19MCE401 - PROCESS PLANNING AND PRODUCT DEVELOPMENT

STUDY NOTES

UNIT 2 - PROCESS PLANNING ACTIVITIES

TOPIC 2 – SELECTION OF JIGS AND FIXTURES

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Selection of Jigs and Fixtures:

With the rapid advancement in manufacturing technology, consumerism has increased. Therefore, to meet the higher demands, manufacturers have developed innovative methods to produce high- quality products faster. The production process has observed the introduction of inventive manufacturing concepts such as Lean Production System, Cellular Manufacturing, Single Minute Exchange of Dies, and Tact Time Analysis. These creative approaches require a horde of efficient, cheaper tools and work-holding devices.

The manufacturing company requires a simple work positioning strategy and devices for correct operations. This is to ensure:

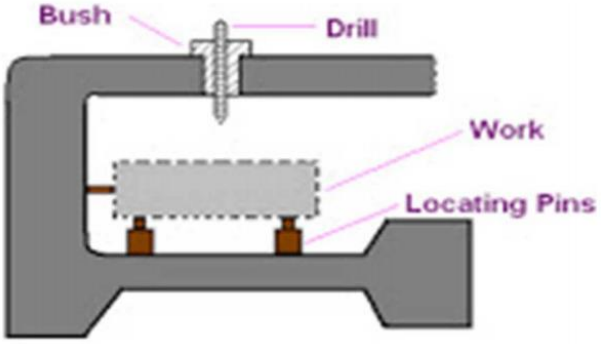
- Non-complexities in assembly and unit cost reduction
- Reduction in the massive manufacturing cost
- Increase their profitability

The industry has resorted to easing up the supply chain to maintain. This resulted in better and cost- effective work-holding devices that ensure better quality products, increase throughput, and reduce lead time. The requirement for the production of standard work-holding devices has paved the way for two specific terms named: Jigs and Fixtures. The jig is the device that guides the tool, while the fixture is a tool that securely and firmly holds the job in position during machining operations.

Jigs:

In simple terms, a jig is *a tool that guides the machining tool.*

A common type of jig is the drill jig, which guides the drill for making holes at desired locations. Using drill jigs increases the production rate drastically. These tools are usually made of metal, such as steel and aluminium, and are generally fitted with positioning devices called bushings. These tools guide the operation of machines and other equipment.

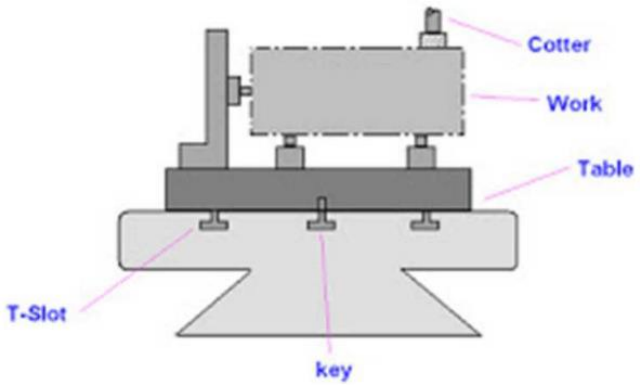


Fixtures:

On the other hand, a fixture is a *tool that firmly grips a workpiece on the machine bed accurately at the desired location.*

The fixture also reduces the loading, unloading, and fixing the time of the workpiece, which significantly reduces the non-productive hours. Fixtures are used for milling, turning, and grinding operations. To ensure proper alignment and hold of parts, fixtures can include a variety of locating components. Some manufacturers are even turning to 3D printing for their fixtures.

Typical jigs and fixtures are made from Cast Iron or Aluminium, though steel versions are also available. These jigs and fixtures can be purchased or custom-built. They are mounted on T-Slot plates and hold a variety of work holding devices.



Differences between Jigs and Fixtures:

"Jig" and "Fixture" are often referred to as synonyms, while sometimes both are used together as jigs-fixtures. Although both jig and fixture are used in the mass production process, functionally, the two are quite different tools. Let us go through the main points which differ a Jig from a fixture.

Jigs	Fixtures
A jig controls and guides the machining tool	A fixture holds and supports the component precisely for machining operations
Jig ensures accuracy, repeatability, and interchangeability	The fixture provides a reduction in error by holding a component firmly on a table
Jigs are usually on the lighter side	The fixture is bulky, rigid, and heavy

Jigs can be put in place and held by hand pressure	Fixtures are always placed firmly on a machine table
Some of the standard jig functions are drilling, reaming, tapping, and boring	Fixtures are used explicitly in milling machines, slotting machines, and shapers
Jigs cost more	Fixtures are not that cost-savvy compared to Jigs
Jigs require intricate design operations	Fixture design operations are relatively less complicated

Advantages of Jigs and Fixtures:

Jigs and Fixtures have made manufacturing processes less time-consuming, more precise, and hassle-free from a human factor perspective. The benefits of jigs and fixtures include but are not limited to the following:

- Increase in production
- The consistent quality of manufactured products due to low variability in dimension
- Cost reduction
- Inter-changeability and high accuracy of parts
- Inspection and quality control expenses are significantly reduced
- The decrease in an accident with improved safety standards
- Due to relatively simple manoeuvrability, semi-skilled workers can operate these tools, reducing the workforce's cost.
- The machine tool can be automated to a reasonable extent
- Complex, rigid and heavy components can be easily machined
- Simple assembly operations reduce non-productive hours
- Eliminates the need for measuring, punching, positioning, alignments, and setting up for each workpiece, thereby reducing the cycle and setting up a time
- Increases technological capacities of machine tools
- More than one device can be used simultaneously on a workpiece
- Setting higher values of some operating conditions like depth of cut, speed, and rate of feed can be attained because of the increased clamping capability of jigs and fixtures.

Both jigs and the fixtures are used to ease machining operations and reduce the non-productive time of any mass production process. The principle of location or the 3-2-1 principle, CAD

tools, and FEA tools are used to design jigs and fixtures. The following article will go through more detailed information about the 3-2-1 principle and design standards of jigs and fixtures. In the manufacturing industry, innovation is often about maximizing existing resources and building on the strengths of individual companies. Focus on jigs and fixtures helps companies increase productivity and production speed and cut overall expenses. They reduce the time required for quality control, cut down on errors, and speed up the production process. Furthermore, they are easier to use, even by semi-skilled operators. And since they are standardized, they ensure that every part produced is consistent, reducing the risk of human error.

Design principle of Jigs and Fixtures:

The art of metalworking has a primary concern, locating the part to be machined relative to the platform. A CNC machine starts machining at a specific point corresponding to the fixture and proceeds from there. Therefore, the preciseness with which a job is machined is dependent on the accuracy that holds in the fixture. The accurate location of every part loaded into the fixture is essential. Any deviation in part location adds to the dimensional tolerance that must be assigned to the finished pieces. Furthermore, improper supporting and securing the part in the fixture affects surface finishes by temporarily or permanently deforming it. Hence, techniques for supporting, clamping, and locating must be considered together to assure repeatability from part to part.

Basic principles of Jigs and Fixtures design:

- LOCATING POINTS: Locating the work is a prime necessity and requires suitable facilities. The correct setup ensures smooth insertion of a workpiece in the proper position and removing a workpiece from a jig without operational hassles or time consumption. The workpiece position needs to be precise with the guiding tool in the jig or setup pieces in the fixture.
- FOOLPROOF: A foolproof design of jigs and fixtures does not permit a tool or workpiece to be placed in any other way other than the intended one.
- REDUCTION OF IDLE TIME: Jigs and Fixtures must be designed in such a way that ensures smooth loading, clamping, machining, and unloading of a
- WEIGHT OF JIGS AND FIXTURES: A jig and fixture must be compact, easy to handle, and low cost regarding the number of materials used without giving up stiffness and rigidity.

- JIGS PROVIDED WITH FEET: Some jigs require feet so that they can be placed on the table firmly.
- MATERIALS FOR JIGS AND FIXTURES: Jigs and Fixtures are usually created with hardened materials to resist wear & tear and avoid frequent damage—for example, Mild steel, cast iron, Die steel, High-speed steel, Caesium.
- CLAMPING DEVICE: A suitable clamp is rated for its strength. It should be able to hold a workpiece firmly in its position while bearing the strain of the cutting tool simultaneously, without springing.

Broad rules of Jigs & Fixtures Design:

- Compare the production cost of work between the existing tools and the tool to be made and see if the manufacturing price is not more than the expected gain.
- Determine location points and outline clamping arrangement.
- Make sure the clamping and binding pieces are as quick to act & efficient as possible.
- Make the jig and fixture foolproof.
- Make sure the locating points are adjustable.
- Do avoid intricate clamping arrangements.
- Round all corners.
- Make sure the operator has handles to make handling tasks easier.
- Provide ample amount of clearance.
- Provide holes for chips to escape.
- Systematically locate clamps to resist the pressure of the cutting tool while machining.
- To avoid springing action, place all clamps in proximity opposite to the bearing point of the workpiece.
- Test the jigs before putting them in a shop.

The 3-2-1 principle

Locating a part to be machined involves mainly three steps: Supporting, Positioning, and Clamping.

Two main intentions when placing a job on a jig/fixture are:

- Precisely positioning the part at the desired coordinates.
- Curbing all six degrees of movement so that the part cannot budge.

An extensively used method for obtaining these objectives is the 3-2-1 principle or six degrees of freedom for part location.

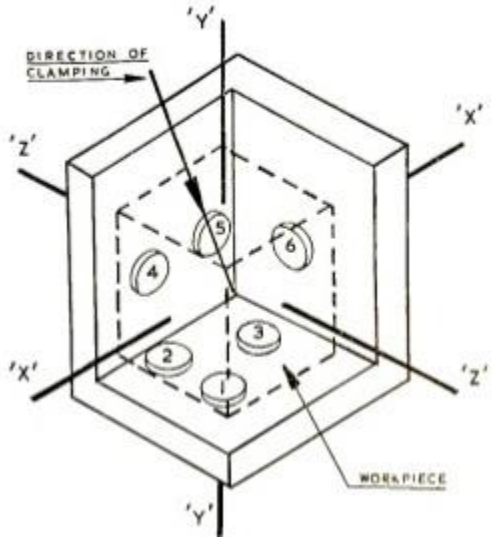


Figure 1. Source: Quora

The 3-2-1 method is a work-holding principle where three pins are located on the 1st principle plane, i.e., either XY, YZ, ZX. And two pins are located on the 2nd plane perpendicular to the 1st plane, and at last, one pin on the plane is mutually perpendicular to the 1st and 2nd planes. The aim is to constrain the movement of the workpiece along all three axes.

Design objectives of Jigs and Fixtures

Before sitting down to design jigs/fixtures, the designer must consider the following points:

- The tool must be foolproof to prevent any mishandling or accidental usage by the operator.
- Easy to operate for increasing efficiency.
- Easy to manufacture using the lowest costs.
- Its ability to weather the tool life instead of appropriate materials.
- Must be consistent at producing high-quality parts.
- Must be safe and secure to use.

The designer must know the basics of the process and the tools associated with it for which the jig/fixture is designed. Overall objectives to look out for a while developing such tools are:

- Cycle time.
- Type of Jig/Fixture.

- Part Assembly sequence or Machining locations.
- Joining or machining process.
- Clamping method and clamping sequence.
- Required output accuracy.
- Type of equipment to be used with the jig.
- Method of ejecting finished output and transferring it to the next. Platform, whether the manual or automatic mode.
- The type of material, recommended weight, number of spots involving welding.

Reference: National Institute of Technology, Calicut