. Button locators shorter,vertical locations.
- Locating buttons-press fit and screwed(wear and tear more – replaceable)

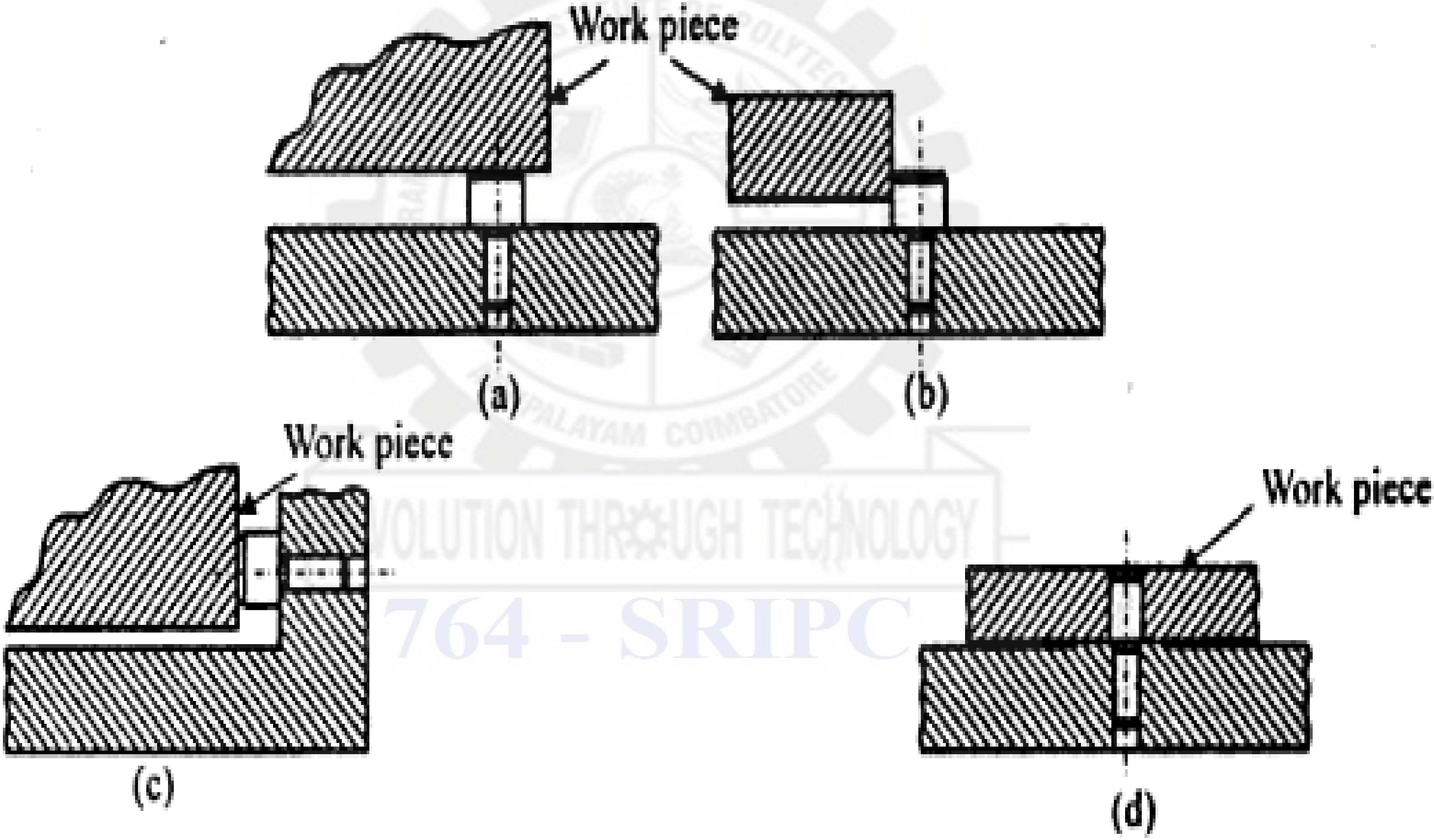


Figure 8.80. Use of Pins and Buttons as Locators

Rest pads and plates

- Used with heavier and larger workpiece.
- To support and locate the work vertically.
- Hold jig or fixture base plate by socket-head cap screws.

Diamond pin locator

- Work piece with the drilled holes use two round pins
- If dimension variation between centre to centre distance of the holes, one round and diamond pin locators are used
- Binding is eliminated
- Prevents movement around the pin and are relieved on two sides to allow variation

$$B = \delta_1 + \delta_2 - 2c$$

where

B = width of the diamond pin

δ_1 → Tolerance on workpiece

δ_2 → Tolerance on Jig

2c → Diametrical clearance in setting the workpiece on cylindrical pin

If $\delta_1 + \delta_2 > 2c$ then diamond pins should not be used.

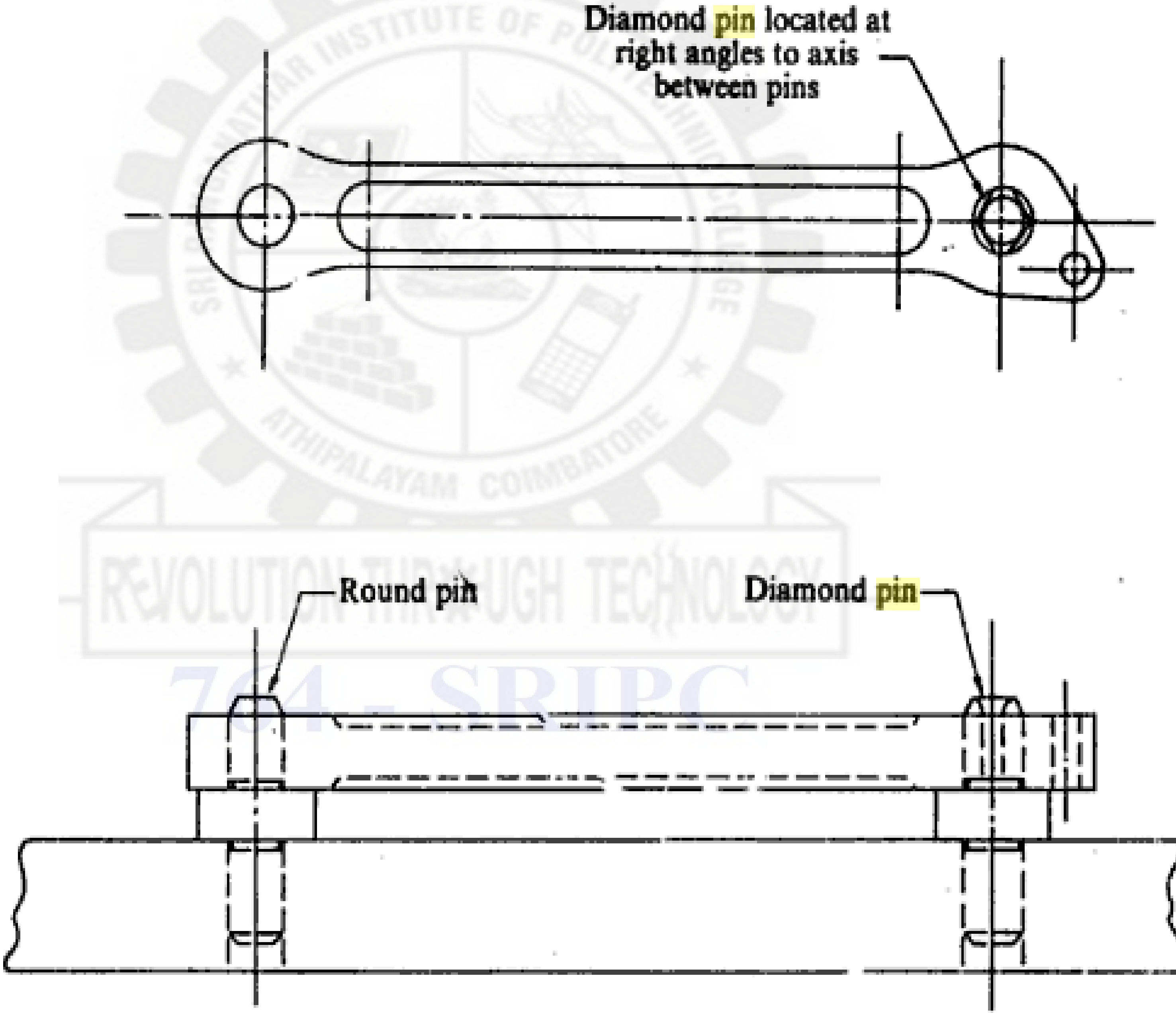


FIGURE 6-22
Use of one round and one diamond locating pin.

Nesting locator or cavity locator

- used to position the work piece
- Accurate method for profile location
- No need of supplementary locating devices
- But it is difficult to lift out of cavity
- Common types:-

Ring Nest

- Used for cylindrical workpiece.
- It encloses the workpieces fully.

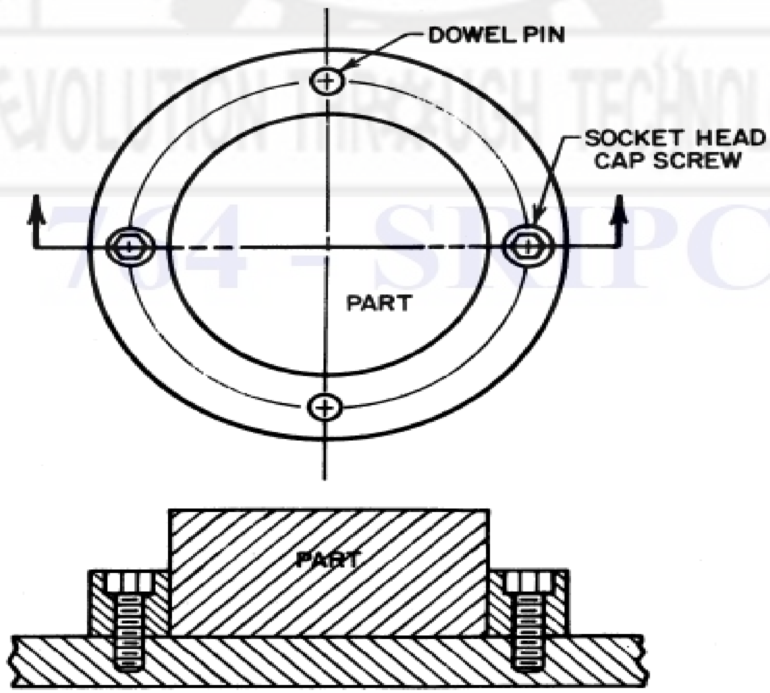
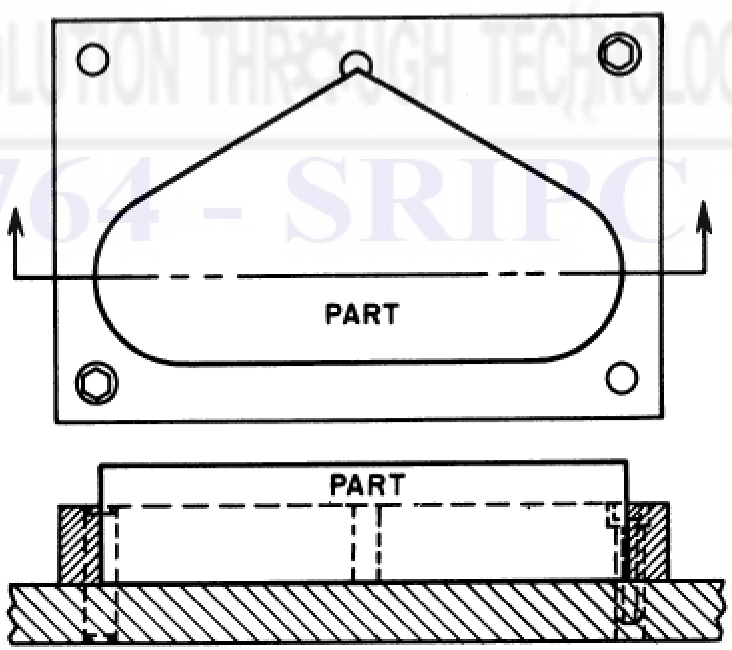


Figure 3–26 Ring nest.

1.Full Nest

- For work pieces other than cylinders.
- Encloses the work completely.



Partial Nest

- For larger work pieces a nest may not be possible to enclose it completely.
- In such cases partial nests are used which encloses certain contours of the work.

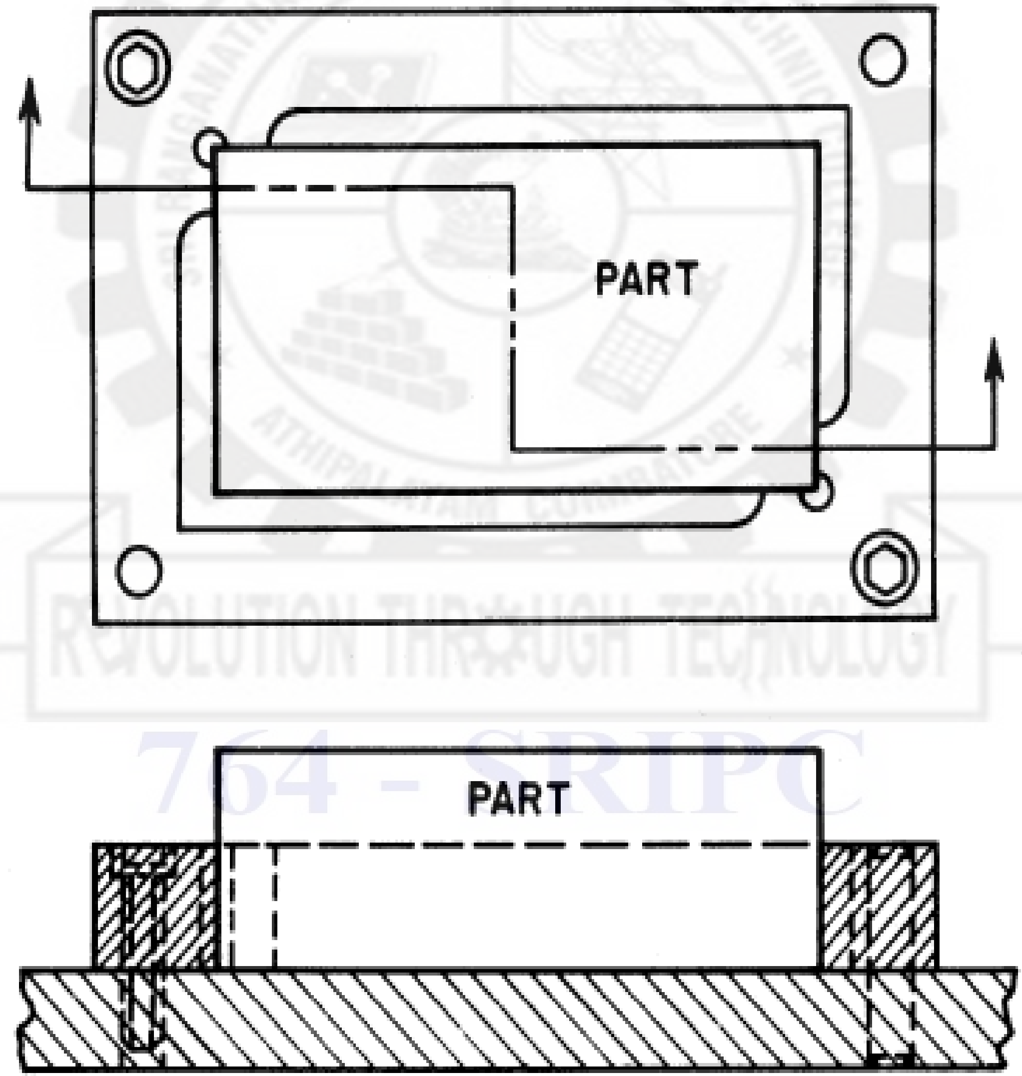
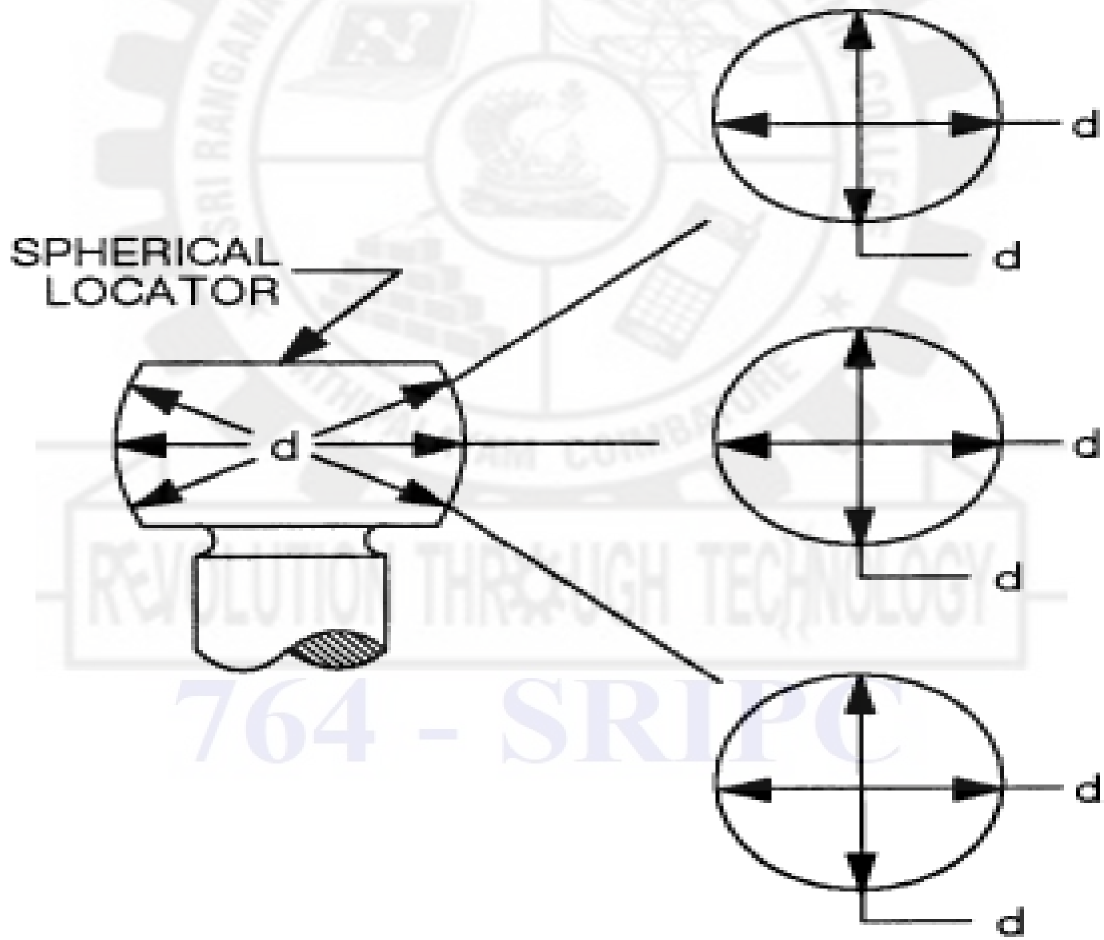


Figure 3–28 Partial nest.

Spherical locator

- Sphercal location reduces contact area.
- Material not in direct contact with the work piece.
- Binding not possible in this case



3–24 Spherical locators.

Split contact locator

- Relieved locator used in thick workpiece
- Locator is relieved in the middle
- Only top and bottom areas come in contact with workpiece

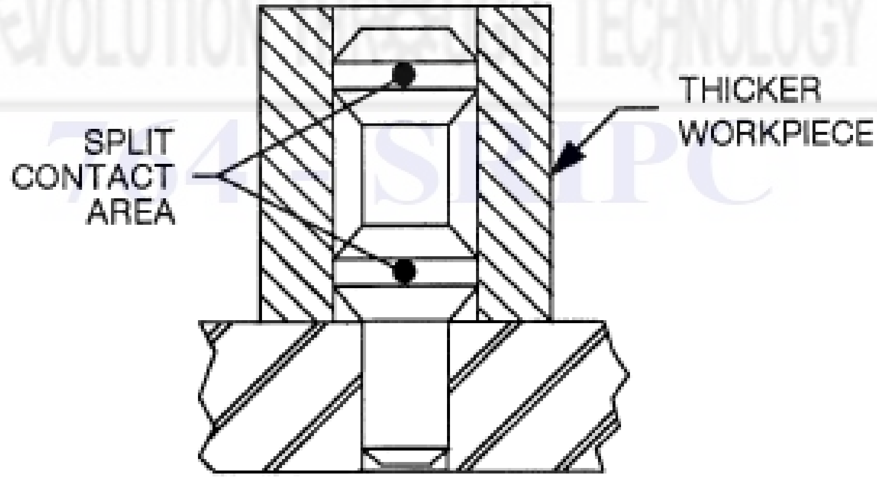


Figure 3-22 Split contact relieved locator.

Raised contact locator

- Raised contact design reducing the chance of binding
- Contact point is raised to the middle of the workpiece and contact area reduced
- Moving the contact area from the base plate reduces the effect of dirt,chip and burrs

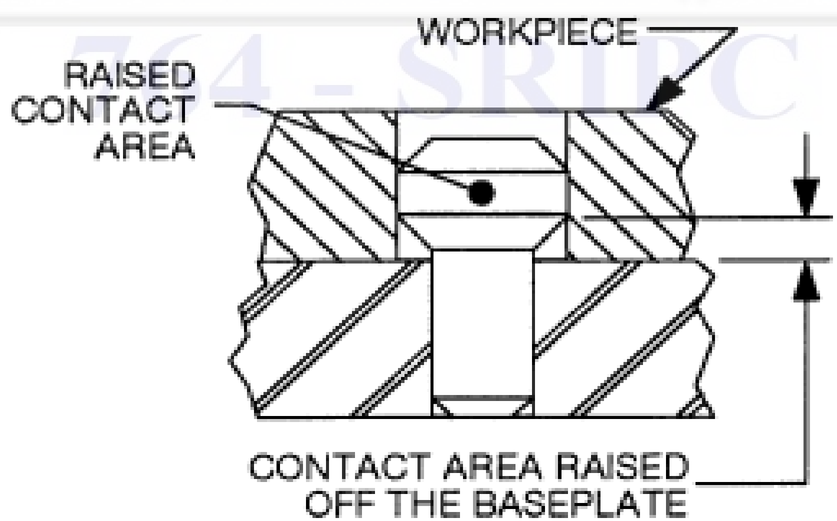


Figure 3–23 Raised contact relieved locator.

Split pin or groove pin

- Used in place of dowel pins to reduce cost and time
- Not so accurate as they don't employ the reamed hole as in the case of dowel pins

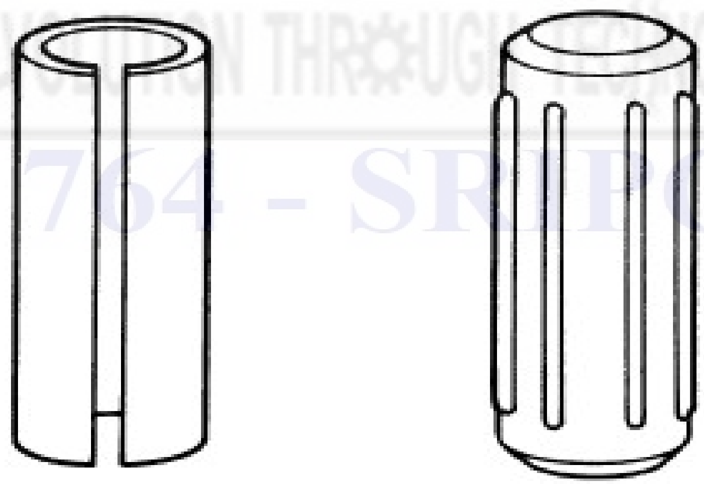


Figure 3–35 Split and grooved dowels.

Dowel pin locator

- Most common type of fixed locator

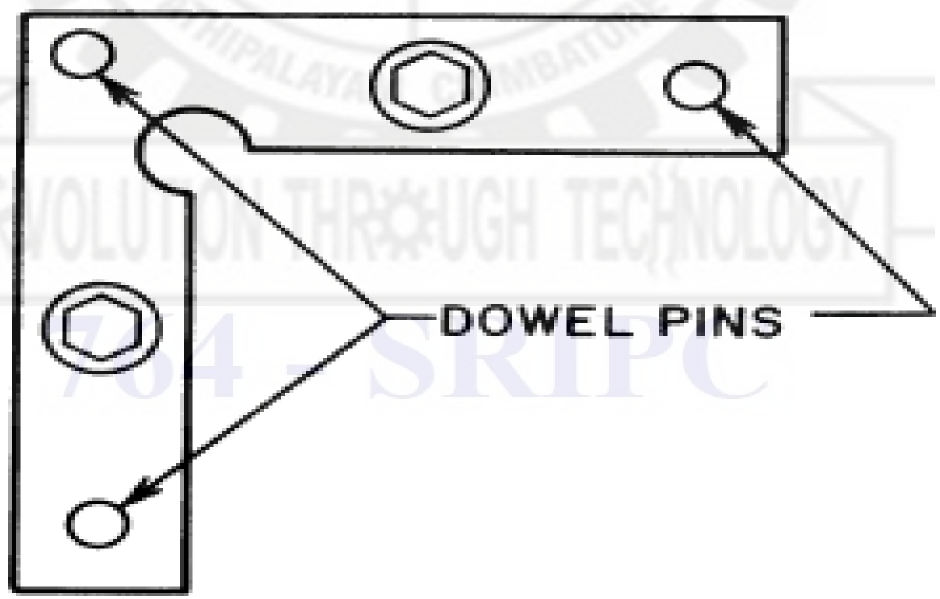
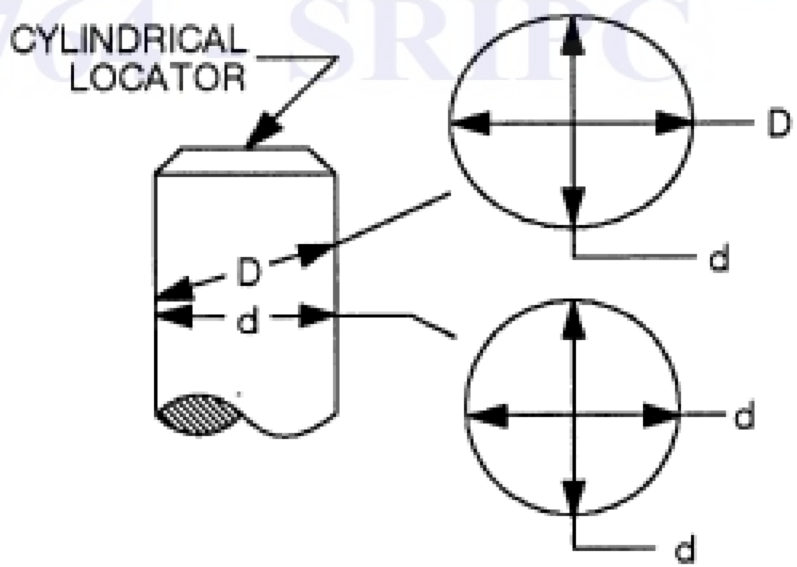


Figure 3–34 Doweled locators.

Cylindrical pin

- Used when the workpiece contains holes drilled into it
- Pin will bind unless centreline of the hole is perfectly aligned with cetreline of locator



Machined Fixed stop locator

- Used for parts that cannot be used in either a nest or V-locator
- Are usually machined into the tool body
- Since they are machined into the tool body the entire body has to be changed when locator is worn out

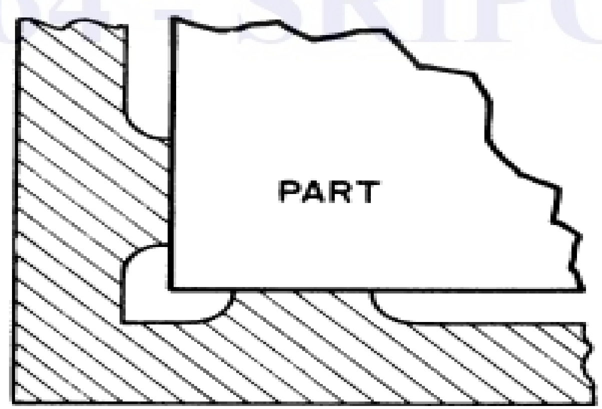


Figure 3–32 Machined fixed-stop locators.

Installed fixed stop locator

- Most economical to use
- Since it is installed into the tool body and not machined it can be easily replaced when worn out
- No need to make the locator body entirely again
- Saves time

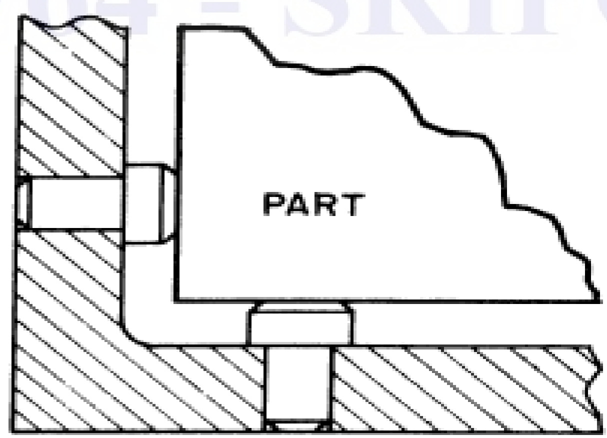
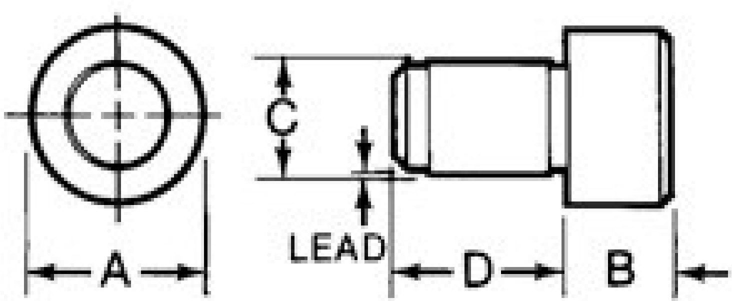


Figure 3–33 Installed fixed-stop locators.

Standard parts
jig button

- Commonly made from case hardening steel (16MnCr5 or 20MnCr5C15)
- Have a hardness value of about 60 HRC
- Have a case depth of 0.3 to 0.5 mm



Jig bush

- Jig bushes locate and guide cutting tools
- Several types like linear,renewable,slip and screw bushes exist
- Made from direct hardening type steel such as En31,T90,20MnV8
- Hardness is usually 60 HRC with case hardened depth of 0.5 to 0.8mm

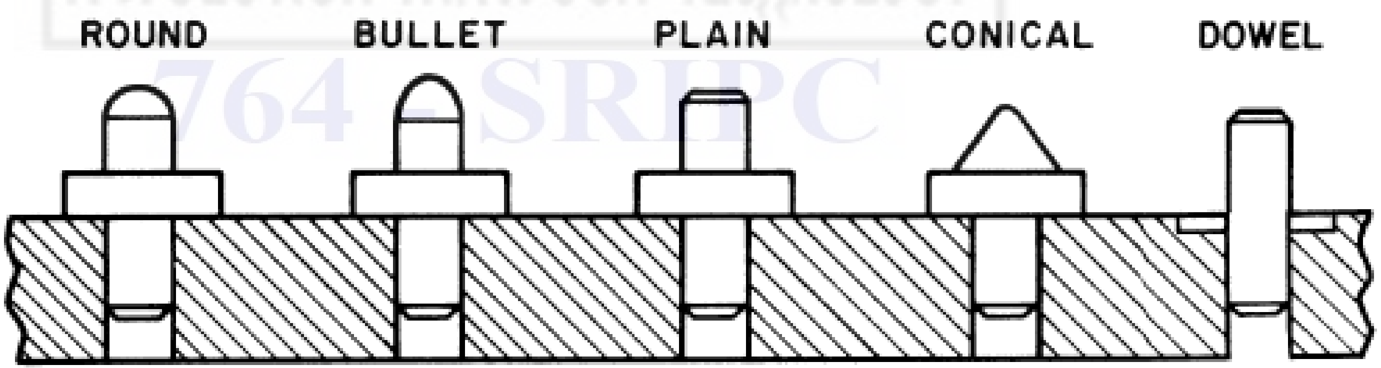


Figure 3-17 Pin locators and bushing.

Ejectors

- Used to remove the workpiece from close fitted locators and are present behind the workpiece
- Speed up the operation by reducing unloading time
- They are of 2 types:
  - Mechanical type
  - Spring plunger

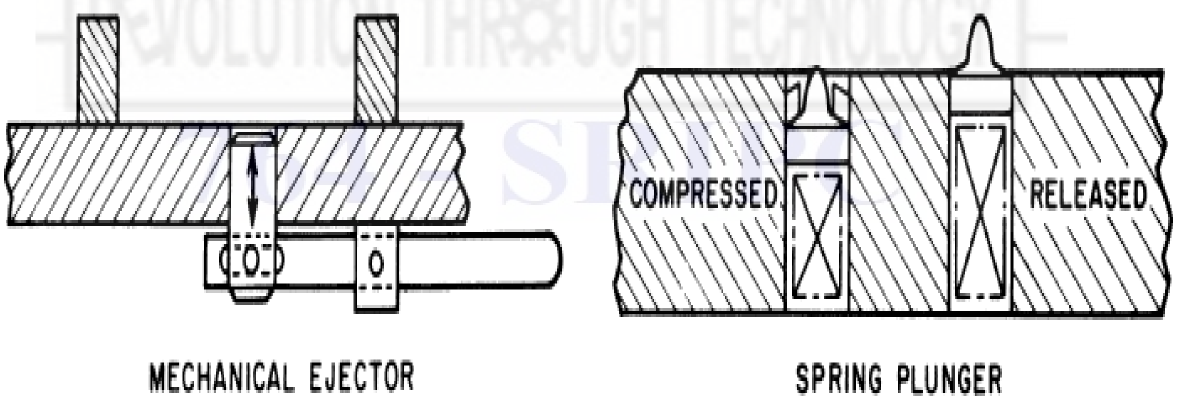
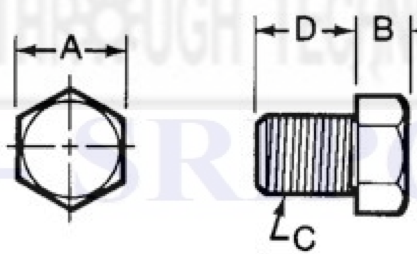
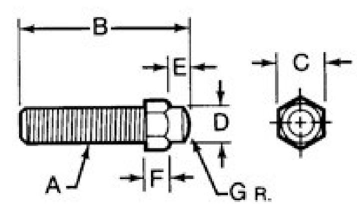


Figure 3-40 Ejectors.

Jig feet bolt and nuts

- Usually purchased as standard parts and they are built into jig body except in casting construction
- Jig feet is bounded with lug and grounded in order to make geometrically true surface





Pressure pads

- Used above or below the workpiece depending on size and shape of workpiece
- Necessary when workpiece contains sharp corners or irregular surfaces
- Also used to absorb shocks
- Pressure for pads applied by springs,air or hydraulics
- Urethane pads require less space than springs since they withstand greater pressure with less deflection compared to springs

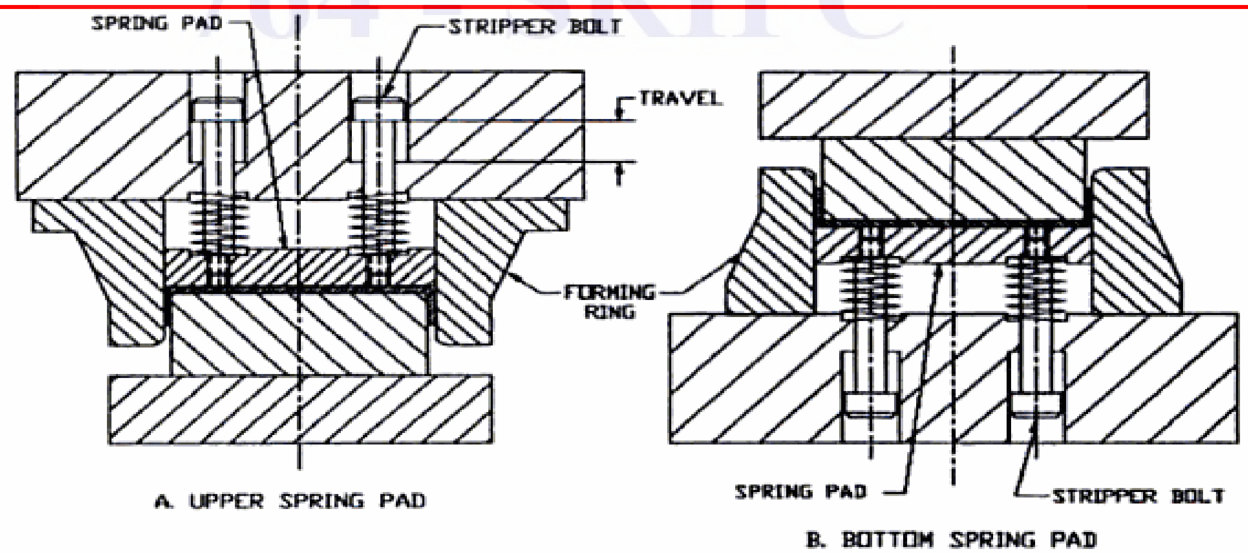


Figure 4-30 Pressure pads.

washer

- Used for positive clamping force
- They should have hardness value less than the mating surface
- Used for compensating length in bolt sizeand to grip the clamping force
- C washer,swing C washer,spherical washer,lock washer ,internal star washer

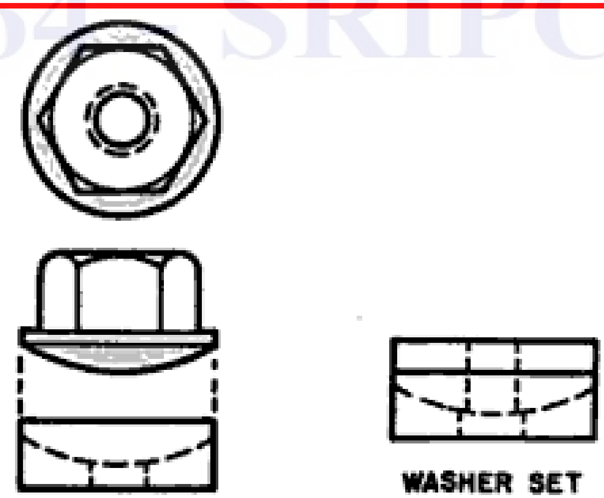


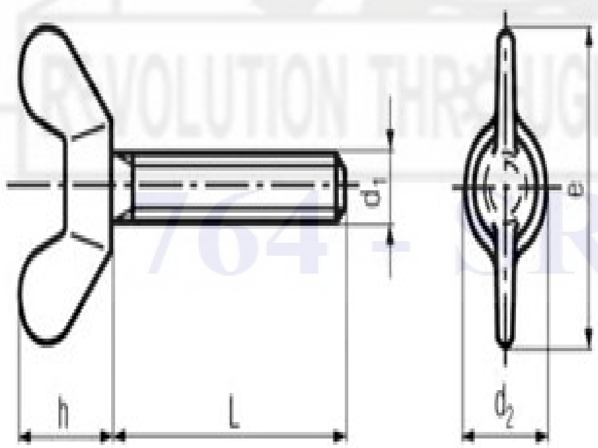
Figure 4-11 Spherical nuts and washers.

Hand grip screws

- Used for positive clamping
- Used to tighten the part
- Cylindrical end,groove end,floating end are the various types

Wing or fly screws

- used for light positive tightening
- Cylindrical end,groove end,floating end are the various types

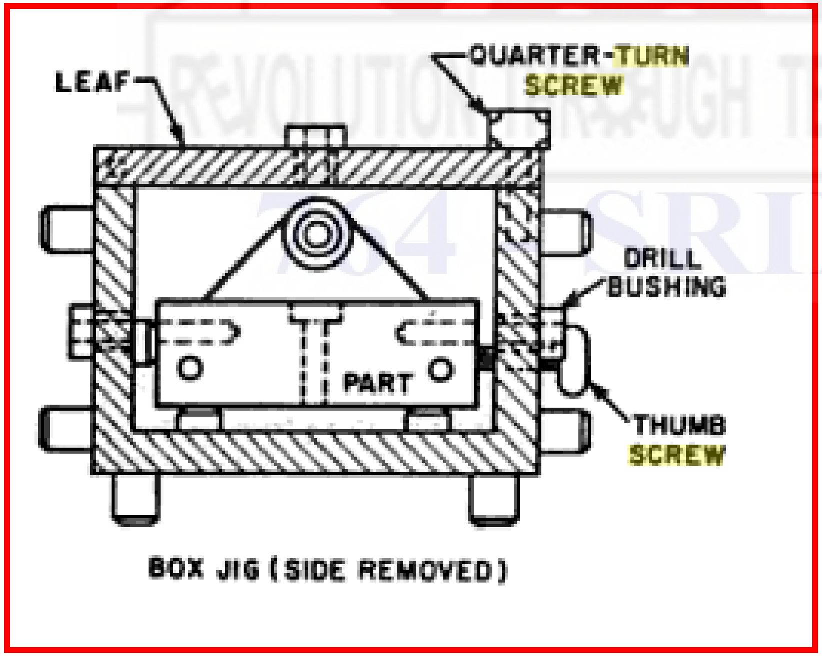


All measurements in millimeters (mm)

DIN 316

Quarter turn screw

- Also called thumbscrew latch
- Designed in such a way that the operator can easily turn the screws even if the threads are covered with dry oil,dust and chips
- It is kept perpendicular to confirm tightening



Sight Locators:

- Used for rough machining.
- Less accurate.
- Work fits into specific slots on the locating plate known as sighting plates.
- 2 types

Sight location by slots on the table.

Sight location by lines etched on the tool.

Manufacturing Tooling
5. Jig Design

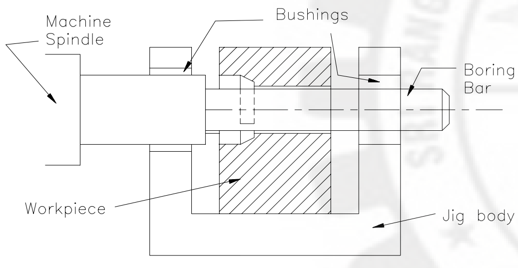
Nageswara Rao Posinasetti

Fixture

- A fixture is a means through which a part is securely fastened to the machine tool table to accurately locate, support and hold the part during the machining operation.

Jig

- A jig is a special class of fixture, which in addition to provide all the functions as above, also guides the cutting tool during machining.
- This is generally used for the operations such as drilling, boring, reaming, tapping, counter boring, etc.



Typical jig used for boring operation

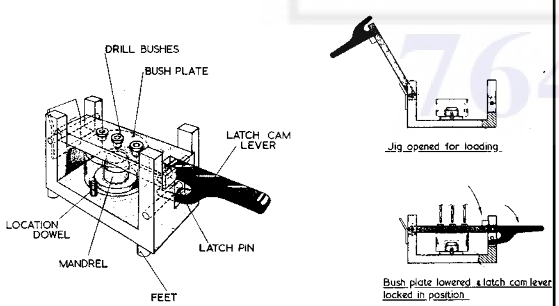


Fig. 21 Drill jig with swinging bush plate & latch cam closure

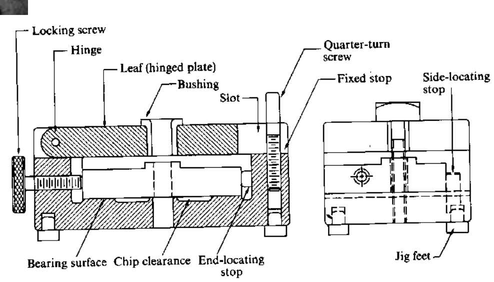


FIGURE 7-2
Simple leaf jig.

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Drill Jigs

- Provide methods for
  - Correctly locate the workpiece with respect to the tool
  - Securely clamp and rigidly support the workpiece during the operation
  - Guide the tool
  - Position and/or fasten the jig on a machine

Drill Jigs

- Advantages
  - Minimize tool breakage
  - Minimize the possibility of human error
  - Permit the use of less skilled labor
  - Reduce manufacturing time
  - Eliminate retooling for repeat orders

Machine Considerations

- Horsepower
- Size limitations
- Weight limitations
- Cutting Tools
- Special Machinery

Process Considerations

- Type of Operations (drilling,reaming, other)
- Number of Operations
  - Similar vs. different
  - Sequential vs. simultaneous
- Sequence
- Inspection Requirements

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Jig Bushes

- To position and guide the cutting tool for cutting.
- Materials
  - Hardened steel
  - Carbide
  - Bronze
  - Stainless steel

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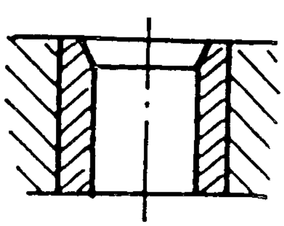
Headless Bush



Most popular and least expensive

Light axial load is expected

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Clearance between Bush and Part

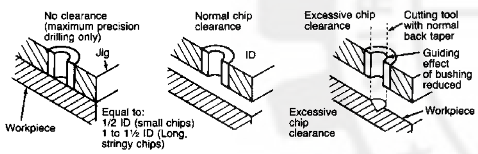
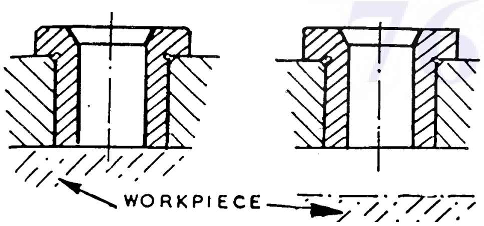
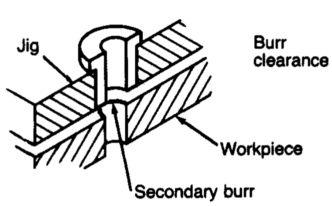


Figure 5-40. Recommended clearance between workpiece and bushing. *(Courtesy, American Drill Bushing Co.)*

Headed Drill Bush



Jig plate can be thinner



5-42. Burr clearance. *(Courtesy, American Drill Busi*

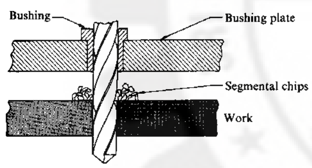


FIGURE 7-19
Chips do not pass through bushing.

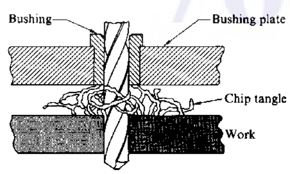


FIGURE 7-20
Chip tangle between bushing plate and workpiece.

Slip Renewable Bush

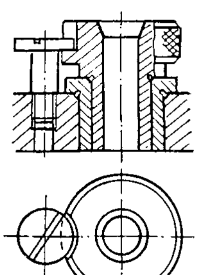
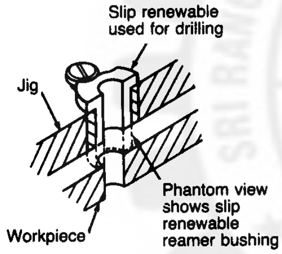


FIG 5.6

Used for multiple operations such as Drilling followed by reaming



5-41. Chip clearance for multiple operations. *(Courtesy,*

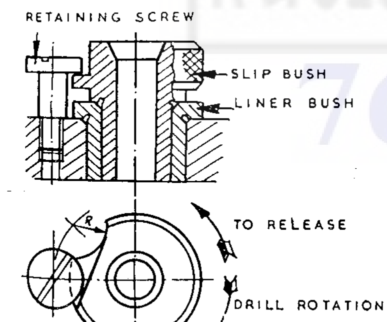


FIG 5.5
SLIP BUSH ARRANGEMENT

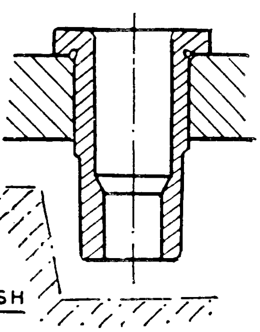


FIG 5.4
EXTENDED
DRILL BUSH

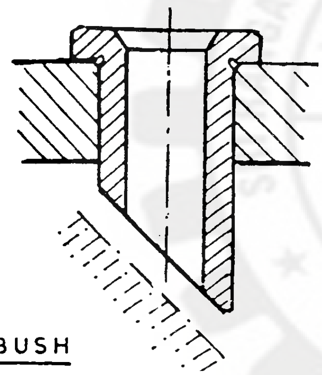


FIG 5·3
SHAPED
DRILL BUSH

Drill bushing position for angular drill entry

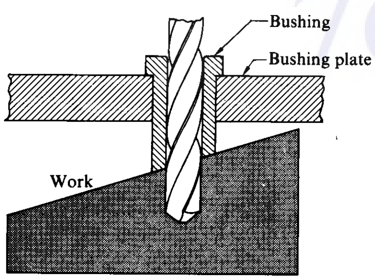
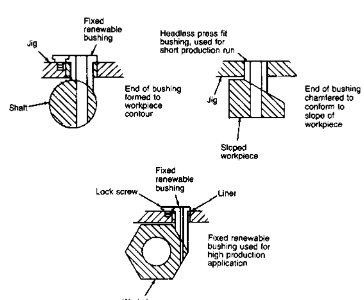


Fig. 5.43 Drilling irregular work surfaces



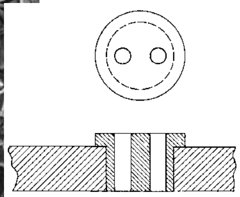


FIGURE 7-29
Use of two holes in one bushing.

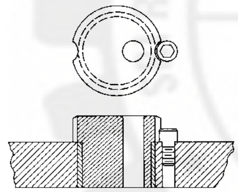
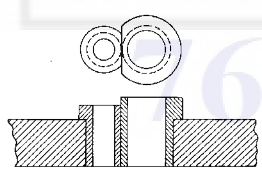


FIGURE 7-30
Use of eccentric for close hole drilling.

FIGURE 7-31
Modification of standard bushings for close hole drilling.



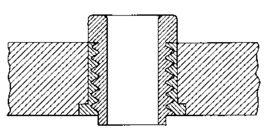


FIGURE 7-32
Plain screw bushing.

Jig Components

- Locators
- Clamps
- Jig plate with bushes
- Jig body
- Other elements as required
  - Supports
  - Jig feet

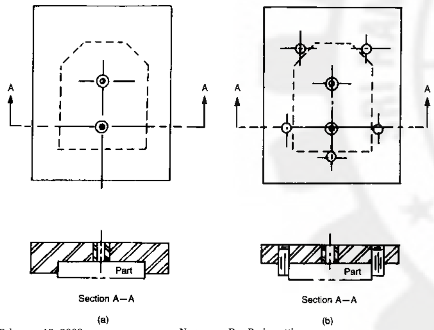
Types of Jigs

- Template jigs
- Plate jigs
- Universal jigs
- Leaf jigs
- Channel and tumble jigs
- Indexing jigs
- Miscellaneous jigs

Template jigs

- No clamping arrangement
- Plates with bushing to guide the tool
- Directly placed on the part
- Simple
- Least expensive

Nesting Template Drill Jigs



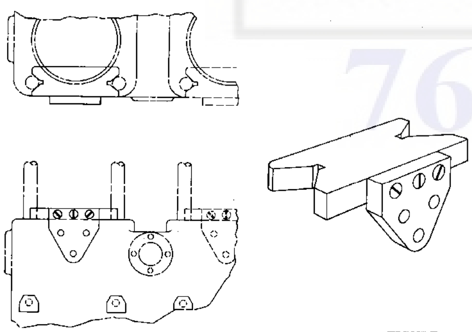


FIGURE 7-9
Template jig.

Template jigs

- Disadvantages
  - Not as foolproof as other types
  - Orientation of the hole pattern to workpiece datums may not be as accurate as other types
  - They are usually not practical when locating datums are dimensioned

Plate jigs

- A template jig with workpiece clamping system

Plate Jig

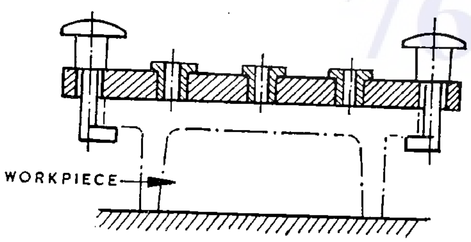
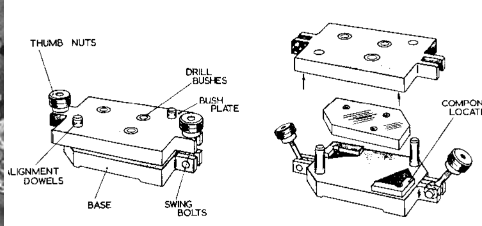


Plate Drill Jig



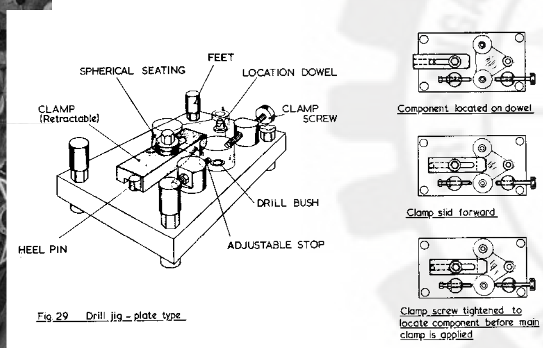


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Fig. 5-7 Plate jigs

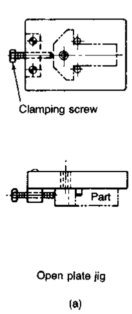

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Fig. 5-7 Plate jigs

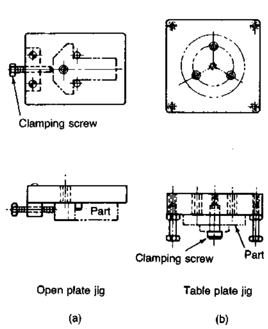

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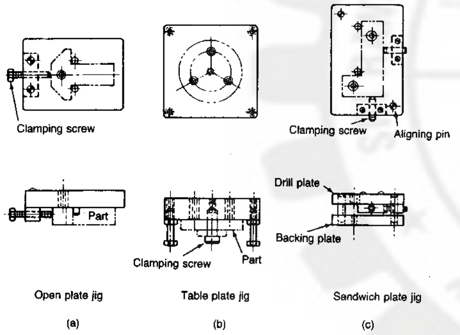
Fig. 5-7 Plate jigs



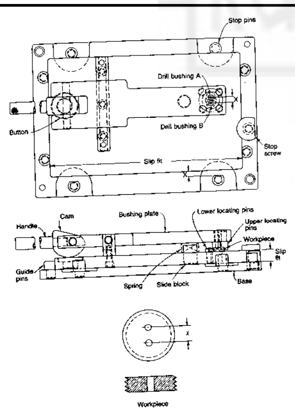


Fig. 8-15 Plate jig with quick-acting cam.

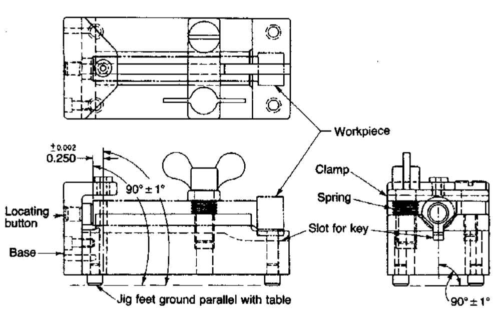
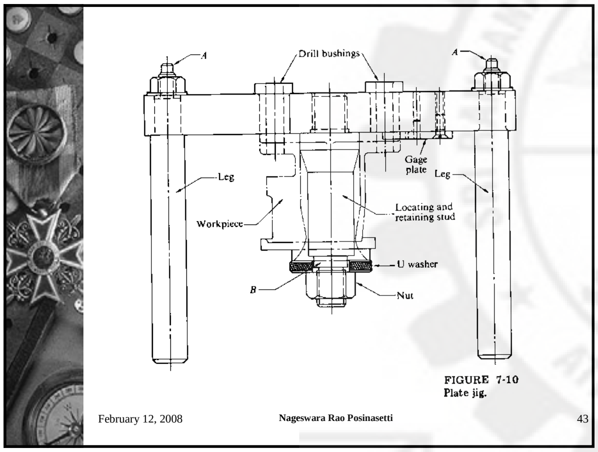


Fig. 8-21 Plate jig for cross-hole drilling. (*Courtesy SME Chapter 100*)


Drill bushings
A
A
Gage plate
Leg
Leg
Workpiece
Locating and retaining stud
U washer
B
Nut
FIGURE 7-10
Plate jig.
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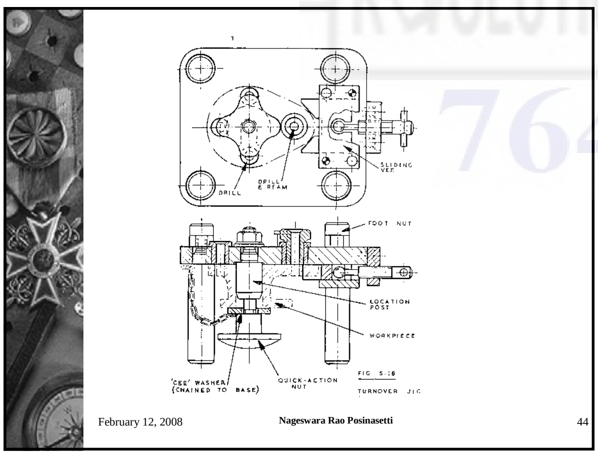
SLIDING VEE
DRILL
DRILL & REAM
FOOT NUT
LOCATION POST
WORKPIECE
'CEE' WASHER (CHAINED TO BASE)
QUICK-ACTION NUT
FIG 5.16
TURNOVER JIG
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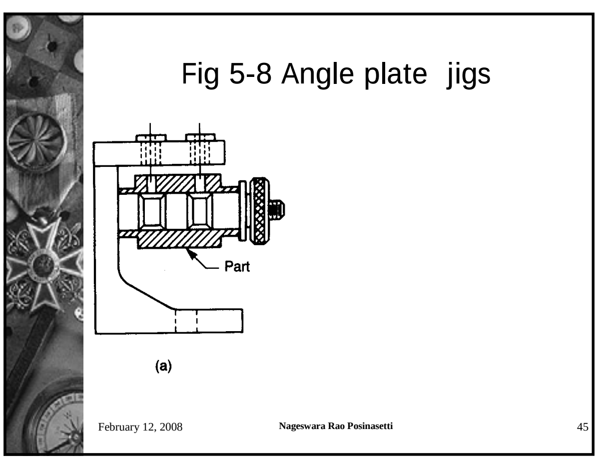
Fig 5-8 Angle plate jigs
Part
(a)
February 12, 2008
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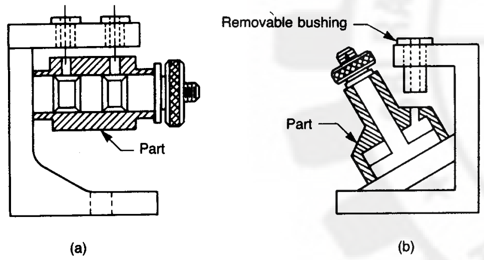
Fig 5-8 Angle plate jigs



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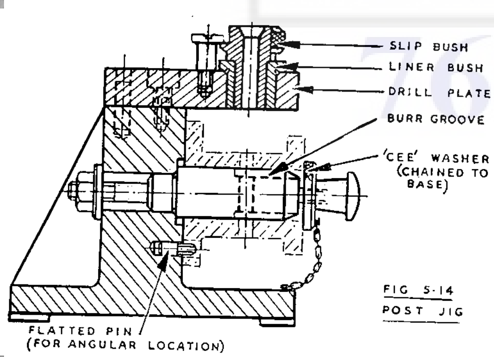

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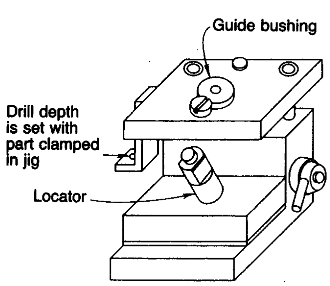

Pump jig for drilling a hole at a 60° angle. (

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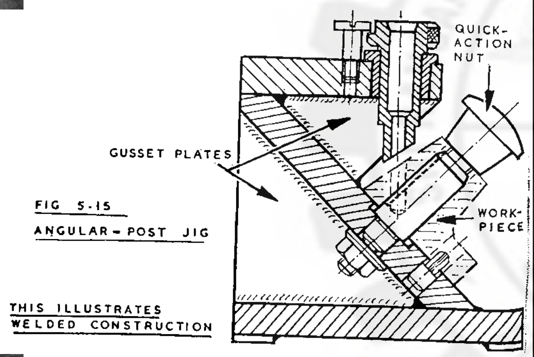
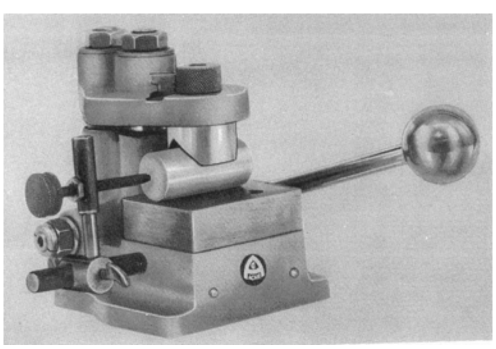
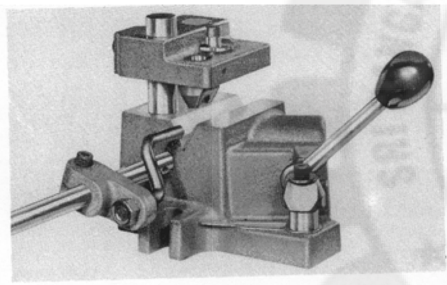


Universal jigs

- Also called as Pump jigs
- Universal that can be used for any given part by adding the necessary locators and bushes





(b)

(a) Universal jig ready for production, (b) adjustable cross-hole drill jig.

Leaf jigs

- Small
- Hinged leaf with bushes which also applies the clamping force

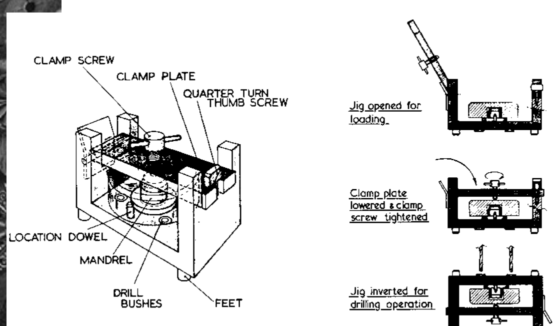


Fig. 22 Drill jig with swinging clamp plate

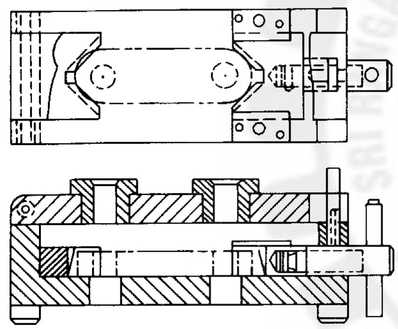


Fig. 8-25 Leaf jig for drilling two holes in a small connecting rod.

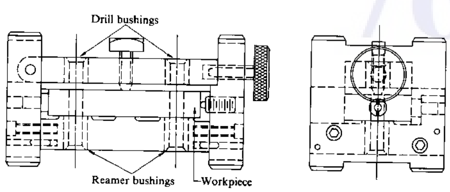


FIGURE 7-3
Leaf jig utilizing drill bushings in hinged plate and reamer bushings in base.

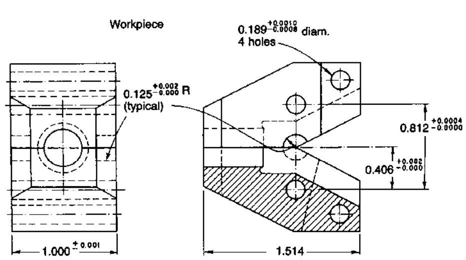


Fig. 8-26 Workpiece and leaf jig for workpiece-assembly drilling. (*Courtesy AMP, Inc.*)

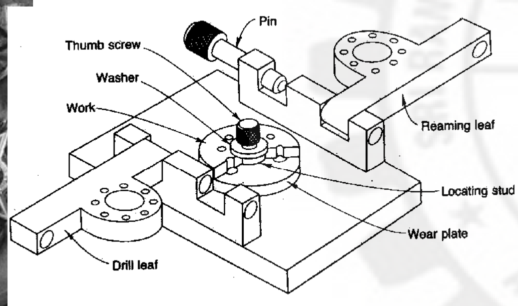


Fig. 8-29 Double leaf jig.[4]

Channel and tumble jigs

- For drilling in more than one surface
- Complicated and expensive

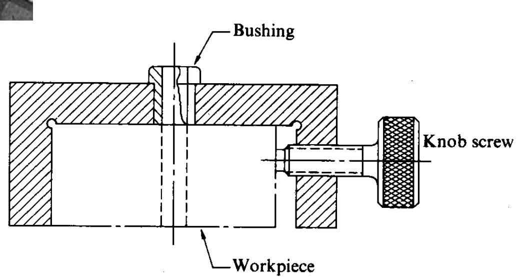


FIGURE 7-8
Channel jig.

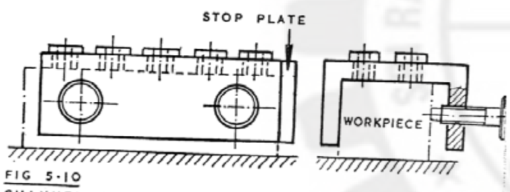


FIG 5-10
CHANNEL JIG

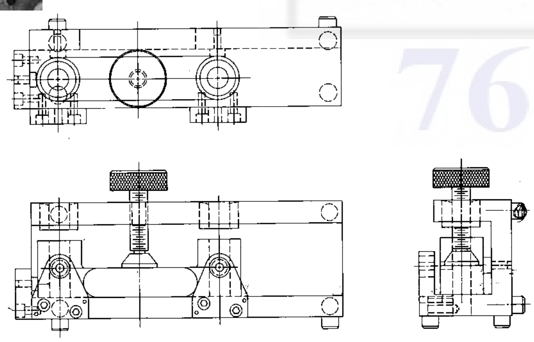


FIGURE 7-7
Box-type tumble jig.

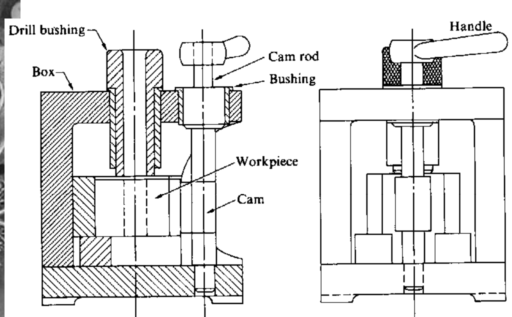


FIGURE 7-5
Box jig.

The example illustrated was designed to drill 4 holes equi-spaced around the tapered hub of a hand-wheel at right angles to the hub diameter.

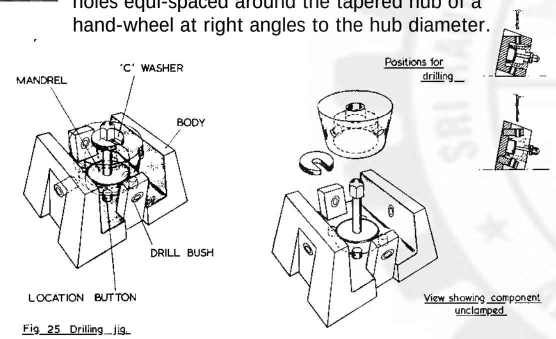


Fig. 25 Drilling jig

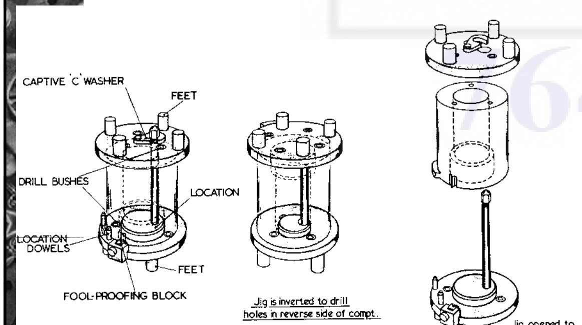


Fig. 26 Drilling jig

Indexing jigs

- To drill holes in a pattern
- Indexing arrangement

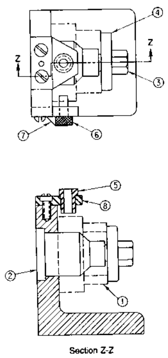


Fig. 8-37 Simple indexing jig with a base of standard angle iron.[4]

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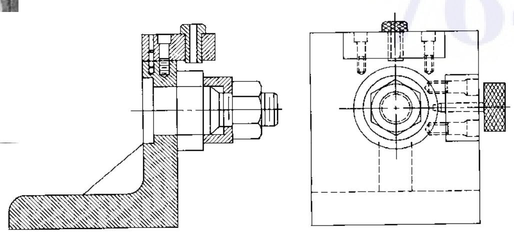

FIGURE 7-11
Simple indexing jig designed for drilling four holes in steel collar.

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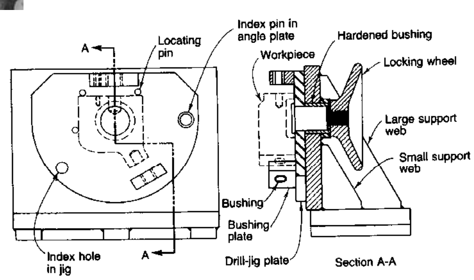

Fig. 8-38 Indexing jig of welded construction.[7]

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Miscellaneous jigs

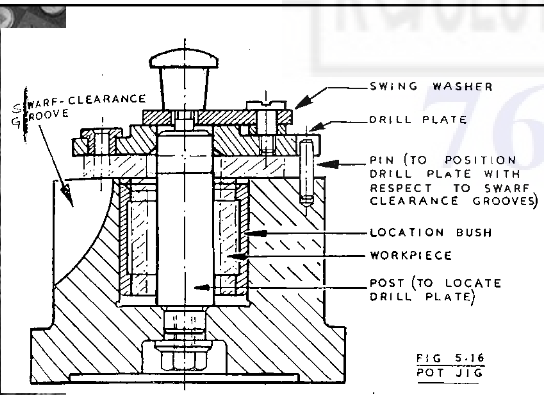


FIG 5.16 POT JIG

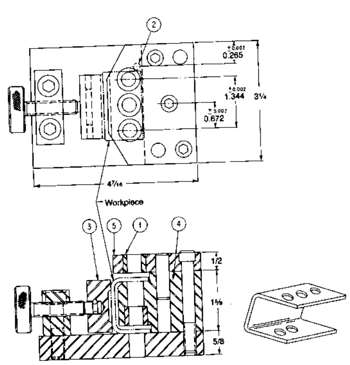


Fig. 8-14 Jig for drilling a channel. (Courtesy Barth Corp.)

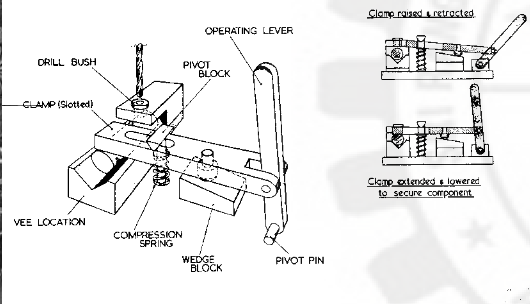
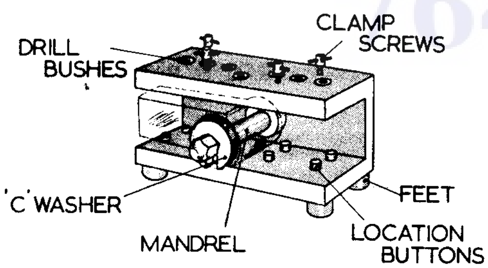
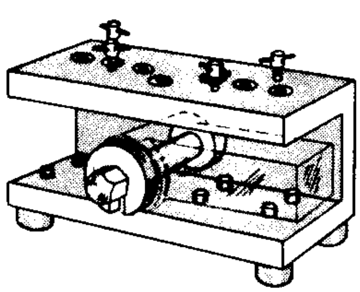


Fig 12 Drill jig with retractable wedge clamp

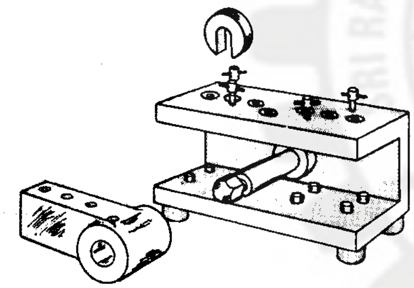
Drill Jig with R H Component



Drill Jig with L H Component



Drill Jig with R H Component unassembled



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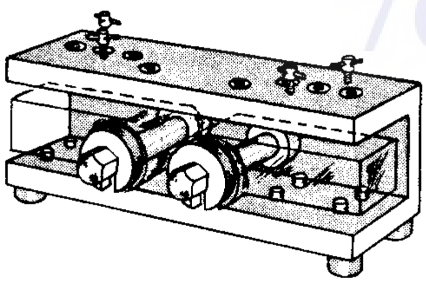
Drill Jig with R H and L H Components simultaneously



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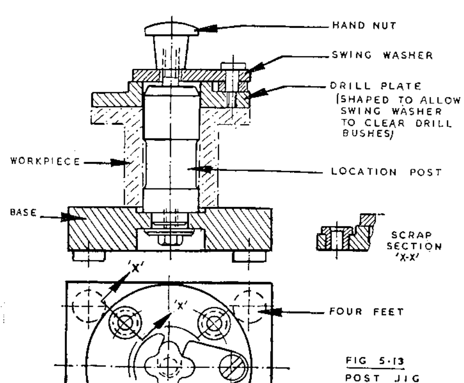

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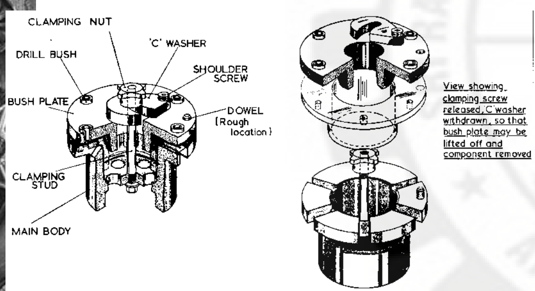
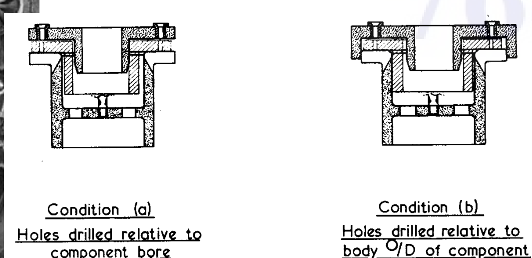
Pot Drill Jig



Pot Drill Jig



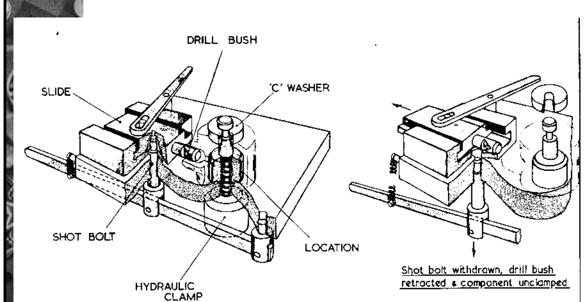
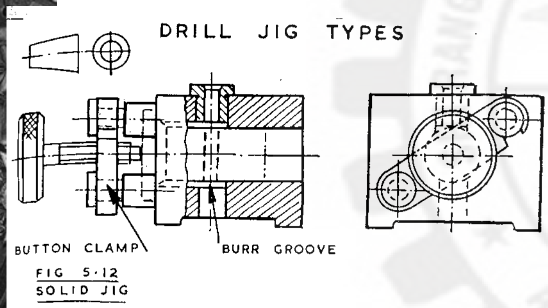


Fig 28 Drill jig with retractable drill bush



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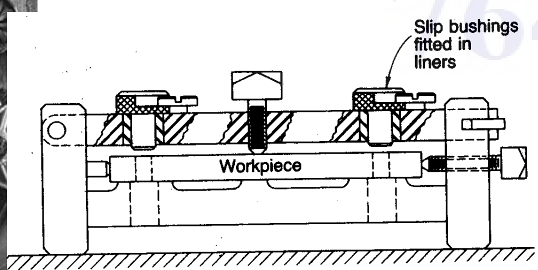

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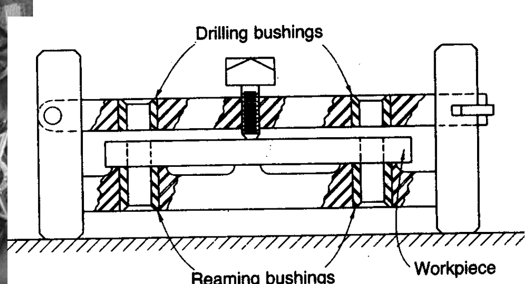

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Jig Design Guidelines

- Drill Jigs should be of light construction, consistent with rigidity to facilitate handling, especially when jigs have to be turned over so that holes can be drilled from more than one side.
- All unnecessary metal should be cored out of the jig body.

Jig Design Guidelines

- A jig which is not bolted to the machine table should be provided with feet, preferably four, opposite all surfaces containing guide bushings, so that it will 'rock' if not standing square on the table and so warn the operator.
- Clearance holes or burr slots should be provided in the jig to allow for the burr formed when the drill breaks through the component and for swarf clearance, particularly from locating faces.

Jig Design Guidelines

- Make all component clamping devices as quick acting as possible.
- Design the jig fool-proof by the use of foul pins and similar devices, that is arrange it so that the component, tools or bushes cannot be inserted except in the correct way.
- Make some locating points adjustable when the component is a rough casting and may be out of alignment.

Jig Design Guidelines

- Locate clamps so that they will be in the best position to resist the pressure of the cutting tool when at work.
- If possible, make all clamps integral parts of the jig and avoid the use of loose parts.
- Avoid complicated clamping and locating arrangements which are liable to wear or need constant attention.

Jig Design Guidelines

- Place all clamps as nearly as possible opposite some bearing point of the component to avoid springing the component and in accessible positions.
- All sharp edges should be removed from the various detail parts of the jig.
- Provide handles or other devices wherever these will make the handling of the jig more convenient.

Jig Design Guidelines

- If possible, place all tool guide bushings inside the geometrical figure formed by connecting the points of location of the feet.
- Make, if possible, all locating points visible to the operator when placing the component in position in the jig so that the component can be seen to be correctly located. The operator should also be able to have an unobstructed view of the clamps.

Jig Design Guidelines

- Before using the jig in the machine shop for commercial purposes, test all jigs as soon as they are made.
- The location points, which are hardened if necessary, are established with considerations to machining operations, if any, to follow and that any mating parts are located from the same datum surface.

Jig Design Guidelines

- Locating and clamping arrangements are designed to reduce idle time to a minimum by using simple clamps which are easy and quick to operate and also operate without damaging the component.
- Springs should be used whenever possible to elevate the clamps clear of the component whilst being loaded or unloaded.

Jig Design Guidelines

- Clamps should be positioned above the points supporting the component, in order to avoid distortion and should be strong enough to hold the component without bending.
- Generally clamps should not be relied upon for holding the work against the pressure exerted by the cutting tool.

Jig Design Guidelines

- Locating and supporting surfaces should, whenever possible, be renewable.
  - – Such surfaces should be of hard material.

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Jig Design Guidelines

- The process of inserting and withdrawing the component from the jig should be as easy as possible.
  - – Ample space should be left between the jig body and the component for hand movements.
  - – Some means of ejection should exist to release the component if it sticks in the jig.

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Jig Design Guidelines

- The design of the jig must be safe.
  - – Handles or levers should be large enough to clear adjacent parts so that pinched fingers are avoided.

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Jig Design Guidelines

- If necessary, make provision for the use of coolant.
- Position locations at places where there is no flash or burr on the component.

Jig Design Guidelines

- If possible, eliminate spanners by the use of levers.
  - If spanners have to be used, make one spanner fit all the clamp operating bolts and nuts.
- Consideration should be given at the design stage to the use of standardised jig components.

Power requirement for Drilling

$$Torque,\ M = K\ A\ f^{0.8}\ d^{1.8}$$

$$Thrust,\ T = 2\ K\ B\ f^{0.8}\ d^{0.8} + K\ E\ d^{2}$$

- d = drill diameter, in
- K, A, B, E - Constants

TABLE 8-1
Work-Material Constants for Calculating Torque and Thrust

Work Material	*K*
Steel, 200 Bhn	24,000
Steel, 300 Bhn	31,000
Steel, 400 Bhn	34,000
Most aluminum alloys	7,000
Most magnesium alloys	4,000
Most brasses	14,000
Leaded brass	7,000
Cast iron, 165 Bhn	15,000
Free-machining mild steel, resulfurized	18,000
Austenitic stainless steel (Type 316)	34,000

TABLE 8-2
Torque and Thrust Constants Based upon Ratios *c/d* or *w/d*

c/d	Approx. *w/d*	Torque constant *A*	Thrust constant *B*	Thrust constant *E*
0.03	0.025	1.000	1.100	0.001
0.05	0.045	1.005	1.140	0.003
0.08	0.070	1.015	1.200	0.006
0.10	0.085	1.020	1.235	0.010
0.13	0.110	1.040	1.270	0.017
0.15	0.130	1.080	1.310	0.022
0.18	0.155	1.085	1.355	0.030
0.20	0.175	1.105	1.380	0.040
0.25	0.220	1.155	1.445	0.065
0.30	0.260	1.235	1.500	0.090
0.35	0.300	1.310	1.575	0.120
0.40	0.350	1.395	1.620	0.160

(*Courtesy National Twist Drill, Div. of Regal-Beloit Corp.*)

* *c* = chisel edge length, in. (mm)
d = drill diameter, in. (mm)
w = web thickness, in. (mm)

TABLE 8-3
Torque and Thrust Terms Based upon Feed

Feed, *f*, ipr	$f^{0.8}$	Feed, *f*, ipr	$f^{0.8}$
0.0005	0.0025	0.012	0.030
0.001	0.004	0.015	0.035
0.002	0.007	0.020	0.045
0.003	0.010	0.025	0.055
0.004	0.012	0.030	0.060
0.005	0.014	0.035	0.070
0.006	0.017	0.040	0.075
0.008	0.020	0.050	0.090
0.010	0.025		

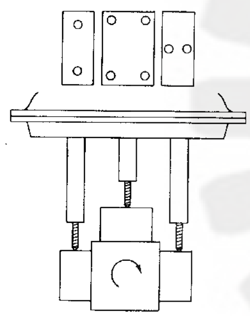

Fig. 8-47 Trunnion fixture.

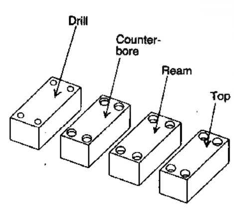

Fig. 8-48 Progressive operations: part and fixture moved to various working positions or stations.

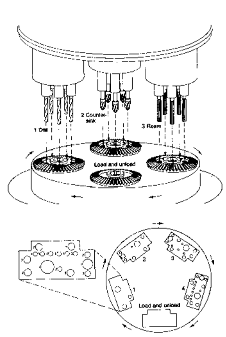

Fig. 8-49 Rotary indexing.

Basic Design Steps

- 1. Method of locating the part – identify the standard components required for locating purpose.
- 2. Design the clamping method. Make a proper choice of clamps – C-washer, swing washer, nut, strap clamp, toggle clamp, etc.
- 3. Design any supports required
- 4. Design the jig bushes required.
- 5. Design the jig body.

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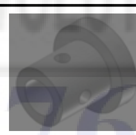
Design Study – Drill Jig



- 1. Method of locating the part – The central hole which helps in locating as well as indexing for the hole.
- 2. Clamping can be done with a nut and a C-washer
- Indexing will have to be done with a plunger type retracting.

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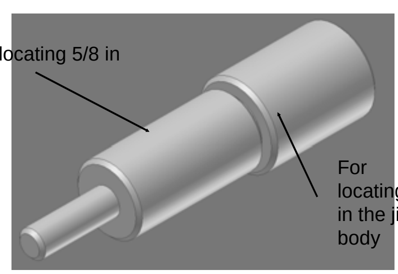

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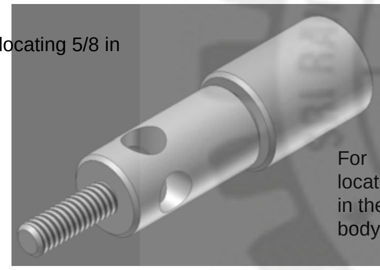

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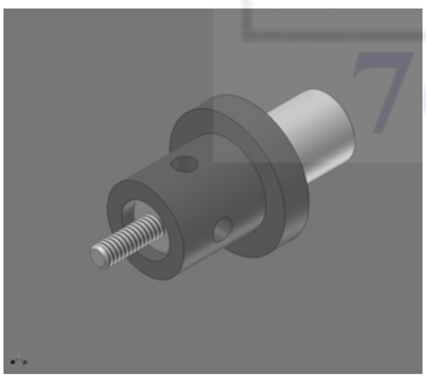

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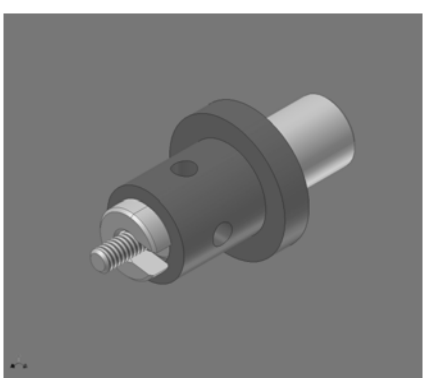

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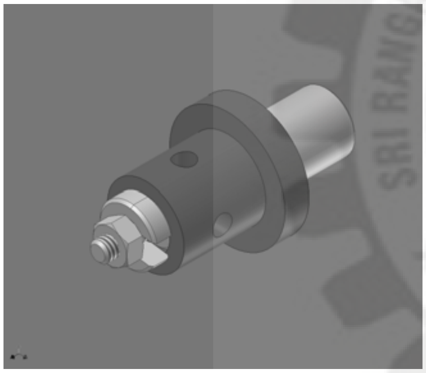

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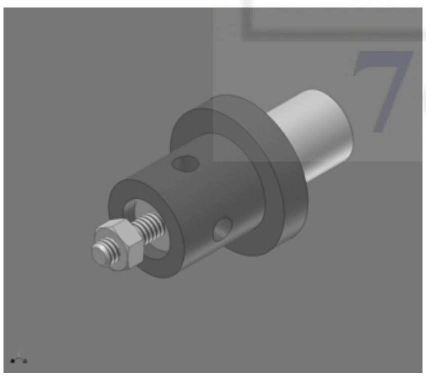

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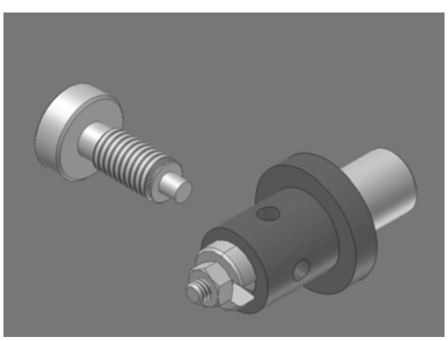

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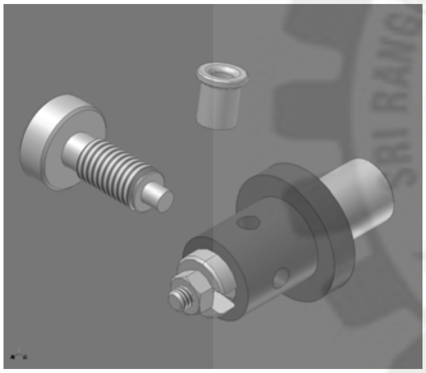

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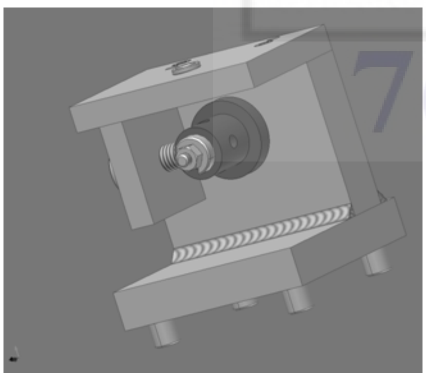

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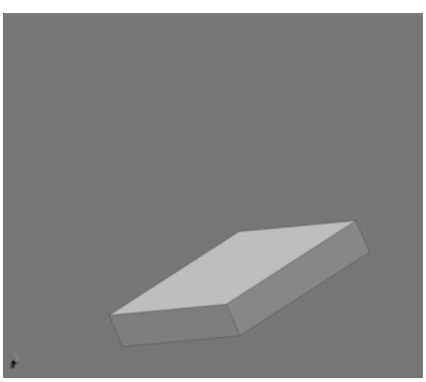

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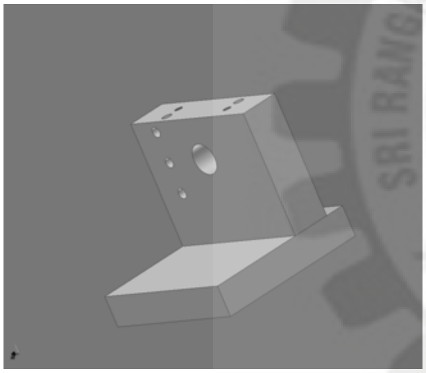

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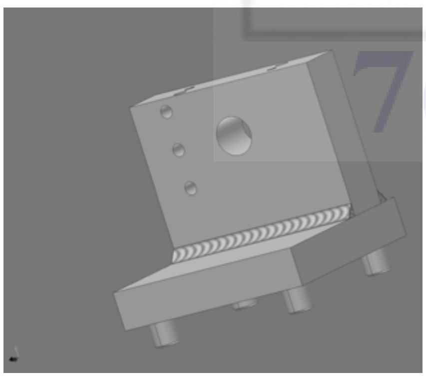

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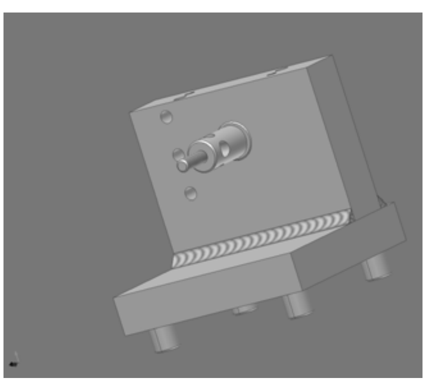

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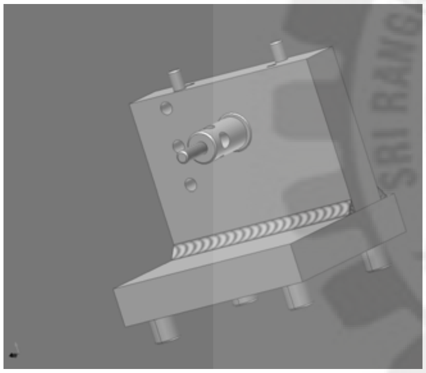

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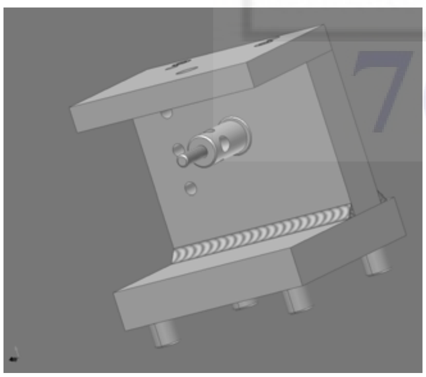

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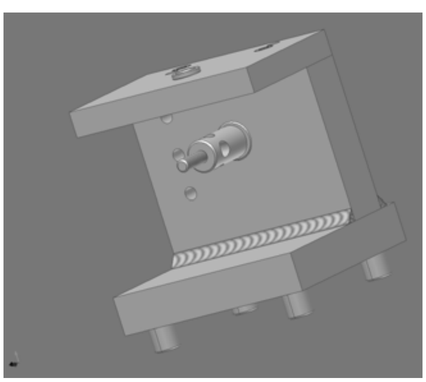

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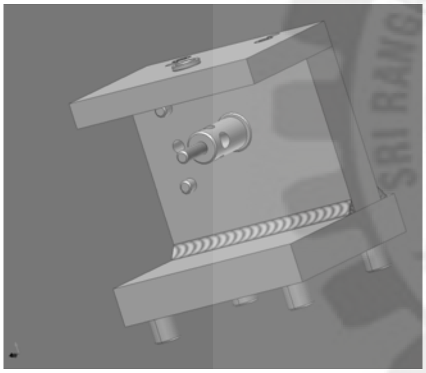

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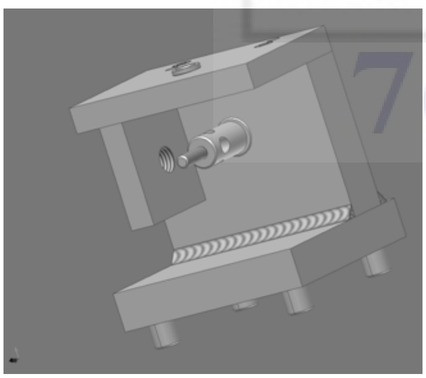

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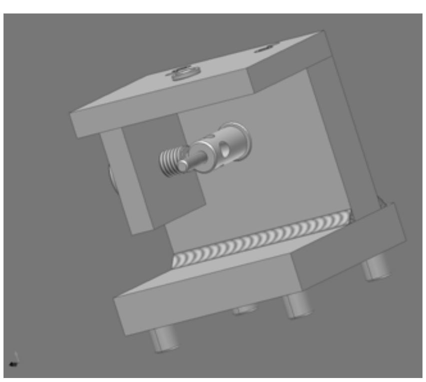

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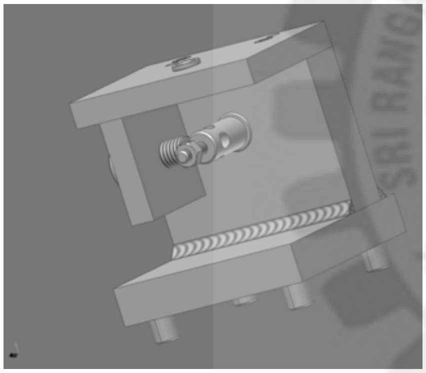

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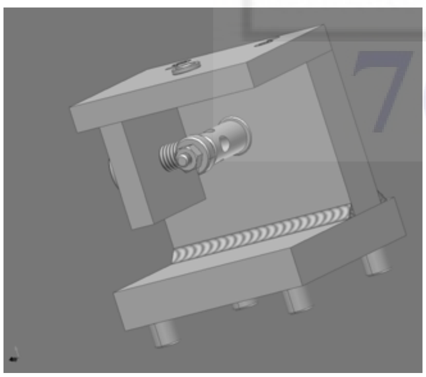

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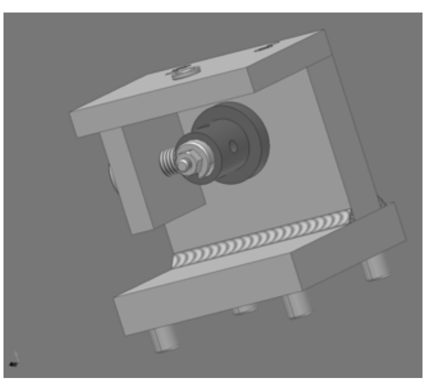

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A Review on Design of Fixtures

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ABSTRACT - In machining fixtures, minimizing workpiece deformation due to clamping and cutting forces is essential to maintain the machining accuracy. The various methodology used for clamping operation used in different application by various authors are reviewed in this paper. Fixture is required in various industries according to their application. This can be achieved by selecting the optimal location of fixturing elements such as locators and clamps. The fixture set up for component is done manually. For that more cycle time required for loading and unloading the material. So, there is need to develop system which can help in improving productivity and time. Fixtures reduce operation time and increases productivity and high quality of operation is possible.

keywords: fixture, accuracy, clamping, productivity.

I. INTRODUCTION

The fixture is a special tool for holding a work piece in proper position during manufacturing operation. For supporting and clamping the work piece, device is provided. Frequent checking, positioning, individual marking and non-uniform quality in manufacturing process is eliminated by fixture. This increase productivity and reduce operation time. Fixture is widely used in the industry practical production because of feature and advantages.

To locate and immobilize workpieces for machining, inspection, assembly and other operations fixtures are used. A fixture consists of a set of locators and clamps. Locators are used to determine the position and orientation of a workpiece, whereas clamps exert clamping forces so that the workpiece is pressed firmly against locators. Clamping has to be appropriately planned at the stage of machining fixture design. The design of a fixture is a highly complex and intuitive process, which require knowledge. Fixture design plays an important role at the setup planning phase. Proper fixture design is crucial for developing product quality in different terms of accuracy, surface finish and precision of the machined parts In existing design the fixture set up is done manually, so the aim of this project is to replace with hydraulic fixture to save time for loading and unloading of component. Hydraulic fixture provides the manufacturer for flexibility in holding forces and to optimize design for machine operation as well as process functionability.

Steps of fixture design

Successful fixture designs begin with a logical and systematic plan. With a complete analysis of the fixture's functional requirements, very few design problems occur. When they do, chances are some design requirements were forgotten or underestimated. The workpiece, processing, tooling and available machine tools may affect the extent of planning needed. Preliminary analysis may take from a few hours up to several days for more complicated fixture designs. Fixture design is a five-step problem-solving process. The following is a detailed analysis of each step.

Step 1: Define Requirements

To initiate the fixture-design process, clearly state the problem to be solved or needs to be met. State these requirements as broadly as possible, but specifically enough to define the scope of the design project. The designer should ask some basic questions: Is the new tooling required for first-time production or to improve existing production?

Step 2: Gather/Analyze Information

Collect all relevant data and assemble it for evaluation. The main sources of information are the part print, process sheets, and machine specifications. Make sure that part documents and records are current. For example, verify that the shop print is the current revision, and the processing information is up-to-date. Check with the design department for pending part revisions. An important part of the evaluation process is note taking. Complete, accurate notes allow designers to record important information. With these notes, they should be able to fill in all items on the "Checklist for Design Considerations." All ideas, thoughts, observations, and any other data about the part or fixture are then available for later reference. It is always better to have too many ideas about a particular design than too few. Four categories of design considerations need to be taken into account at this time: workpiece specifications, operation variables, availability of equipment, and personnel. These categories, while separately covered here, are actually

interdependent. Each is an integral part of the evaluation phase and must be thoroughly thought out before beginning the fixture design.

Step 3: Develop Several Options

This phase of the fixture-design process requires the most creativity. A typical workpiece can be located and clamped several different ways. The natural tendency is to think of one solution, then develop and refine it while blocking out other, perhaps better solutions. A designer should brainstorm for several good tooling alternatives, not just choose one path right away. During this phase, the designer's goal should be adding options, not discarding them. In the interest of economy, alternative designs should be developed only far enough to make sure they are feasible and to do a cost estimate. The designer usually starts with at least three options: permanent, modular, and general-purpose workholding. Each of these options has many clamping and locating options of its own. The more standard locating and clamping devices that a designer is familiar with, the more creative he can be. Areas for locating a part include flat exterior surfaces (machined and unmachined), cylindrical and curved exterior surfaces. The exact procedure used to construct the preliminary design sketches is not as important as the items sketched. Generally, the preliminary sketch should start should start with the part to be fixtured. The required locating and supporting elements, including a base, should be the next items added. Then sketch the clamping devices. Finally, add the machine tool and cutting tools. Sketching these items together helps identify any problem areas in the design of the complete fixture.

Step 4: Choose the Best Option

The total cost to manufacture a part is the sum of per-piece run cost, setup cost, and tooling cost. Expressed as a formula:

$$\text{Cost per Part} = \text{Run Cost} + \frac{\text{Setup Cost}}{\text{Lot Size}} + \frac{\text{Tooling Cost}}{\text{Total Quanity Over Tooling Lifetime}}$$

These variables are described below with sample values from three tooling options: a modular fixture, a permanent fixture, and a hydraulically powered permanent fixture.

Step 5: Implement the Design

The final phase of the fixture-design process consists of turning the chosen design approach into reality. Final details are decided, final drawings are made, and the tooling is built and tested. The following guidelines should be considered during the final-design process to make the fixture less costly while improving its efficiency. These rules are a mix of practical considerations, sound design practices, and common sense [9].

i. Use standard components: The economies of standard parts apply to tooling components as well as to manufactured products. Standard, readily available components include clamps, locators, supports, studs, nuts, pins and a host of other elements. Most designers would never think of having the shop make cap screws, bolts or nuts for a fixture. Likewise, no standard tooling components should be made in-house. The first rule of economic design is: Never build any component you can buy. Commercially available tooling components are manufactured in large quantities for much greater economy. In most cases, the cost of buying a component is less than 20% of the cost of making it.

Labor is usually the greatest cost element in the building of any fixture. Standard tooling components are one way to cut labor costs. Browse through catalogs and magazines to find new products and application ideas to make designs simpler and less expensive.

ii. Use prefinished materials: Prefinished and preformed materials should be used where possible to lower costs and simplify construction. These materials include precision-ground flat stock, drill rod, structural sections, cast tooling sections, precast tooling bodies, tooling plates, and other standard preformed materials. Including these materials in a design both reduces the design time and lowers the labor cost.

iii. Eliminate finishing operations: Finishing operations should never be performed for cosmetic purposes. Making a fixture look better often can double its cost. Here are a few suggestions to keep in mind with regard to finishing operations.

iv. Keep tolerances as liberal as possible: The most cost-effective tooling tolerance for a locator is approximately 30% to 50% of the workpiece's tolerance. Tighter tolerances normally add extra cost to the tooling with little benefit to the process. Where necessary, tighter tolerances can be used, but tighter tolerances do not necessarily result in a better fixture, only a more expensive one.

II .IMPORTANT CONSIDERATIONS WHILE DESIGNING JIGS AND FIXTURES.

Designing of jigs and fixtures depends upon so many factors. These factors are analyzed to get design inputs for jigs and fixtures. The list of such factors is mentioned below :

a. Study of workpiece and finished component size and geometry.

b. Type and capacity of the machine, its extent of automation.

c. Provision of locating devices in the machine.

d. Available clamping arrangements in the machine.

e. Available indexing devices, their accuracy.

f. Evaluation of variability in the performance results of the machine.

g. Rigidity and of the machine tool under consideration.

h. Study of ejecting devices, safety devices, etc.

i. Required level of the accuracy in the work and quality to be produced.

III. MEANING OF LOCATION

The location refers to the establishment of a desired relationship between the workpiece and the jigs or fixture correctness of location directly influences the accuracy of the finished product. The jigs and fixtures are desired so that all undesirable movements of the workpiece can be restricted. Determination of the locating points and clamping of the workpiece serve to restrict movements of the component in any direction, while setting it in a particular pre-decided position relative to the jig. Before deciding the locating points it is advisable to find out the all possible degrees of freedom of the workpiece. Then some of the degrees of freedom or all of them are restrained by making suitable arrangements. These arrangements are called locators. These are described in details below[11]:

1.PRINCIPLES OF LOCATIONS

The principle of location is being discussed here with the help of a most popular example which is available in any of the book covering jigs and fixtures. It is important that one should understand the problem first. Any rectangular body many have three axis along x-axis, y-axis and z-axis. It can more along any of these axes or any of its movement can be released to these three axes. At the same time the body can also rotate about these axes too. So total degree of freedom of the body along which it can move is six. For processing the body it is required to restrain all the degree of freedom (DOF) by arranging suitable locating points and then clamping it in a fixed and required position. The basic principle used to locate the points is desirable below. Six Points Location of a Rectangular Block. It is made to rest on several points on the jig body. Provide a rest to workpiece on three points on the bottom x-y surface. This will stop the movement along z-axis, rotation with respect to x-axis and y-axis. Supporting it on the three points is considered as better support then one point or two points. Rest the workpiece on two points of side surface (x-z), this will fix the movement of workpiece along y-axis and rotation with respect to z-axis. Provide a support at one point of the adjacent surface (y-z) that will fix other remaining free movements. This principle of location of fixing points on the workpiece is also named as 3-2-1 principle of fixture design as numbers of points selected at different faces of the workpiece are 3, 2 and 1 respectively. If the operation to be done on the cylindrical object requires restriction of the above mentioned free movements also than some more locating provisions must also be incorporated in addition to use of the Vee block. Guohua Qin[1] focuses on the fixture clamping sequence. It consists of two parts:

a. For the first time he evaluated varying contact forces and workpiece position errors in each clamping step by solving a nonlinear mathematical programming problem. This is done by minimizing the total complementary energy of the workpiece-fixture system. The prediction proves to be rigorous and reasonable after comparing with experimental data and referenced results.

b. The optimal clamping sequence is identified based on the deflections of the workpiece and minimum position error. Finally, To predict the contact forces and to optimize the clamping sequence three examples are discussed.

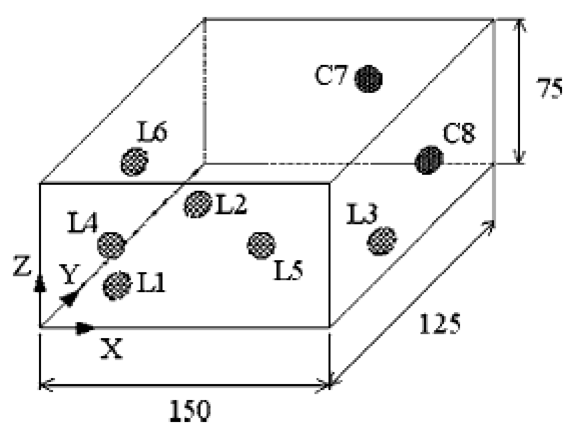

Fig. 1 Scheme of 3-2-1 fixture setup [1].

First mathematical modeling for clamping sequence is done then he determined the contact forces in clamping sequence as shown in fig. 1. After that he optimized of clamping sequence for higher stiffness workpiece and low stiffness workpiece. He found that with the use of optimal clamping sequence, good agreements are achieved between predicted results and experimental data and the workpiece machining quality can be improved .

For a fixture designer, the major portion of design time is spent deciding how to locate the work piece in the fixture. You know that any free body has a total of twelve degrees of freedom as below:

6 translational degrees of freedom**: +X, -X, +Y, -Y, +Z, -Z**

And 6 rotational degrees of freedom:

- Clockwise around X axis (**CROT-X**)

- Anticlockwise around X axis (**ACROT-X**)

- Clockwise around Y axis (**CROT-Y**)

- Anticlockwise around Y axis (**ACROT-Y**)

- Clockwise around Z axis (**CROT-Z**)

- Anticlockwise around Z axis (**ACROT-Z**)

You must fix all the 12 degrees of freedom except the three transitional degrees of freedom (-X, -Y and -Z) in order to locate the work piece in the fixture. So, 9 degrees of freedom of the work piece need to be fixed. But, how? By using the **3-2-1 method** as shown below in fig. 2 :

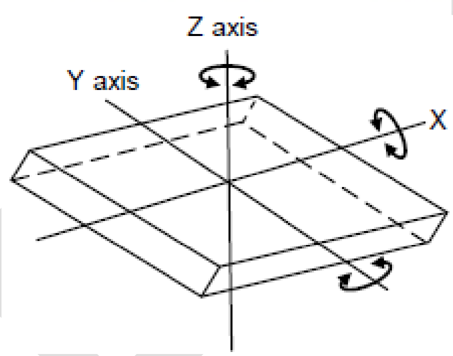

Fig. 2 Available Degree of Freedom of Rectangular Block[11]

Now, rest the work piece at **two** points of side surface (XZ), and you will be able to fix the **+Y** and **ACROT-Z** degrees of freedom. Now, rest the work piece at **one** point of the adjacent surface (YZ), and you will be able to fix the **+X** and **CROT-Z** degrees of freedom. So, you can successfully fixate **9** required degrees of freedom by using the 3-2-1 principle of fixture design.

Nicholas Amaral [6] develop a method for modeling workpiece boundary conditions and applied loads during a machining process, optimize support locations, using finite element analysis (FEA) and analyses modular fixture tool contact area deformation. The workpiece boundary conditions are defined by locators and clamps. To constrain using linear spring-gap elements the locators are placed in a 3-2-1 fixture configuration and modeled using all degrees of freedom of the workpiece. To model cutting forces during drilling and milling machining operations, the workpiece is loaded. Fixture design integrity is verified. To develop an algorithm to automatically optimize fixture support and clamp locations. To minimize deformation in workpiece, subsequently increasing machining accuracy ANSYS parametric design language code is used. Unnecessary and uneconomical "trial and error" experimentation on the shop floor is eliminated by implementing

FEA in a computer-aided-fixture-design environment.

2. DIFFERENT METHODS USED FOR LOCATION

There are different methods used for location of a work. The locating arrangement should be decided after studying the type of work, type of operation, degree of accuracy required. Volume of mass production to be done also mattes a lot. Different locating methods are described below.:

Flat Locator

Flat locators are used for location of flat machined surfaces of the component. Three different examples which can be served as a general principle of location are described here for flat locators. These examples are illustrated in Fig. 3

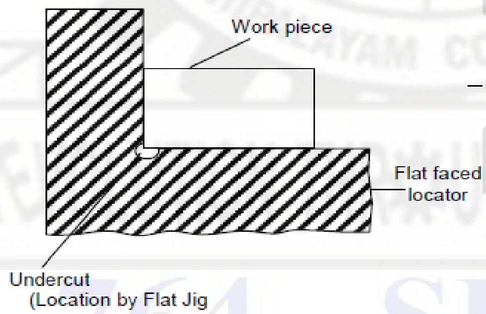

Fig. 3 Flat locator[11]

A flat surface locator can be used as shown in first figure. In this case an undercut is provided at the bottom where two perpendicular surfaces intersect each other. This is made for swarf clearance. The middle figure shows flat headed button type locator. There is no need to made undercut for swarf clearance. It is used for locating components having drilled holes. The cylindrical component to be located is gripped by a cylindrical locator fitted to the jig's body and inserted in the drilled hole of the component.

Jack Pin Locator

Jack pin locator is used for supporting rough workpieces from the button as shown in Fig. 4. Height of the jack pin is adjustable to accommodate the workpieces having variation in their surface texture. So this is a suitable method to accommodate the components which are rough and un-machined.

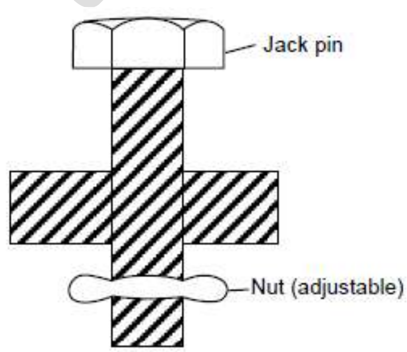

Fig. 4 Jack Pin Locator[11]

Drill Bush Locator

The drill bush locator is used for holding and locating the cylindrical workpieces. The bush has conical opening for locating purpose and it is sometimes screwed on the jigs body for the adjustment of height of the work.

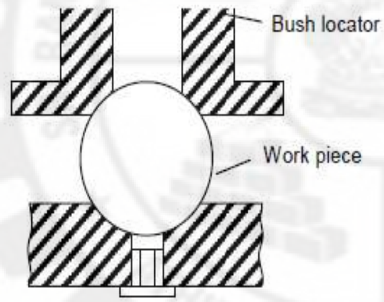

Fig. 5 Drill Bush Locator[11]

Vee Locators

This is quick and effective method of locating the workpiece with desired level of accuracy. This is used for locating the circular and semi-circular type of workpiece. The main part of locating device is Vee shaped block which is normally fixed to the jig. This locator can be of two types fixed Vee locator and adjustable Vee locator. The fixed type locator is normally fixed on the jig and adjustable locator can be moved axially to provide proper grip of Vee band to the workpiece.

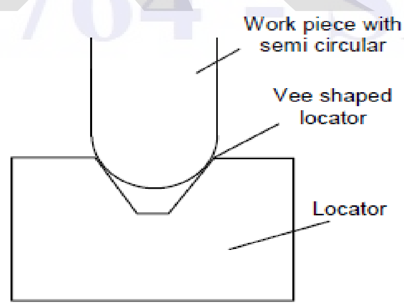

Fig. 6 Vee Locator[11]

Locating error and machining error were studied by systematic method of error identification and calculation, in which. using finite element analysis (FEA). The machining error, the surface error shown in fig. 7 generated from machining operations by Y. Wang [7].

Fig. 7 Surface error sources [7].

A methodology of machined surface error calculation and error decomposition was presented in this paper. The research has focused on (a) surface error including both locating error and machining error, also machining error generated during multi machining operations was analyzed; (b) the sensitivity of individual errors was investigated, and the resultant surface error of locating and machining was evaluated against tolerance; and (c) the method is suitable for both components with complex geometry as well as simple geometry.

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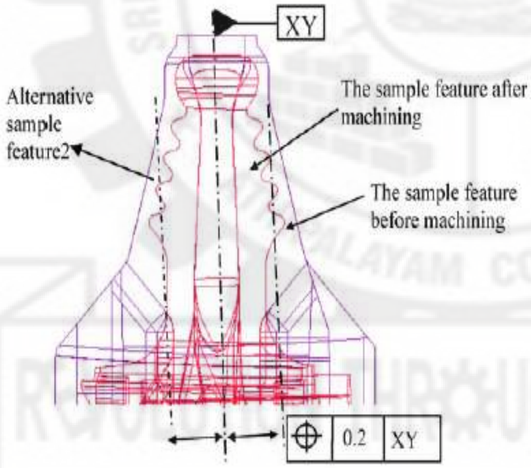

Fig. 8 Tolerance of the sample feature [7]

The surface error analysis of a sample feature of turbine blades was presented to demonstrate the developed procedure and analysis. The result suggested that the component does not satisfy the tolerance requirement due to fixture related errors such as clamping deformation shown in fig. 8, workpiece movement, and workpiece twist. The methods of error reduction were proposed

IV. CLAMPING

To restrain the workpiece completely a clamping device is required in addition to locating device and jigs and fixtures. A clamping device holds the workpiece securely in a jig or fixture against the forces applied over it during on operation. Clamping device should be incorporated into the fixture, proper clamp in a fixture directly influence the accuracy and quality of the work done and production cycle time. Basic requirement of a good clamping device are listed below :

a. It should rigidly hold the workpiece.

b. The workpiece being clamped should not be damaged due to application of clamping pressure by the clamping unit.

c. The clamping pressure should be enough to overcome the operating pressure applied on the workpiece as both pressure act on the workpiece in opposite directions.

d. Clamping device should be capable to be unaffected by the vibrations generated during an operation.

e. It should also be user friendly, like its clamping and releasing should be easy and less time consuming. Its maintenance should also be easy.

f. Clamping pressure should be directed towards the support surfaces or support points to prevent undesired lifting of workpiece from its supports.

g. Clamping faces should be hardened by proper treatments to minimize their wearing out.

h. To handle the workpieces made of fragile material the faces of clamping unit should be equipped with fiber pads to avoid any damage to workpiece.

J. Cecil[5] proposed an innovative clamping design approach is described in the context of fixture design activities. The clamping design approach involves identification of clamping surfaces and clamp points on a given workpiece. This approach can be applied in conjunction with a locator design approach to hold and support the workpiece during machining and to position the workpiece correctly with respect to the cutting tool. Detailed steps are given for automated clamp design. Geometric reasoning techniques are used to determine feasible clamp faces and positions. The required inputs include CAD model specifications, features identified on the finished workpiece, locator points and elements.

1.DIFFERENT TYPES OF CLAMPS

Different variety of clamps used with jigs and fixtures are classified into different categories are discussed here:

Strap Clamp

This is also called edge clamp. This type clamping is done with the help of a lever pressure acting as a strap on the workpiece. Different types of strap clamps are discussed below.

Heel Clamp

Rotation of the clamp in clockwise direction is prevented and it is allowed in anticlockwise direction. For releasing the workpiece the clamping nut is unscrewed. The free movements in anticlockwise direction takes place before un-securing the nut to release the workpiece.

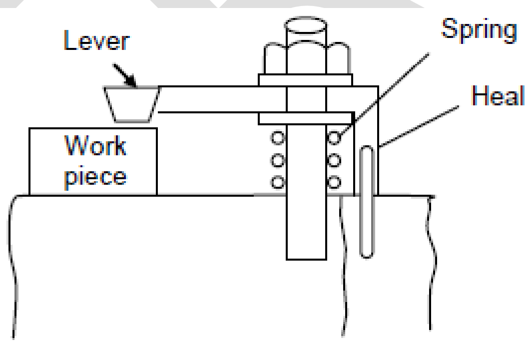

Fig. 9 Heel Clamp[11]

Bridge Clamp

The bridge clamp applies more clamping pressure as compared to heel clamp. The clamping pressure experienced by the workpiece depends on the distances „x‟ and „y‟ marked. To release the workpiece the nut named as clamping nut is unscrewed. The spring lifts the lever to release the workpiece.

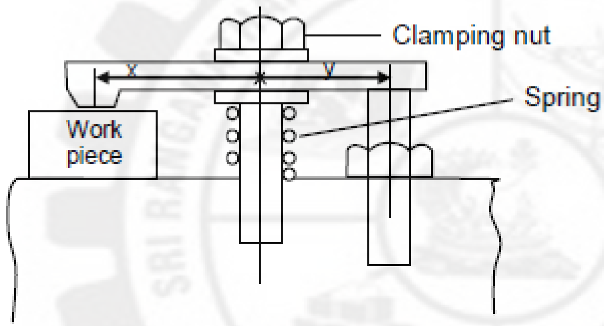

Fig. 10 Bridge Clamp

Edge Clamp or Side Clamp

A side clamp is also known as edge clamp. In this case the surface to be machined is always clamped above the clamping device. This clamping device is recommended for fixed length workpiece. Releasing and clamping of the workpiece can be accomplished by unscrewing and screwing of the clamping nut respectively.

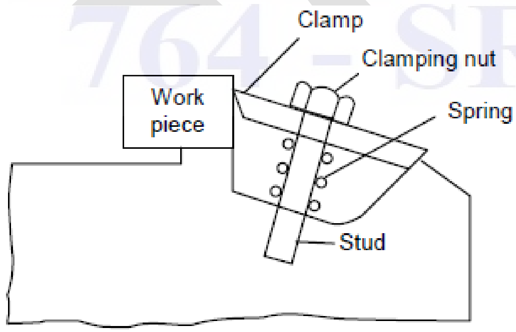

Fig. 11 Edge Clamp or Side Clamp[11]

Screw Clamp

The screw clamp is also known as clamp screw. This clamping apply pressure directly on the side faces of the workpiece.

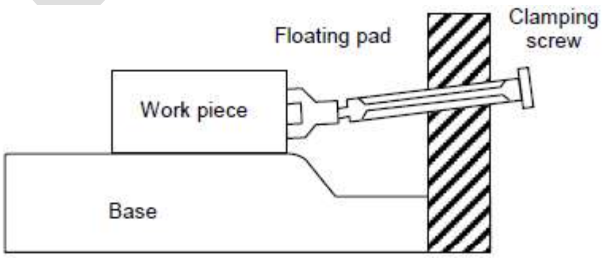

Fig. 12 Screw Clamp[11]

There is a floating pad at their end to serve the following purposes :

a. It prevents displacement of workpiece and slip.

b. It prevents denting of clamping area of workpiece.

c. The available cushion prevents deflection of screw.

In addition to the above there are some disadvantages associated with this method. The clamping pressure largely depends on the workpiece; it varies from one workpiece to other. It is more time consuming and more efforts are required.

Latch Clamp

Latch clamps are used to clamp the workpiece, the clamping system is normally locked with the help of a latch provided. To unload the workpiece the tail end of the latch is pushed that causes the leaf to swung open, so releasing the workpiece. Here time consumed in loading and unloading is very less as no screw is tightened but clamping pressure is not so high as in other clamping devices. Life of this type of clamping device is small.

Equalizing Clamps

Equalizing clamp is recommended to apply equal pressure on the two faces of the work. The pressure applied can be varied by tightened or loosening the screw provided for the purpose.

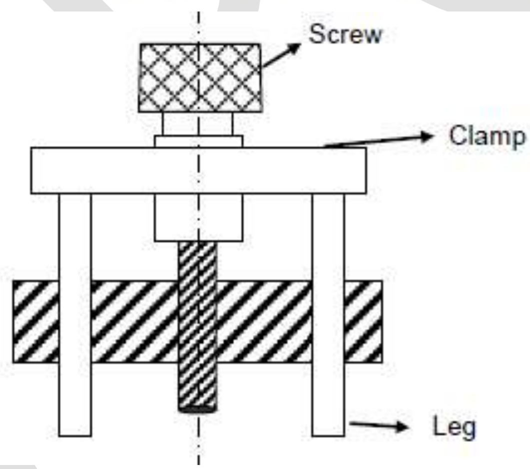

Fig. 13 Equalizing Clamps[11]

Power Driven Clamping

Light duty clamps are used manually because small power is required to operate these clamps. Hand clamping leads to application of variable pressure, operator's fatigue and more time consumed. The power driven clamping over comes the above mentioned problems of hand clamping. Power clamps are operated on the base of hydraulic or pneumatic power. Power clamps are high pressure clamping, these are quick acting, easily controllable, reliable and less time consuming.

V. SOFTWARE FOR FIXTURE DESIGN

NX streamlines the entire tool development process including part design, tool assembly layout, and detailed tooling design and validation. Using NX's advanced functionality, step-by-step guidance and associatively with part designs, you can work with even the most challenging tooling and fixture designs. These are discussed below[10]

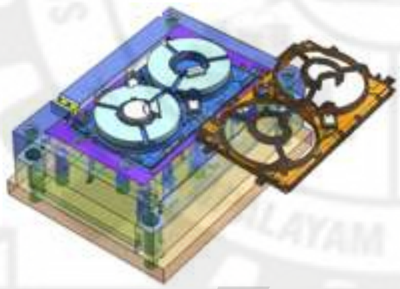

Fig. 14 NX Mold Design[10]

NX Mold Design shown in fig. 14 automates and streamlines the entire mold development process including part design, tool design and motion validation. You can ensure fast response to design changes and high-quality molds.

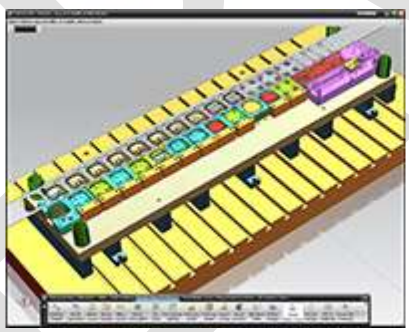

Fig. 15 NX Progressive Die Design[10]

NX guides you through all of the stages required to design a progressive die, automating the most tedious tasks and streamlining the most complex processes which is shown in fig.15. NX Progressive Die Design is a comprehensive solution for both straight break and freeform sheet metal parts. You can design the complete die structure with associatively to the part design at every stage.

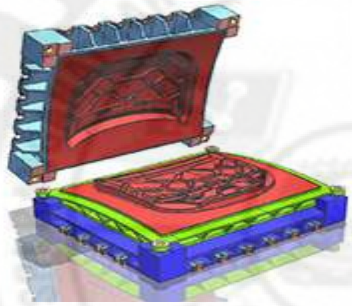

Fig. 16 NX Stamping Die Design[10]

The advanced capabilities in NX for designing automotive stamping dies include formability analysis, die planning, die face design, detailed die structure design and die validation. NX Stamping Die Design guides you in defining the process used to manufacture complex stamped sheet metal parts, producing a representation of the press line and modeling the shape of the sheet metal as it leaves each press.

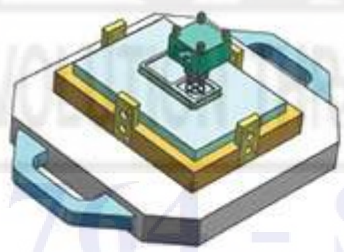

Fig. 17 NX Electrode Design[10]

NX Electrode Design incorporates numerous industry best practices into a step-by-step approach that automates the electrode design and manufacturing process.

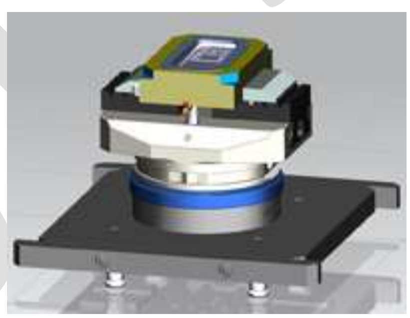

Fig. 18 NX for Jig and Fixture Design[10]

Because jig and fixture designs are fully associative to the part model, you can quickly and accurately update fixtures based on part model changes. You can easily position and mate fixture components with the NX assembly capabilities, and then automatically create drawings and documentation for the fixture and its components. NX also allows you to simulate the kinematics of fixtures, such as opened and closed positions, and check for strength and distortion.

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Michael Stampfer[2] presented a paper which deals with the problem of setup and fixture planning for the machining of box-shaped parts on the horizontal machining centers. The setup and fixture planning shown in fig. 2. The central topic of this research is the automation of the conceptual design of fixtures shown in fig. 3. This topic is deal with the setup planning.

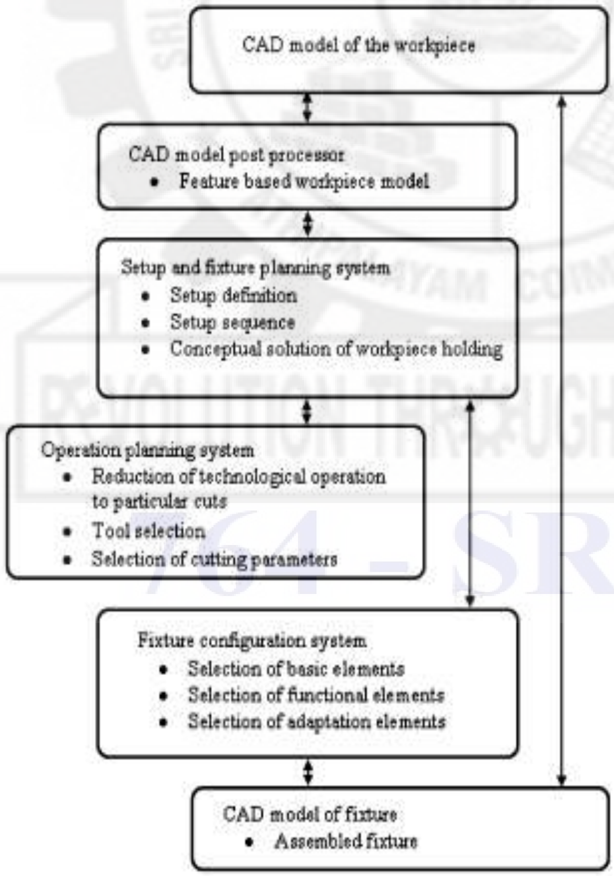

Fig. 19 Integrated process planning and fixture planning system[2].

The integrated handling of tasks of setup and fixture planning and the finding of solution in an integrated system is , the main aim of the author. Based on the workpiece model, the setup sequence, the conceptual solution of fixture for each setup determined automatically by the developed system.

1.Fixturing Functional Requirements

From a layout point of view, fixtures have six basic functional requirements **:**

(1) Stable resting, (2) accurate localization. (3) support reinforcement, (4) stable clamping, (5) foreclosure(or total restraint) and (6) quality performance.

The functions have strong precedence conditions. The first five functions are required at the fixturing stage, and sequentially. When a workpiece is placed into a fixture, it must first assume a stable resting against the gravity. Then, the locators should provide accurate localization. Next, supports are moved in place, and finally clamps are activated for the part immobilization (force-closure). The part location must be maintained in the process of instantiating clamps without workpiece lift-off. The performance of the fixture is ultimately defined as workpiece geometric error during the manufacturing stage. The geometric error is mainly determined by the fixture localization accuracy and the workpiece static and elastic deformation during manufacturing. There are additional constraints to be satisfied such as interference-free and easy loading and unloading.

2. Design Consideration in Fixtures

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

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

c. Clamping should be fast enough and require least amount of effort.

d. Clamps should be arranged so that they are readily available and may be easily removed.

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

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

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

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

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

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

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

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

The importance of fixture design automation is emphasized by Djordje Vukelic [3]. General structure of the automated design system shown in fig. 20 with a highlight on the fixture design systems and their main characteristics.

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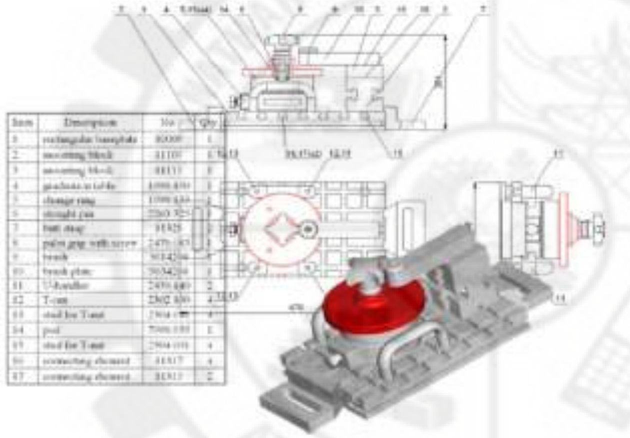

Fig. 20 Layout of working [3].

It also shows a structure and a part of output results of the automated modular fixture design system. The expert systems have been mostly used for the generation of partial fixture solutions, i.e., for the selection of locating and clamping elements.

Shrikant [8] discussed various design and analysis methods in the context of to improve the life of fixture, different fixture geometries are compared experimentally and are selected. The proposed eccentric shaft fixture will fulfilled researcher Production target and enhanced the efficiency, fixture reduces operation time and increases productivity, high quality of operation,

Weifang Chen [4] developed a multi-objective model was established to increase the distributing uniformity of deformation and to reduce the degree of deformation. The deformation is analyzed by optimizing the finite element method. To solve the optimization model a genetic algorithm was developed. A satisfactory result was obtained by illustrating an example, which is superior than the experiential one.

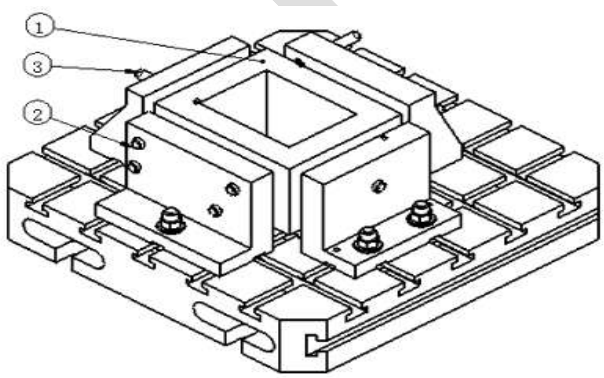

Fig. 21 A real case fixture configuration [4]

The multiobjective model can reduce the machining deformation effectively and improve the distribution condition. This paper presented a fixture layout design shown in fig. 21 and clamping force optimization procedure based on the GA and FEM. The optimization procedure is multi-objective: minimizing the maximum deformation of the machined surfaces and maximizing the uniformity of the deformation. The ANSYS software package has been used for FEM calculation of fitness values. The combination of GA and FEM is proven to be a powerful approach for fixture design optimization problems. In this study, both friction effects and chip removal effects are considered. a database is established to reduce the computation time, for the chromosomes and fitness values, and the meshed workpiece FEA model is repeatedly used in the optimization process.

Fig. 22 shows the existing CAD model of fixture which is used for machining of hydraulic lift housing. In this fixture clamping is done manually so there is extra time loss for loading and unloading operation. To avoid this problem there is necessity to develop new design to improve the productivity.

Fig. 22 CAD model of complete fixture assembly

- **Type of machine**

-Vertical machining centre.

- **Operations**

-Drilling.

-Reaming.

-Champer.

Machining parameter for drilling

- Cutter diameter 18 mm
- Number of flute 4
- Spindle speed 500 rpm
- Feed 0.15 mm/rev
- Radial depth 18 mm
- Projection length 90 mm

Machining parameters for reaming

- Cutter diameter 26 mm
- Number of flute 4
- Spindle speed 120 rpm
- Feed 0.25 mm/rev
- Radial depth 26 mm
- Projection length 90 mm

3.TYPES OF FIXTURE AND ITS INDUSTRIAL APPLICATIONS

Vise Fixture It is easy to clamp workpiece with regular shape and parallel sides in a vise. However, workpieces with round or irregular shapes are very difficult to clamp properly. Hence, special jaws are created to hold workpieces with irregular shape properly and at the same time, it also avoid damage to the important surfaces. Stop pin is used to prevent bending of the workpiece by the application of clamping force. guide pins are used to secure alignment. When it is necessary to hold the workpiece firmly in all the direction.

Fig. 23 Vise Fixture[11]

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.

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.

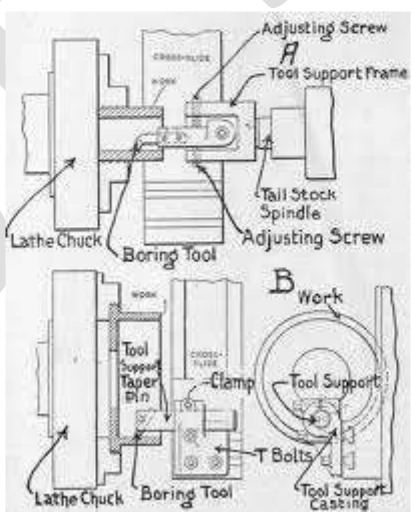

Fig. 24 Boring Fixture[11]

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. Face plate fixture is useful for facing number of workpieces simultaneously on the lathe.

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 . 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.

Fig. 25 Turning Fixture[11]

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.

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.

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. 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.

Fig. 26 Grinding Fixture[11]

VI.HYDRAULIC CLAMPING

Hydraulic clamping is actuated by cylinders. Clamping fixtures mainly consist of clamping nut which is attached to cylinder ram. A Pressurized fluid pulls ram and clamps against workpiece. Unclamping, port connected to unpressurized discharge line. For clamping and unclamping we use three way direction control valve, lever and pedal.

MULTIPLE CLAMPING

Single direction control valve can actuate number of clamps through number of cylinders to pressure or discharge lines. Clamping pressure is varied by regulating pressure of fluid.

High pressure – heavy roughing cut

Low pressure – light finish cut.

A risk of sudden pressure drop in event of power failure can be countered by provision of non return valve in pressure supply line.

AIR ASSISTED HYDRAYLIC WORK HOLDING

It is divided into three groups of components. First group of component, the shop air system (6-12bar) provides power, in the form of pneumatic pressure. Shop air(pressurized air) system consists of air inlet, filter/regulator/lubricator device, the safety valve /release valve. The second group of component is hydraulic booster consists of booster, check valve, and manifold. The final group is clamping system- hold, position, and support work piece.

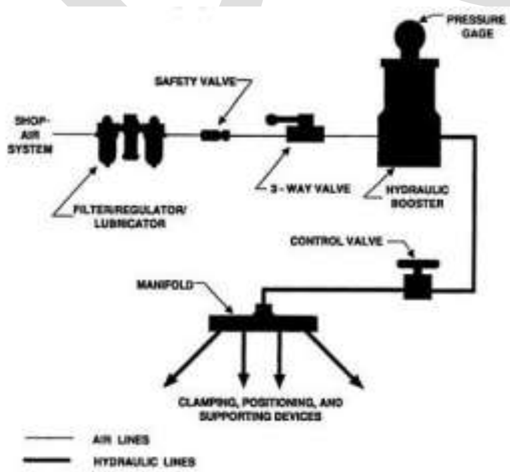

Fig. 23 Hydraulic workholding system.

Shop air is just used for boosting .In addition electric booster and hydraulic pump are used to air- operated booster system. Hydraulic pump is used for larger applications. Accumulator is installed between clamps and power source which maintain the necessary pressure when power is disconnected

VII. Conclusion

The efficiency and reliability of the fixture design has enhanced by the system and the result of the fixture design has made more reasonable. To reduce cycle time required for loading and unloading of part, this approach is useful. If modern CAE, CAD are used in designing the systems then significant improvement can be assured. To fulfill the multi-functional and high performance fixturing requirements optimum design approach can be used to provide comprehensive analyses and determine an overall optimal design. Fixture layout and dynamic clamping forces optimization method based on optimal fixture layout could minimize the deformation and uniform the deformation most effectively .The proposed fixture will fulfilled researcher production target and enhanced the efficiency, Hydraulic fixture reduces operation time and increases productivity, high quality of operation, reduce accidents.

REFERENCES:

1. Guohua Qin, Weihong, Zhang Min Wan "Analysis and Optimal Design of Fixture Clamping Sequence ASME for publication in the JOURNAL OF MANUFACTURING SCIENCE AND ENGINEERING, 2006.

2. Michael Stampfer "Automated setup and fixture planning system for box-shaped Parts" International Journal of Advance Manufacturing Technology 45:540–552 DOI 10.1007/s00170-009-1983-1, 2008.

3. Djordje Vukelic, Uros Zuperl & Janko Hodolic "Complex system for fixture selection, modification, and design" Int J Adv Manuf Technol 45:731–748 DOI 10.1007/s00170-009-2014-y, 2009

4. Weifang Chen ,Lijun Ni & Jianbin Xue "Deformation control through fixture layout design and clamping force optimization" Int J Adv Manuf Technol 38:860–867 DOI 10.1007/s00170-007-1153-2,2008

5. J. Cecil "A Clamping Design Approach for Automated Fixture Design" Int J Adv Manuf Technol 18:784–789,2008

6. Nicholas Amaral · Joseph J. Rencis · Yiming (Kevin) Rong "Development of a finite element analysis tool for fixture design integrity verification and optimization" Int J Adv Manuf Technol 25: 409–419, 2005

7. Y. Wang, X. Chen. N, Gindy "Surface error decomposition for fixture development" Int J Adv Manuf Technol DOI 10.1007/s00170-005-0270-z, 2007

8. Shrikant.V.Peshatwar, L.P Raut "Design and development of Fixture for eccentric shaft: A Review" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 3, Issue 1, February 2013.

9. http://www.carrlane.com/Articles/StPartCL.cfm

10.http://www.plm.automation.siemens.com/en_us/products/nx/for-manufacturing/tooling-fixture-design

11. http://www.ignou.ac.in/upload/jig.pdf

UNIT 4 LIMIT GAUGING

Structure

4.1 INTRODUCTION

Gauging, done in manufacturing processes, refers to the method by which it is determined quickly whether or not the dimensions of the checking parts in production, are within their specified limits. It is done with the help of some tools called gauges. A gauge does not reveal the actual size of dimension.

A clear distinction between measuring instruments and gauges is not always observed. Some tools that are called gauges are used largely for measuring or layout work. Even some are used principally for gauging give definite measurement.

High carbon and alloy steels have been the principal material used for many years. Objections to steel gauges are that they are subjected to some distortion because of the heat-treating operations and that their surface hardness is limited. These objections are largely overcome by the use of chrome plating or cemented carbides as the surface material. Some gauges are made entirely of cemented carbides or they have cemented carbides inserted at certain wear points.

Objectives

After studying this unit, you should be able to

- understand the fundamental of the gauges and their classifications, and
- explain the working principles of various types of gauges and their applications.

4.2 GAUGES AND THEIR CLASSIFICATIONS

Gauges are the tools which are used for checking the size, shape and relative positions of various parts but not provided with graduated adjustable members. Gauges are, therefore, understood to be single-size fixed-type measuring tools.

Classifications of Gauges

(a) Based on the standard and limit
  - (i) Standard gauges
  - (ii) Limit gauges or "go" and "not go" gauges

(b) Based on the consistency in manufacturing and inspection
  - (i) Working gauges
  - (ii) Inspection gauges
  - (iii) Reference or master gauges

(c) Depending on the elements to be checked
  - (i) Gauges for checking holes
  - (ii) Gauges for checking shafts
  - (iii) Gauges for checking tapers
  - (iv) Gauges for checking threads
  - (v) Gauges for checking forms

(d) According to the shape or purpose for which each is used
  - (i) Plug
  - (ii) Ring
  - (iii) Snap
  - (iv) Taper
  - (v) Thread
  - (vi) Form
  - (vii) Thickness
  - (viii) Indicating
  - (ix) Air-operated

4.2.1 Standard Gauges

Standard gauges are made to the nominal size of the part to be tested and have the measuring member equal in size to the mean permissible dimension of the part to be checked. A standard gauge should mate with some snugness.

4.2.2 Limit Gauges

These are also called 'go' and 'no go' gauges. These are made to the limit sizes of the work to be measured. One of the sides or ends of the gauge is made to correspond to maximum and the other end to the minimum permissible size. The function of limit gauges is to determine whether the actual dimensions of the work are within or outside the specified limits. A limit gauge may be either double end or progressive. A double end gauge has the 'go' member at one end and 'no go' member at the other end. The 'go' member must pass into or over an acceptable piece but the 'no go' member should not. The progressive gauge has 'no go' members next to each other and is applied to a workpiece with one movement. Some gauges are fixed for only one set of limits and are said to be solid gauges. Others are adjustable for various ranges.

4.3 WORKING GAUGES, INSPECTION GAUGES AND REFERENCE GAUGES

To promote consistency in manufacturing and inspection, gauges may be classified as working, inspection, and reference or master gauges :

Working Gauges

Working gauges are those used at the bench or machine in gauging the work as it being made.

Inspection Gauges

These gauges are used by the inspection personnel to inspect manufactured parts when finished.

Reference Gauges

These are also called master gauges. These are used only for checking the size or condition of other gauges and represent as exactly as possible the physical dimensions of the product.

4.4 GAUGES FOR CHECKING ELEMENTS

Hole Gauge

It is used to check the dimensions of the hole present in the element.

Shaft Gauge

It is used to check the dimensions of the shaft.

Taper Gauge

It is used to check the dimensions of the tapers.

Thread Gauge

It is used to check the threading of the element.

Form Gauge

It is used to check the forms of the elements.

4.5 GAUGES COMMONLY USED IN PRODUCTION WORK

Some of the important gauges which are commonly used in production work have been discussed as follows :

4.5.1 Plug Gauges

These gauges are used for checking holes of many different shapes and sizes. There are plug gauges for straight cylindrical holes, tapered, threaded square and splined holes. Figure 4.1 shows a standard plug gauge used to test the nominal size of a cylindrical hole. Figure 4.2 shows a double-ended limit plug gauge used to test the limits of size. At one end, it has a plug minimum limit size, the ‘go’ end and; at the other end a plug of maximum limit, the ‘no go’ end. These ends are detachable from the handle so that they may be renewed separately when worn in a progressive limit plug gauge. The ‘go’ and ‘no go’ section of the gauge are on the same end of the handle. Large holes are gauged with annular plug gauges, which are shell-constructed for light weight, and flat plug gauges, made in the form of diametrical sections of cylinders.

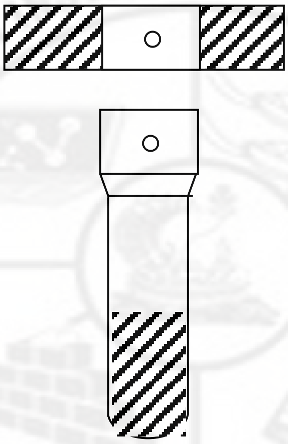

Figure 4.1 : Standard Ring and Plug Gauges

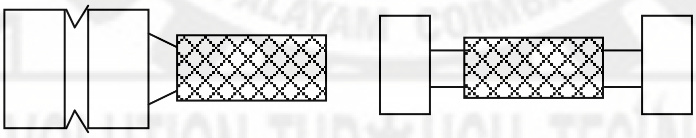

Figure 4.2 : Progressive and Double Ended Limit Plug Gauges

4.5.2 Ring Gauges

Ring gauges are used to test external diameters. They allow shafts to be checked more accurately since they embrace the whole of their surface. Ring gauges, however, are expressive manufacture and, therefore, find limited use. Moreover, ring gauges are not suitable for measuring journals in the middle sections of shafts. A common type of standard ring gauge is shown in Figure 4.1. In a limit ring gauge, the 'go' and 'no go' ends are identified by an annular groove on the periphery. About 35 mm all gauges are flanged to reduce weight and facilitate handling.

4.5.3 Taper Gauges

The most satisfactory method of testing a taper is to use taper gauges. They are also used to gauge the diameter of the taper at some point. Taper gauges are made in both the plug and ring styles and, in general, follow the same standard construction as plug and ring gauges. A taper plug and ring gauge is shown in Figure 4.3.

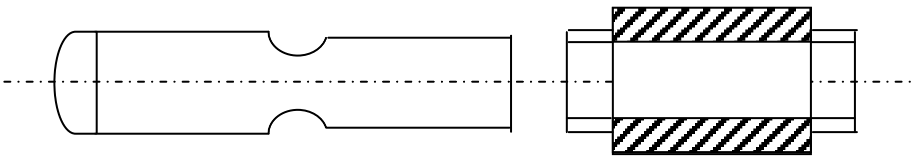

Figure 4.3 : Taper Plug and Ring Gauge

When checking a taper hole, the taper plug gauge is inserted into the hole and a slight pressure is exerted against it. If it does not rock in the hole, it indicates that the taper angle is correct.

The same procedure is followed in a ring gauge for testing tapered spindle.

The taper diameter is tested for the size by noting how far the gauge enters the tapered hole or the tapered spindle enters the gauge. A mark on the gauge show the correct diameter for the large end of the taper.

To test the correctness of the taper two or three chalk or pencil lines are drawn on the gauge about equidistant along a generatrix of the cone. Then the gauge is inserted into the hole and slightly turned. If the lines do not rub off evenly, the taper is incorrect and the setting in the machine must be adjusted until the lines are rubbed equally all along its length. Instead of making lines on the gauge, a thin coat of paint (red led, carbon black, Purssian blue, etc.) can be applied.

The accuracy of a taper hole is tested by a taper limit gauge as shown in Figure 4.4. This has two check lines ‘go’ and ‘no go’ each at a certain distance from the end of the face. The go portion corresponds to the minimum and ‘no go’ to the maximum dimension.

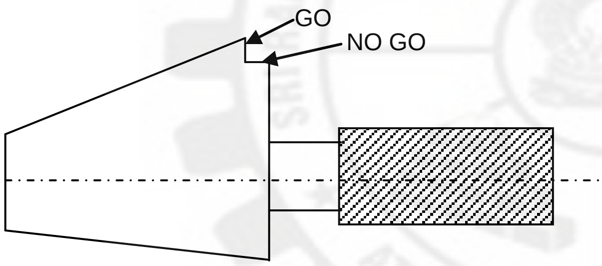

Figure 4.4 : Limit Taper Plug Gauge

4.5.4 Snap Gauges

These gauges are used for checking external dimensions. Shafts are mainly checked by snap gauges. They may be solid and progressive or adjustable or double-ended. The most usual types are shown in Figure 4.5.

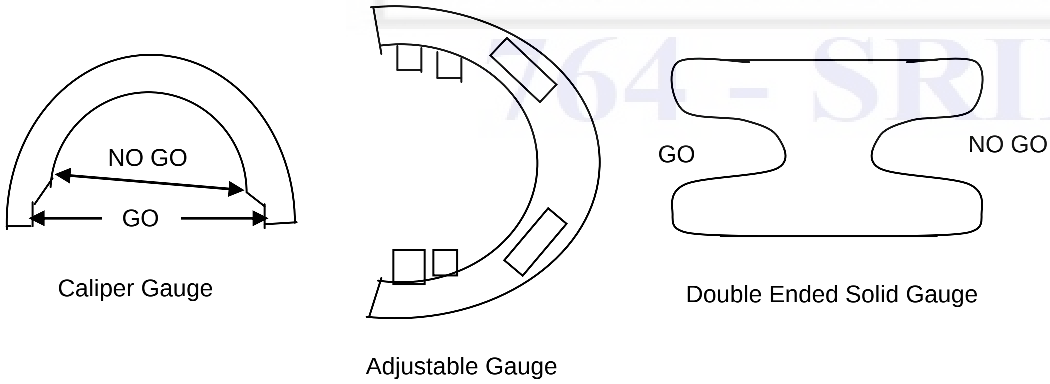

Figure 4.5 : Snap Gauges

(a) Solid or non-adjustable caliper or snap gauge with ‘go’ and ‘no go’ each is used for large sizes.

(b) Adjustable caliper or snap gauge used for larger sizes.

This is made with two fixed anvils and two adjustable anvils, one for ‘go’ and another for the ‘no go’.

The housing of these gauges has two recesses to receive measuring anvils secured with two screws. The anvils are set for a specific size, within an available range of adjustment of 3 to 8 mm. The adjustable gauges can be used for measuring series of shafts of different sizes provided the diameters are within the available range of the gauge.

(iii) Double-ended solid snap gauge with ‘go’ and ‘no go’ ends is used for smaller sizes.

4.5.5 Thread Gauges

Thread gauges are used to check the pitch diameter of the thread. For checking internal threads (nut, bushes, etc.), plug thread gauges are used, while for checking external threads (screws, bolts, etc.), ring thread gauges are used. Single-piece thread gauges serve for measuring small diameters. For large diameters the gauges are made with removable plugs machined with a tang. Standard gauges are made single-piece. Common types of thread gauges are shown in Figure 4.6.

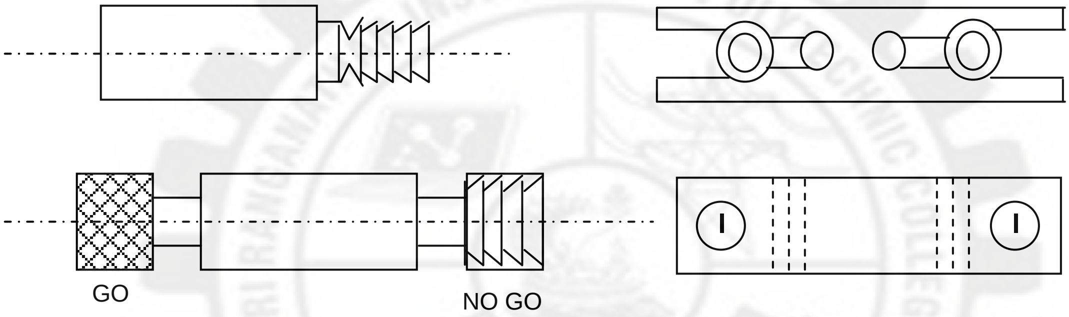

Figure 4.6 : Thread Gauge

Standard plug gauges may be made of various kinds :

(a) Plug gauge with only threaded portion.

(b) Threaded portion on one end and plain cylindrical plug on opposite end to give correct "core" diameter.

(c) Thread gauge with core and full diameters.

Limit plug gauges have a long-thread section on the 'go' and a short-threaded section on the 'no go' end to correspond to the minimum and maximum limits respectively.

Roller rings gauges, similarly have 'go' and 'no go' ends. They may also be solid and adjustable.

Roller Snap gauges are often used in production practice for measuring external threads. They comprise a body, two pairs 'go' rollers and two pairs 'no go' rollers.

Taper thread gauges are used for checking taper threads. The taper-ring thread gauge are made in two varieties – rigid (non-adjustable) and adjustable. The "go" non-adjustable ring gauges are full threaded while the 'no go' have truncated thread profile.

4.5.6 Form Gauges

Form gauges may be used to check the contour of a profile of workpiece for conformance to certain shape or form specifications.

Template Gauge

It is made from sheet steel. It is also called profile gauge. A profile gauge may contain two outlines that represent the limits within which a profile must lie as shown in Figure 4.7.

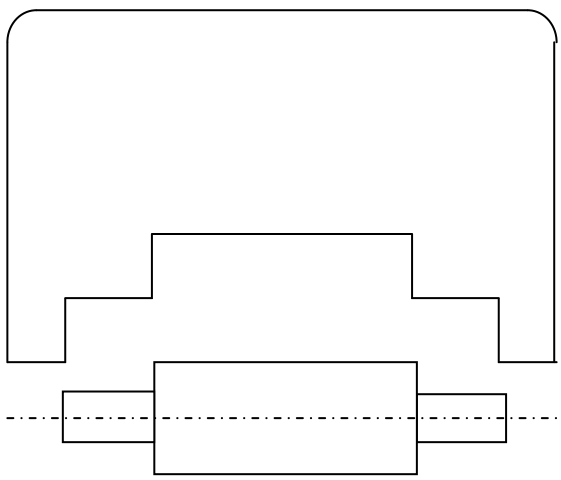

Figure 4.7 : A Template Gauge

4.5.7 Screw Pitch Gauges

Screw pitch gauges serve as an everyday tool used in picking out a required screw and for checking the pitch of the screw threads. They consist of a number of flat blades which are cut out to a given pitch and pivoted in a holder as shown in Figure 4.8. Each blade is stamped with the pitch or number of thread per inch and the holder bears an identifying number designing the thread it is intended for. The sets are made for metric threads with an angle 60^o, for English threads with an angle of 55^o.

A set for measuring metric threads with 30 blades has pitches from 0.4 to 0.6 mm and for English threads with 16 blades has 4 to 28 threads per inch.

In checking a thread for its pitch the closest corresponding gauge blade is selected and applied upon the thread to be tested. Several blades may have to be tried until the correct is found.

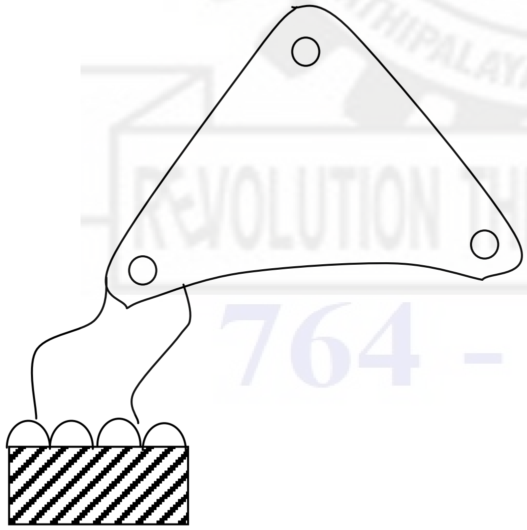

Figure 4.8 : Screw Pitch Gauge

4.5.8 Radius and Fillet Gauges

The function of these gauges is to check the radius of curvature of convex and concave surfaces over a range from 1 to 25 mm. The gauges are made in sets of thin plates curved to different radius at the ends as shown in Figure 4.9. Each set consists of 16 convex and 16 concave blades.

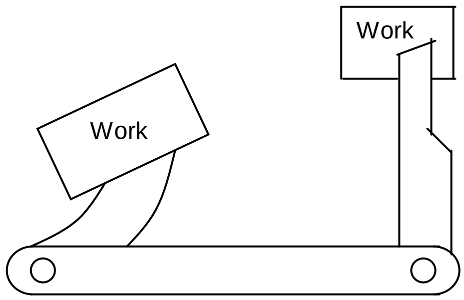

Figure 4.9 : Radius and Fillet Gauges

4.5.9 Feller Gauges

Feller gauges are used for checking clearances between mating surfaces. They are made in form of a set of steel, precision machined blade 0.03 to 1.0 mm thick and 100 mm long. The blades are provided in a holder as shown in Figure 4.10. Each blade has an indication of its thickness. The Indian standard establishes seven sets of feller gauges : Nos 1, 2, 3, 4, 5, 6, 7, which differ by the number of blades in them and by the range of thickness. Thin blades differ in thickness by 0.01 mm in the 0.03 to 1 mm set, and by 0.05 mm in the 0.1 to 1.0 mm set.

To find the size of the clearance, one or two blades are inserted and tried for a fit between the contacting surfaces until blades of suitable thickness are found.

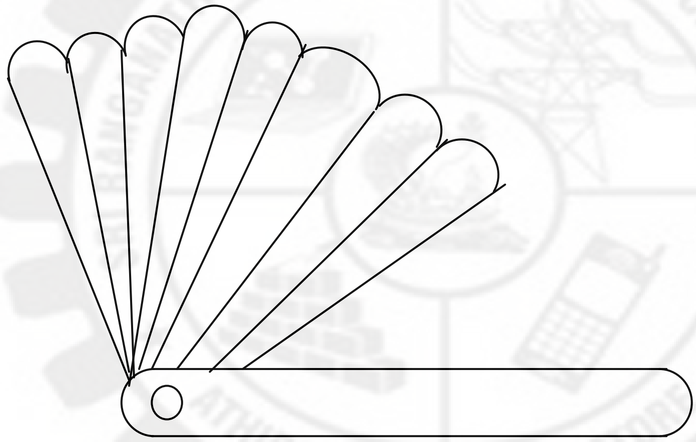

Figure 4.10 : Feller Gauge

4.5.10 Plate and Wire Gauges

The thickness of a sheet metal is checked by means of plate gauges and wire diameters by wire gauges. The plate gauge is shown in Figure 4.11. It is used to check the thickness of plates from 0.25 to 5.0 mm, and the wire gauge, in Figure 4.12, is used to check the diameters of wire from 0.1 to 10 mm.

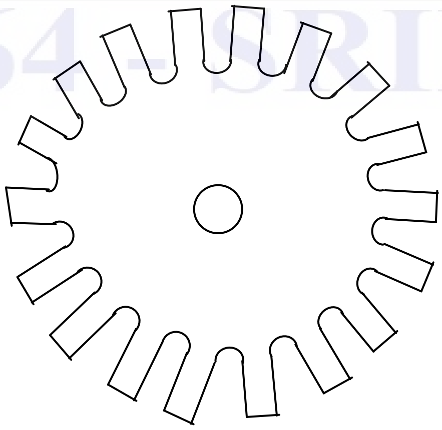

Figure 4.11 : Plate Gauge

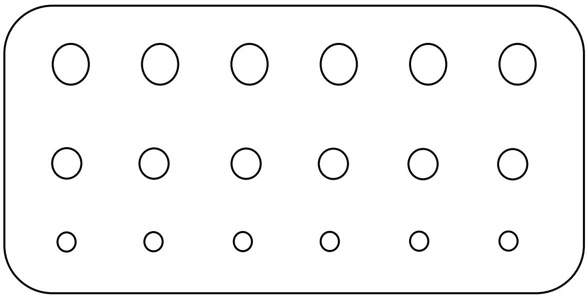

Figure 4.12 : Wire Gauge

4.5.11 Indicating Gauges

Indicating gauges employ a means to magnify how much a dimension deviates, plus or minus, from a given standard to which the gauge has been set. They are intended for measuring errors in geometrical form and size, and for testing surfaces for their true position with respect to one another. Beside this, indicating gauges can be adapted for checking the run out of toothed wheels, pulleys, spindles and various other revolving parts of machines.

Indicating gauges can be of a dial or lever type, the former being the most widely used.

4.5.12 Air Gauges

Pneumatic or air gauges are used primarily to determine the inside characteristics of a hole by means of compressed air. There are two types of air gauges according to operation: a flow type and a pressure type gauge. The flow type operates on the principle of varying air velocities at constant pressure and the pressure type operates on the principle of air escaping through an orifice.

SAQ 1

(a) What are gauges?

(b) Classify the gauges based on the purposes for which they are used.

(c) What is the difference between standard gauges and limit gauges?

SAQ 2

(a) What are the functions of the following gauges :

- (i) Form gauge
- (ii) Taper gauge
- (iii) Reference gauge
- (iv) Feller gauge
- (v) Air gauges

(b) Mention the name of the gauge that can be used for checking each of the following :

- (i) Shaft
- (ii) Wire
- (iii) Wheels
- (iv) Pulleys
- (v) Screw
- (vi) Nut
- (vii) Bolt
- (viii) Hole

(c) Mention the types of material used for making gauges.

4.6 SUMMARY

Gauging is the method by which it is determined quickly whether or not the dimensions of the checking parts, in the production, are within their specified limits. The tools which are used for the same are called gauges.

Materials which are used for making gauges are high carbon and alloy steels, cemented carbides, etc.

Gauges can be classified mainly as follows :

(a) Based on the standard and limit

- (i) Standard gauge
- (ii) Limit gauge

(b) Based on the consistency in manufacturing process and inspection

- (i) Working gauge
- (ii) Inspection gauge
- (iii) Reference gauge

(c) According to the shape or purpose for which each is used

- (i) Plug
- (ii) Ring
- (iii) Snap
- (iv) Taper
- (v) Thread
- (vi) Form
- (vii) Indicating
- (viii) Feller
- (x) Air-gauges

4.7 KEY WORDS

Standard Gauges : These are made to the nominal size of the parts to be tested.

Limit Gauges : These are 'go' and 'no go' gauges.

Plug Gauges : These are used for checking holes of many different shapes and sizes.

Ring Gauges : External diameter measuring gauges.

Taper Gauges : Taper testing gauges.

Snap Gauges : These are used for checking shafts.

Thread Gauges : These are used for pitch diameter of the thread.

Form Gauges : These are used to check the contour of a profile.

Feller Gauges : For checking the clearance between the mating surfaces.

Indicating Gauges : To measure the position of the surfaces.

Air Gauge : To measure inside characteristics of a hole using air.

4.8 ANSWERS TO SAQs

SAQ 1

(a) Gauges are the tools which are used for checking the size, shape and relative positions of various parts.

(b) (i) Plug gauges

(ii) Ring gauges

(iii) Taper gauges

(iv) Thread gauges

(v) Snap gauges

(vi) Indicating gauges

(vii) Air gauges

(c) Standard gauges are made to the nominal size of the part to be tested and have the measuring member equal in size to the mean permissible dimensions of the part to be checked, whereas the limit gauges are made to the limit sizes of the work to be measured.

SAQ 2

(a) (i) **Gauge :** It may be used to check the contour of a profile of a workpiece for conformance to certain shape or form specifications.

(ii) **Taper Gauge :** It is used to check the taper. It is also used to measure the diameter of the taper at some point.

(iii) **Reference Gauge :** It is used only for checking size or condition of other gauges.

(iv) **Snap Gauge :** It is used for checking external diameters. Shafts are mainly checked by the snap gauges.

(v) **Feller Gauge :** It is used for checking clearances between mating surfaces.

(vi) **Air Gauges :** It is used primarily to determine the inside characteristics of the hole by means of compressed air.

(b) (i) **Shaft :** Snap gauges, Ring gauges.

(ii) **Wire :** Wire gauges.

(iii) **Wheels :** Indicating gauges.

(iv) **Pulleys :** Indicating gauges.

(v) **Screw :** Thread gauges.

(vi) **Nut :** Thread gauges.

(vii) **Bolt :** Thread gauges.

(viii) **Hole :** Plug gauges.

(c) (i) High carbon and alloy steel.

(ii) Cemented carbides.