Trade of Toolmaking	
Module 5:	Press Tools, Jigs & Fixtures, Mouldmaking
Unit 5:	Jigs and Fixtures
	Phase 2

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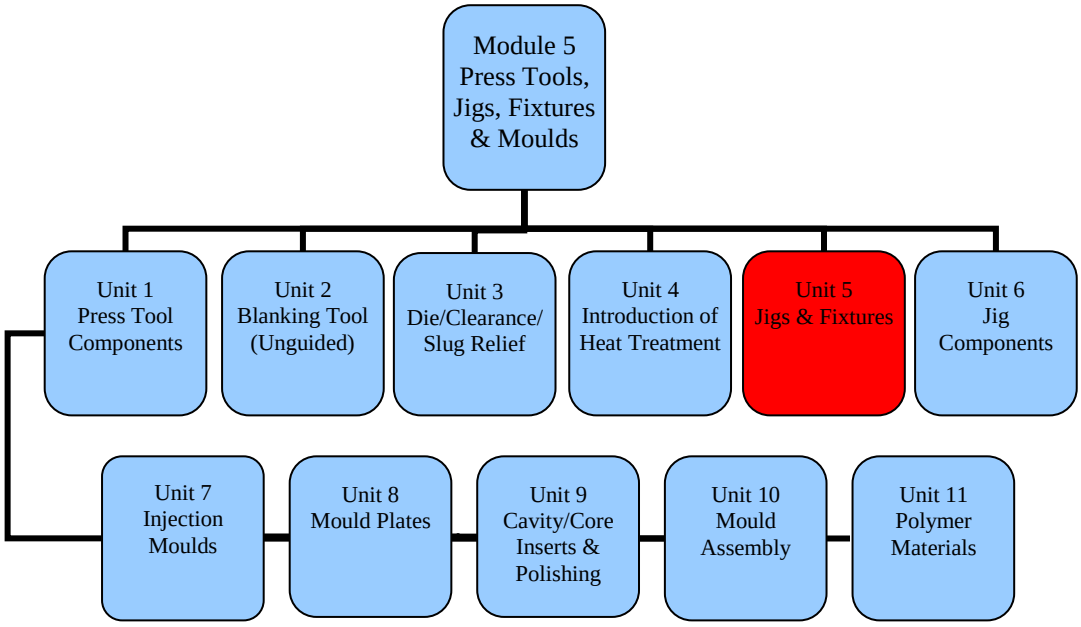
Unit Objective

On completion of this unit you will be able to differentiate between jigs and fixtures and explain methods of locating and clamping the workpiece.

Introduction

Module five of this course covers Press Tools, Jigs & Fixtures, Mouldmaking. This is the fifth unit in module five and explains the design, manufacture and use of jigs and fixtures. Jig and fixtures are used throughout industry and are generally used for large scale production by semi-skilled operators. They can also be used by skilled operators to machine small batch production, where interchangeability is important and for parts that are difficult to hold and machine accurately in a standard vice.



By the end of this unit you will be able to:

- Differentiate between jigs and fixtures and describe the advantage of each arrangement.
- Draw methods of clamping single or multiple components using different clamping devices.
- Name different types of part locators.
- Calculate the clamping force required on a part using the law of the lever formula.
- Procedure and assemble jig and fixture component parts.

1.0 Differentiating Between Jigs And Fixtures And The Advantages Of Each

Key Learning Points

Principle difference between jigs and fixtures. Advantages of jigs: locate and hold the work and guide the cutting tool, dedicated purpose to the manufacture of a particular component.

1.1 Principle Difference Between Jigs And Fixtures

A *Jig* is a device for locating and clamping a component in the required position. The Jig also guides the tool during the machining operation and is mainly used for drilling and reaming operations. A *Fixture* is a device for holding and clamping a component in the required position, but the tool is not guided. Fixtures are mainly used for milling and grinding operations.

1.2 Advantages Of Jigs: Locate And Hold The Work And Guide The Cutting Tool, Dedicated Purpose To The Manufacture Of A Particular Component

The advantages of using a Jig are as follows:

- To reduce manufacturing time.
- To reduce the cost of manufacturing multiple products to size consistently.
- To produce components to close tolerances economically.
- To ensure that components are identical in form and size.
- To produce components that are interchangeable with each other e.g. spare parts.
- Can be used by unskilled operators.

Ref: Timings, R.L. 1998, Manufacturing technology, vol. 1, 3rd edn, Pearson Education Limited, chapter 3, *Toolholding and workholding*, p. 94.
ISBN-13: 9780582356931

2.0 Drawing Methods Of Clamping Single Or Multiple Components

Key Learning Points

Process planning: selection of jigs and fixtures to produce components. Utilisation of standard parts catalogues.

2.1 Process Planning: Selection Of Jigs And Fixtures To Produce Components. Utilisation Of Standard Parts Catalogues

Jig and fixture design is a step-by step process, whereby we initially draw the component and the jig or fixture conforms to the design. When designing jigs and fixtures the following must be considered:

- Positioning of the component in the jig or fixture. The location points may need to be hardened in order to reduce wear.
- Clamping method. How is the component being clamped and where on the component. What part of the component is being clamped?
- Operator safety must be ensured at all times.
- Time taken to load and unload the component should be kept to a minimum.
- The jig or fixture must remain rigid when the component is clamped.
- The component must not be distorted when clamped.
- Jigs and fixtures must be easily cleaned of swarf following machining and cutting fluid must be allowed to flow away.
- Parts that wear of break must be easily replaced.
- Use standard components where possible e.g. Clamps, Bushings, Knobs, Handles, Baseplates, etc., as this will save time and reduce costs. Standard parts catalogues are available for this purpose.

A body in space has six degrees of freedom, it can move back and forth along the X-axis, side to side along the Y-axis and up and down along the Z-axis. It can also rotate about these three axis. In order for a workpiece to be safely worked on, it must be located in the required position and restrained from moving in any of the six degrees of freedom. Locators are used to position the workpiece and the restraints, such as clamping screws, prevent the workpiece from moving.

2.2 Utilisation Of Standard Parts Catalogues

When designing jigs and fixtures, standard off-the-shelf parts can be used, which will be more economical and have a proven record. Various catalogues are available for this purpose.

3.0 Different Types Of Part Locators

Key Learning Points

Knowledge of the following: bushes, locations, clamping. Meaning of redundant location and where it applies. Location and quantity of buttons in a box jig.

3.1 Knowledge Of The Following: Bushes, Locations, Clamping

A *bush* is used to guide the drill into the work piece. The bush is usually replaceable and locates in the bushing liner of the jig or fixture. If the hole needs to be reamed, then the bush can be used to guide the drill and then removed when reaming, as the reamer will follow the axial alignment of the drilled hole. The bush is manufactured from tool steel, which is bored to a tight tolerance and a good surface finish. It is then hardened to resist wear form the rotating drill.

Clamps used in jigs and fixtures should be quick and easy to operate in order to reduce setup time. It should hold the workpiece against the cutting forces without damaging the workpiece.

Ref: Timings, R.L. 1998, Manufacturing technology, vol. 1, 3rd edn, Pearson Education Limited, chapter 3, *Toolholding and workholding*, p. 94.
ISBN-13: 9780582356931

3.2 Meaning Of Redundant Location And Where It Applies

Redundant location occurs when two locators are attempting to constrain one degree of freedom from two location points and should be avoided.

3.3 Location And Quantity Of Buttons In A Box Jig

Locators can be (i) flat, (ii) cylindrical, (iii) conical or (iv) vee. They can be fixed or adjustable and are made from hardened tool steel in order to reduce wear. The base of the jig or fixture can be used to locate the workpiece on one of its flat surfaces and restrains it in the vertical plane (z direction). Location pegs are used to locate the work piece and are positioned so as to locate at strategic points on the work piece, such as the datum edges or in existing holes. They provide positive location and constraint in the x and y directions.

Ref: Timings, R.L. 1998, Manufacturing technology, vol. 1, 3rd edn, Pearson Education Limited, chapter 3, *Toolholding and workholding*, p. 94.
ISBN-13: 9780582356931

4.0 Calculation Of Clamping Forces Using The Law Of The Lever Formula

Key Learning Points

Law of the lever and bending forces. Action of cutting forces.

4.1 Law Of The Lever And Bending Forces

A lever is a bar that is capable of rotating about a fixed point called the fulcrum. The clamp on a jig or fixture acts like a lever, where the *effort* is applied to the locking screw or knob, the force exerted on the workpiece is called the *load* and the clamp rotates about a pin or axis, which is called the *fulcrum*. In order to determine the force exerted on the workpiece moments are taken about the fulcrum. The sum of the clockwise moments are equal to the sum of the anticlockwise moments.

A bending moment (force) exists in a beam when a moment is applied so that it causes the beam to bend. This occurs in the clamping arm on a jig or fixture when it is holding the workpiece. Failure will occur when the tensile stresses when the bending moment is greater then the yield stress of the beam.

4.2 Action Of Cutting Forces

In a milling fixture for example, it is important to position a positive restraint at one end of the workpiece. This will resist the cutting forces and prevent movement when the cutter is being fed in the direction of the restraint.

Ref: Timings, R.L. 1998, Manufacturing technology, vol. 1, 3rd edn, Pearson Education Limited, chapter 3, *Toolholding and workholding*, fig. 3.3, p. 96.
ISBN-13: 9780582356931

5.0 Producing And Assembling Jig And Fixture Components

Key Learning Points

Machining to unilateral tolerances. Classes of fit and types of fit. Hole and shaft based system. Integration of fixtures when quality, quantity and time schedule are considered in current work practices.

5.1 Machining To Unilateral Tolerances

Unilateral tolerances: Machining to unilateral tolerances means that the tolerance zones lie to one side of the basic dimension

5.2 Classes Of Fit And Types Of Fit

Classes of fit: There are three classes of fit (i) clearance, (ii) transition and (iii) interference fits

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 19, *Limits and fits*, p. 154.
ISBN-13: 9780750651202

5.3 Hole And Shaft Based System

There are two bases of the limits and fits system, (i) the **Hole Basis** (Ref.: BSI data sheet 4500A) and (ii) the **Shaft Basis** (Ref.: BSI data sheet 4500B). In the Hole Basis system the hole size is kept constant and the shaft size varied to provide the required fit. Whereas in the Shaft Basis system the shaft is kept constant and the hole is varied to provide the required fit. The Hole Basis system is the most widely used system and is more cost effective. In this system one size reamer can be used and a range of fits can be produced by varying the shaft limits.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 19, *Limits and fits; Bases of fits*, p. 155.
ISBN-13: 9780750651202

5.4 Integration Of Fixtures When Quality, Quantity And Time Schedule Are Considered In Current Work Practices

The decision to manufacture a jig or a fixture is mainly an economic one. The cost of the jig or fixture must be related to the reduction in cost and also the time involved producing the components. The use of the jig or fixture will result in high quality interchangeable parts, which are geared towards large-scale production

Summary

Differentiating between jigs and fixtures and the advantages of each: A *Jig* is a device for locating and clamping a component in the required position. The Jig also guides the tool during the machining operation and is mainly used for drilling and reaming operations. A *Fixture* is a device for holding and clamping a component in the required position, but the tool is not guided. Fixtures are mainly used for milling and grinding operations.

Drawing methods of clamping single or multiple components: Jig and fixture design is a step-by step process, whereby we initially draw the component and the jig or fixture conforms to the design.

A body in space has six degrees of freedom, it can move back and forth along the X-axis, side to side along the Y-axis and up and down along the Z-axis. It can also rotate about these three axes. In order for a workpiece to be safely worked on, it must be located in the required position and restrained from moving in any of the six degrees of freedom. Locators are used to position the workpiece and the restraints, such as clamping screws, prevent the workpiece from moving.

Different types of part locators: Locators can be (i) flat, (ii) cylindrical, (iii) conical or (iv) vee. They can be fixed or adjustable and are made from hardened tool steel in order to reduce wear. The base of the jig or fixture can be used to locate the workpiece on one of its flat surfaces and restrains it in the vertical plane (z direction). Location pegs are used to locate the work piece and are positioned so as to locate at strategic points on the work piece, such as the datum edges or in existing holes. They provide positive location and constraint in the x and y directions.

A *bush* is used to guide the drill into the work piece. The bush is usually replaceable and locates in the bushing liner of the jig or fixture. If the hole needs to be reamed, then the bush can be used to guide the drill and then removed when reaming, as the reamer will follow the axial alignment of the drilled hole. The bush is manufactured from tool steel, which is bored to a tight tolerance and a good surface finish. It is then hardened to resist wear form the rotating drill.

Clamps used in jigs and fixtures should be quick and easy to operate in order to reduce setup time. It should hold the workpiece against the cutting forces without damaging the workpiece.

Redundant location occurs when two locators are attempting to constrain one degree of freedom from two location points and should be avoided.

Calculation of clamping forces using the law of the lever formula: A lever is a bar that is capable of rotating about a fixed point called the fulcrum. The clamp on a jig or fixture acts like a lever, where the *effort* is applied to the locking screw or knob, the force exerted on the workpiece is called the *load* and the clamp rotates about a pin or axis, which is called the *fulcrum*. In order to determine the force exerted on the workpiece moments are taken about the fulcrum. The sum of the clockwise moments are equal to the sum of the anticlockwise moments.

Producing and assembling jig and fixture components: Drawings should be read carefully prior to carrying out any task and it is important to plan the sequence of operations. The main body of the jig or fixture can be machined from mild steel or aluminium and assembled together with screws and dowels. Locators and bushes are manufactured separately from tool steel and are hardened in order to reduce wear and are then assembled with the main assembly. Clamps, screws, handles etc., can be sourced from catalogues.

Suggested Exercises

1. Design a simple jig for drilling a Ø10 hole into a mild steel plate.
2. What is the principle difference between a jig and a fixture?
3. List the advantages of using a jig.
4. Explain the six degrees of freedom in relation to jig and fixture design.
5. Explain the meaning of redundant location.

Questions

1. What is the definition of a Jig and a Fixture?
2. Give an example of a Jig and a Fixture.
3. In a fixture, what is a bush used for?
4. What are the main functions of a clamp used in a Jig and Fixture?
5. What are the functions of Location Pegs?

Answers

1. A Jig is a device for locating and clamping a component in the required position. The Jig also guides the tool during the machining operation.
   A Fixture is a device for holding and clamping a component in the required position, but the tool is not guided. Fixtures are mainly used for milling and grinding operations.
2. A Jig is mainly used for drilling and reaming operations.
   A Fixture is mainly used to hold work during milling and grinding operations.
3. A bush is used to guide the drill into the work piece. It can be fixed or removable.
4. Clamps used in jigs and fixtures should be quick and easy to operate in order to reduce setup time. It should hold the workpiece against the cutting forces without damaging the workpiece.
5. Location pegs are used to locate the work piece and are positioned so as to locate at strategic points on the work piece, such as the datum edges or in existing holes. They provide positive location and constraint in the X and Y directions

Recommended Additional Resources

Reference Books

Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology.

ISBN-13: 9780750660730

Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology.

ISBN-13: 9780750651202

Timings, R.L. 1998, *Manufacturing technology*, vol. 1, 3rd edn, Pearson Education Limited.

ISBN-13: 9780582356931