
UNIT 4 JIGS AND FIXTURES

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4.1 INTRODUCTION

The jigs and fixtures are the economical ways to produce a component in mass. So jigs and fixtures are used and serve as one of the most important facility of mass production system. These are special work holding and tool guiding device. Quality of the performance of a process largely influenced by the quality of jigs and fixtures used for this purpose. 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 the cases hold a workpiece during an operation. A jig differs from a fixture in the sense that it guides the tool to its correct position or towards its correct movement during an operation in addition to locating and supporting the workpiece.

An example of jig is when a key is duplicated, the original key is used as base for the path reader which guides the movement of tool to make its duplicate key. The path reader of a CWC machine here works as a jig and the original is called template. Sometimes the template and jig both are the name of same part of a manufacturing system.

Objectives

After studying this unit, you should be able to understand

- introduction of jigs and fixtures,
- purpose and advantages of jigs and fixtures,
- important considerations while designing jigs and fixtures,
- know the meaning and principles of location,
- describe the different types of locations,
- explain the clamping and its different type,
- the requirements of a good clamping device,
- know the different types of clamps,

- explain the jigs and their different types, and
- know about the milling fixtures.

4.2 PURPOSE AND ADVANTAGES OF JIGS AND FIXTURES

Following the purpose and advantages of jigs and fixtures :

- (a) It reduces or sometimes eliminates the efforts of marking, measuring and setting of workpiece on a machine and maintains the accuracy of performance.
- (b) The workpiece and tool are relatively located at their exact positions before the operation automatically within negligible time. So it reduces product cycle time.
- (c) Variability of dimension in mass production is very low so manufacturing processes supported by use of jigs and fixtures maintain a consistent quality.
- (d) Due to low variability in dimension assembly operation becomes easy, low rejection due to less defective production is observed.
- (e) It reduces the production cycle time so increases production capacity. Simultaneously working by more than one tool on the same workpiece is possible.
- (f) The operating conditions like speed, feed rate and depth of cut can be set to higher values due to rigidity of clamping of workpiece by jigs and fixtures.
- (g) Operators working becomes comfortable as his efforts in setting the workpiece can be eliminated.
- (h) Semi-skilled operators can be assigned the work so it saves the cost of manpower also.
- (i) There is no need to examine the quality of produce provided that quality of employed jigs and fixtures is ensured.

4.3 IMPORTANT CONSIDERATIONS WHILE DESIGNING JIGS AND FIXTURES

Designing of jigs and fixtures depends upon so many factors. These factors are analysed 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.

4.4 MEANING OF LOCATION

It is very important to understand the meaning of location before understanding about the jigs and fixtures. The location refers to the establishment of a desired relationship between the workpiece and the jig 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.

4.5 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 move 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

Considering the six degree of freedom of a rectangular block as shown in Figure 4.1. 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 than 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 number of points selected at different faces of the workpiece are 3, 2 and 1 respectively.

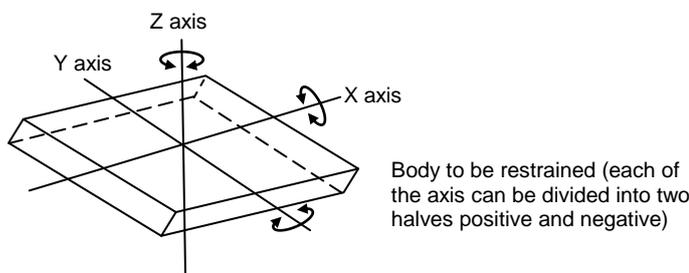


Figure 4.1 : Available Degree of Freedom of Rectangular Block

Location of a Cylinder on a Vee Block

The analysis of the principle of location of a cylinder on a Vee block is indicated in Figure 4.2. All the degrees of freedom of the cylindrical object are restrained. It is only fixed to move along axis AB . It can rotate about the axis AB . These free movements are also indicated in the figure. 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.

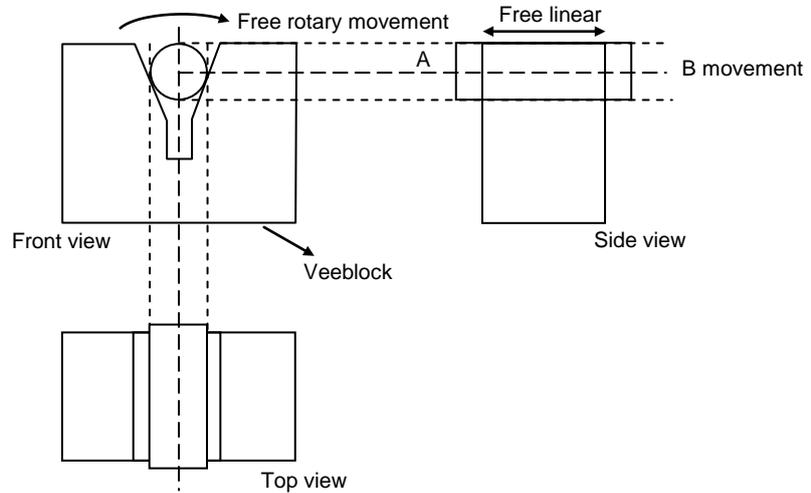


Figure 4.2 : Locating a Cylinder on a Vee Block

4.6 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 matters 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 Figure 4.3.

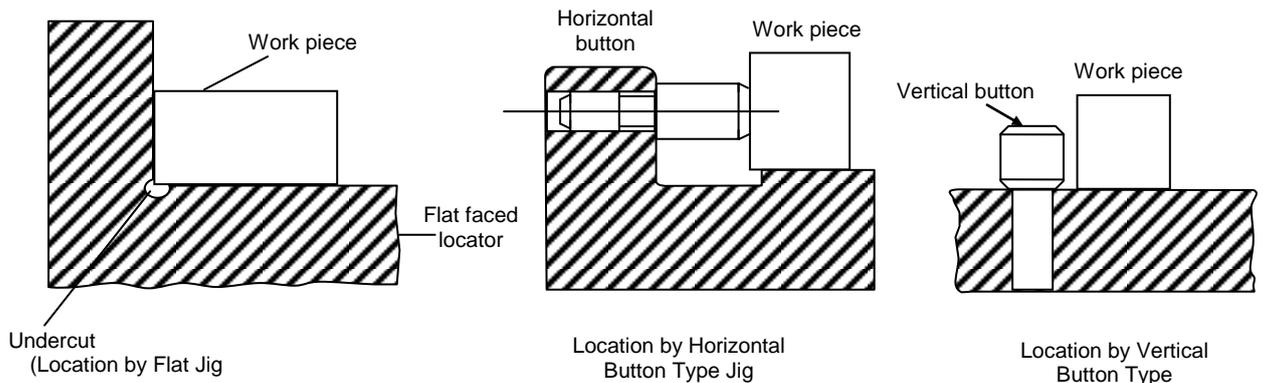


Figure 4.3 : Method of Locating using Flat Locators

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. The button can be adjusted to decide very fine location of the workpiece. There can be a vertical button support as shown in third figure, which is a better arrangement due to its capacity to bear end load and there is a provision for swarf clearance automatically.

Cylindrical Locators

A cylindrical locator is shown in Figure 4.4. 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. The face of the jig's body around the locator is undercut to provide space for swarf clearance.

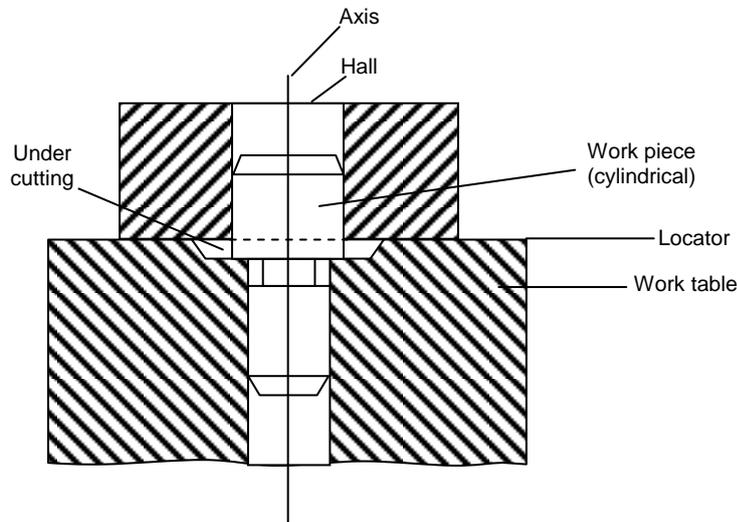


Figure 4.4 : Cylindrical Locator

Conical Locator

A conical locator is illustrated in Figure 4.5. This is used for locating the workpieces having cylindrical hole in the workpiece. The workpiece is found located by supporting it over the conical locator inserted into the drilled hole of the workpiece. A conical locator is considered as superior as it has a capacity to accommodate a slight variation in the hole diameter of the component without affecting the accuracy of location. Degree of freedom along z-axis can also be restrained by putting a template over the workpiece with the help of screws.

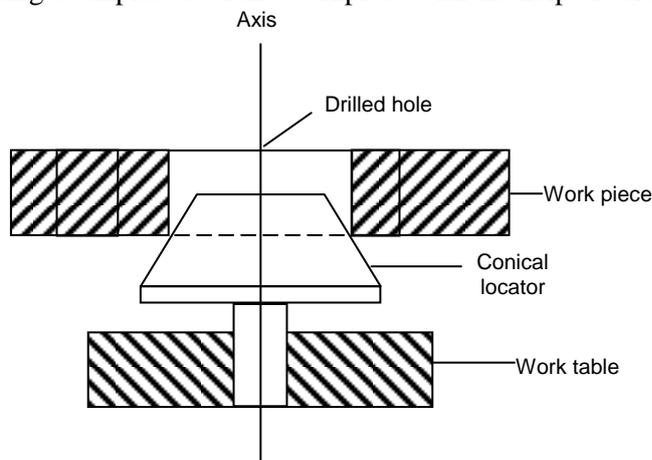


Figure 4.5 : Conical Locator

Jack Pin Locator

Jack pin locator is used for supporting rough workpieces from the bottom as shown in Figure 4.6. 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.

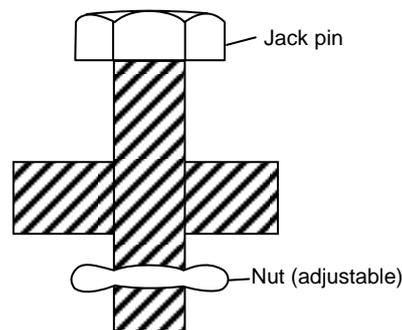


Figure 4.6 : Jack Pin Locator

Drill Bush Locator

The drill bush locator is illustrated in Figure 4.7. It is used for holding and locating the cylindrical workpieces. The bush has conical opening for locating purpose and it is sometimes screwed on the jig's body for the adjustment of height of the work.

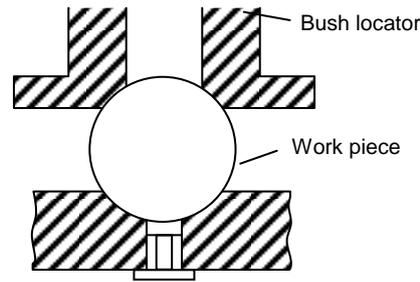
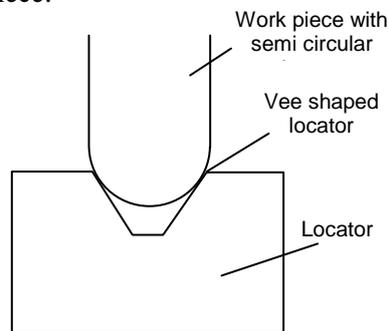


Figure 4.7 : Drill Bush Locator

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 workpieces as shown in Figure 4.8. 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.



Figur 4.8 : Fixed V Locator

4.7 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 over come 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 fibre pads to avoid any damage to workpiece.

4.8 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

The simple form of a heel clamp is shown in Figure 4.9. 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 movement in anticlockwise direction takes place before un-securing the nut to release the workpiece.

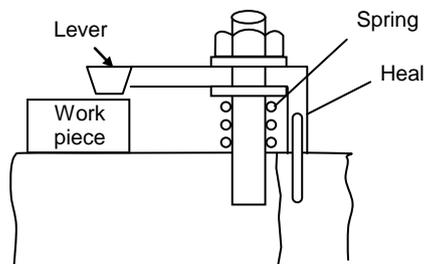


Figure 4.9 : Heel Clamp

Bridge Clamp

The bridge clamp is illustrated in Figure 4.10. It applies more clamping pressure as compared to heel clamp. The clamping pressure experienced by the workpiece depends on the distances 'x' and 'y' marked in the Figure 4.10. To release the workpiece the nut named as clamping nut is unscrewed. The spring lifts the lever to release the workpiece.

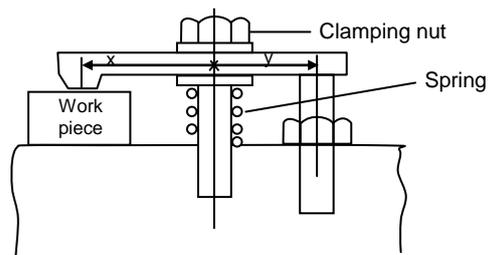


Figure 4.10 : Bridge Clamp

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. The clamping device is illustrated in Figure 4.11. Releasing and clamping of the workpiece can be accomplished by unscrewing and screwing of the clamping nut respectively.

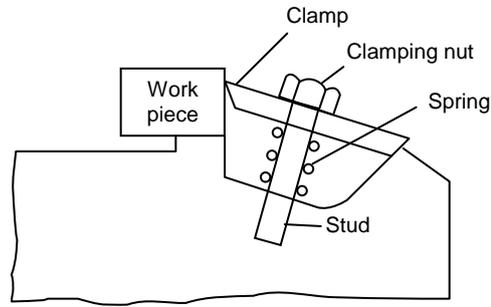


Figure 4.11 : Edge Clamp or Side Clamp

Screw Clamp

The screw clamp is illustrated in Figure 4.12. It is also known as clamp screw. This clamping apply pressure directly on the side faces of the workpiece. 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.

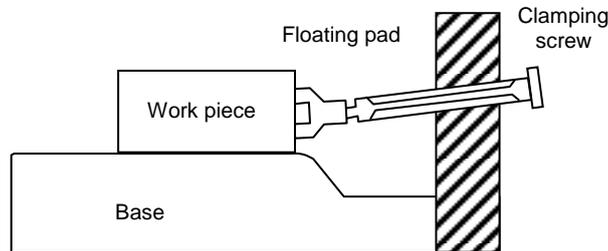


Figure 4.12 : Screw Clamp

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 illustrated in Figure 4.13. It 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.

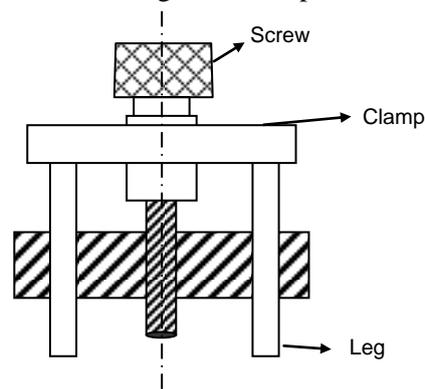


Figure 4.13 : Equalizing Clamp

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.

4.9 JIGS

Jigs along with fixtures are specifically designated machine parts, which can be manufactured by any of the following methods : (a) Machining, (b) Forging, (c) Casting and (d) Complicated.

Jigs are fabricated in different pieces and joined together by welding.

Normally jigs are made of hardened steel, which are wear resistant, corrosion resistant, and thermally insensitive. Their dimensional accuracy directly influences the accuracy of performance of the operations where these are used.

4.10 DIFFERENT TYPES OF JIGS

Different types of jigs used are described below :

Drilling Jigs

Drilling jigs are used for large number of operations. Different types of drilling jigs are described below.

Template Jig

This is a simple plate of metal or wood which carries correct locations of holes to be made in the workpiece. Size of template jig should be same as that of the workpiece. It is overlapped with the workpiece and drilling is done quickly. Use of this jig avoids the marking operation completely.

Plate Type Jig

If the work is to be done on very large scale, an improvement can be made to template jig that is plate type jig. This uses a plate having drill pushes and suitable means to hold and locate the works that it can be clamped to the plate and holds drilled directly through the bushes in correct positions.

Open Type Jig

In this jig the top is kept open and workpiece is placed on the base of the jig and the drill plate. Carrying the drill bushes is placed on the top to guide the tool. After the operation is over, the drill plate is removed and workpiece is replaced. It is shown in Figure 4.14.

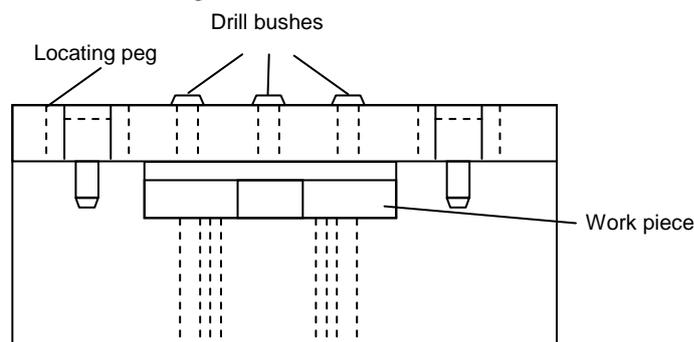


Figure 4.14 : Open Type Jig

Swinging Leaf Type Jig

This type of jig carries a leaf or plate, arranged at the top or on one side, which is capable of swinging about a fulcrum. It is normally the drill plate itself which is pivoted about a point at its one end. A swinging leaf type jig is shown in Figure 4.15. The work is loaded and unloaded with the help of swinging bolt.

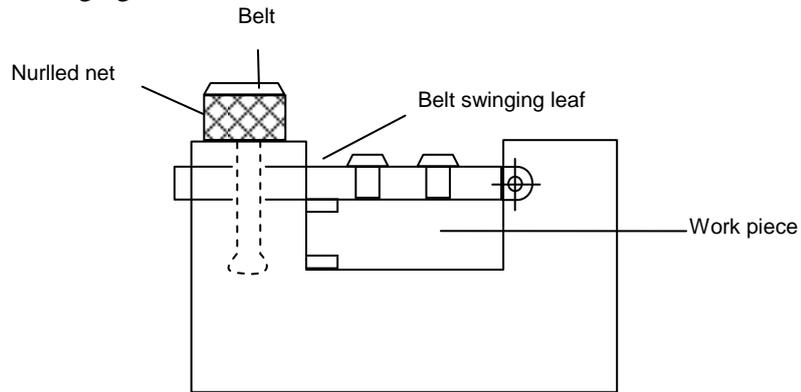


Figure 4.15 : Swinging Type Jig

Box Type Jig

Its construction is like a box and it is used for the components having irregular shape and to be operated at different places. This type of jig provides rigid support, so machining on the various places of workpiece becomes comfortable.

Solid Type Jig

This is also used for drilling holes in articles of simple shapes and relatively smaller sizes. This is made of standard section of rolled steel.

Pot Type Jig

This jig is used for drilling holes in hollow cylindrical components having smaller size. Here the body of the jig is like a pot that is used to accommodate the workpiece comfortably. Location on the inside surface of the component is provided by the clamp projecting from the bush plate located over the top of the workpieces.

Index Jigs

This type of jig is equipped with the facility of indexing, which creates positional division of the workpiece suitably. This jig is used for quick drilling of equidistant holes on the circular surface of the workpiece. By means of indexing device a hole is drilled then the workpiece is moved (indexed) to next position under the drill bush for drilling automatically.

Multi-station Jigs

These jigs are designed for multi-spindle machine where many operations can be performed simultaneously. Each spindle of the machine carries a different tool to perform a different operation. Tools and spindles are arranged in the sequence in which operations are to be performed.

Universal Jig

As indicated by the name universal jigs are meant to do large number of operations. These may have replaceable elements on them. Selection and mounting of an element depends on the type of operation to be performed.

4.11 FIXTURES

Fixtures are designed specifically for an operation and so these are named on the base of the operation to be carried out with their help. Fixtures are used to hold the workpiece properly to carryout the operations. Different types of fixtures are listed below.

- (a) Turning fixtures
- (b) Milling fixtures
- (c) Fixture for grinding
- (d) Fixture for broaching
- (e) Fixture for boring/drilling
- (f) Tapping fixture
- (g) Fixture for welding
- (h) Assembling fixture

Out of these fixtures two fixtures are described below.

Milling Fixtures

Fixtures used to perform different types of milling operations are called milling fixtures. The fixture is probably located on the table of the machine and secured in position by means of bolts and nuts. The workpiece located on the base of fixture and clamped. The fixture and associated jigs holds the workpiece and direct the tool to right position by avoiding frequent measurement and marking. The experience of varying forces by the workpiece are also overcome by the concerning fixtures and jigs. Proper locations of the fixture on the machine table is usually achieved with the help of two tons provided under the fixture base. These tons enter a T-slot of the table to provide the required location. The fixture base can then be secured to the table by means of T-bolts and nuts. The fixtures for milling operations are designed and described on the basis of milling operations, milling techniques and clamping power techniques.

- (a) On the basis of types of operations the milling fixture may be of different types are listed below :
 These are straddle milling fixture, face milling, slot milling, plain milling, side milling, form milling and gang milling fixtures.
- (b) On the basis on technique of milling machining, milling fixtures are named as single piece milling fixture, string milling, reciprocal milling, index milling and abreast milling fixture.
- (c) On the basis of clamping power and clamping method milling fixtures are named as fixture with mechanical clamping, hydraulic clamping, pneumatic clamping, automatic clamping and vice jaw clamping fixture. Some examples of sturdy fixtures which are 1/4" steel are illustrated in Figure 4.16. The holes are spaced to go between the 'T' posts in the milling table. There is a 3/8" holes in each corner, and that if for the cap head screws that may go into the 'T' slots nuts of the table. In third case the positioning bar holds the table absolutely parallel to the front of the table.

Figure 4.16 : Examples of Milling Fixtures

Welding Fixtures

Welding fixtures are normally designed to hold and support the various components (workpieces) to be welded. It is necessary to support them in a proper location which is capable of preventing distortions in workpieces during welding. For this the locating elements need to be placed carefully, clamping has to be light but firm, placement of clamping elements has to be clear of the welding area and the fixture has to be quite stable and rigid to withstand the welding stresses. There is no limit of designing a welding fixture. Its design depends on and driven by the hard facts that are what you want, and how to overcome the problems appearing with the current fixture. Keeping the defect free fast production rate as major target. The famous saying “Need is the mother of invention” hold perfectly true in case of welding fixture design.

In many cases, most preferred practice is to first tack weld the structure by holding it in a welding jig and then transfers it to a holding fixture for full welding.

This helps in reducing the chances of distortion considerably and also the fixture is subjected to lesser stresses.

An example of a welding fixture is illustrated in Figure 4.17. The fixture is equipped with a rotatable clamp at variable speeds. There is an adjustable torch holder which can be moved to the right position in the limited space. This fixture is recommended for the welding on circular shaped objects.

Figure 4.17 : Example of a Welding Fixture

4.12 SUMMARY

The unit contents description of jigs and fixtures as a clamping tool for workpiece and guiding tool for the tool. Use of jigs and fixture directly influence the quality of performance of the operation. It improves efficiency of work by eliminating production

of poor quality products and reducing the product cycle time. Design of jigs and fixtures truly depends on the type of operation and machine tool to be used for that operation. The use of jig and fixture involve locating the workpiece in right position on the machine tool. The meaning of location is determining the points on the work where it should be supported to restrain all the motions so that the work can be done without any problem. Some principles of locations are followed for this purpose like 3-2-1 principle of location, location on a 'Vee' block, flat locator, cylindrical and conical and jack pin locators. The major objective of the principle of location is to clamp the rigidity of clamping. At the same time this all keep the processing area clear and available for processing. Different types of clamping devices and characteristics of a good clamping device are also described in the unit.

Along with the fixtures jigs are used to guide the tool movement during an operation. These are made of hardened steel, wear resistant and corrosion resistant steel. Different types of jigs are used for different types of operations. The commonly used fixtures are also described in the unit. Common fixtures are milling fixture and welding fixture.

4.13 ANSWERS TO SAQs

Refer the preceding text for all the Answers to SAQs.