Trade of Toolmaking	
Module 1:	Induction & Bench Fitting
Unit 5:	Assembly & Doweling
	Phase 2

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Document Release History

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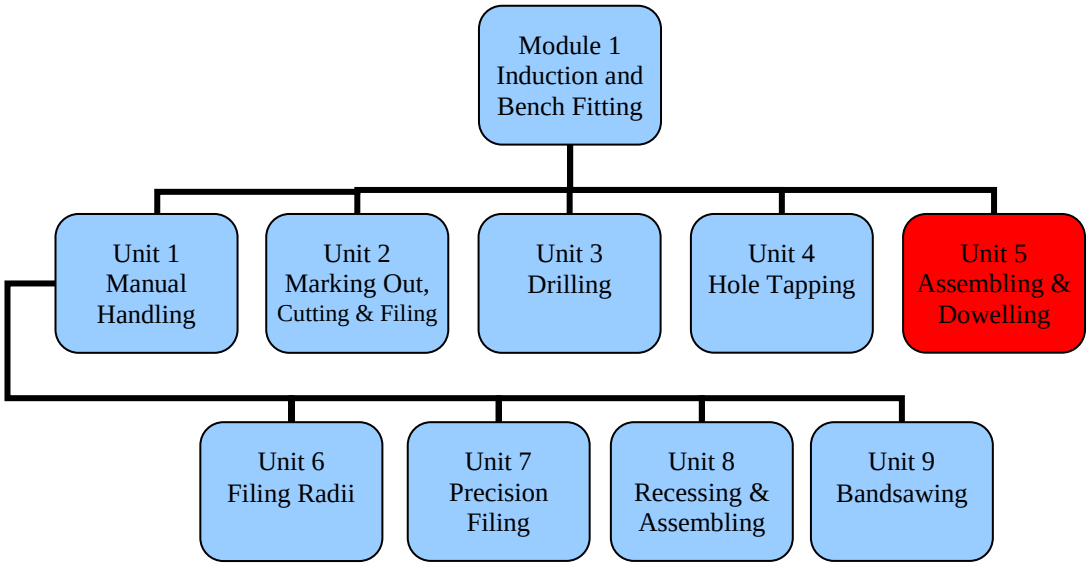
Unit Objective

On completion of this unit you will be able to plan the sequence of operations for the safe assembly of mating components. You will be able to mark out, drill and assemble with screws prior to reaming the components.

Introduction

Module one of this course covers induction and bench fitting. This is the fifth unit in module one and explains how to plan the sequence of operations to safely assemble mating components. This involves marking out components using datum edges, drilling, reaming and doweling of components.

As explained in previous units, drilling, counterboring, countersinking and tapping operations are used for assembling metal plates together. For many applications in the industry the assembly of components with screws only, may be adequate, but if more precision is required then the use of dowels is necessary. The dowels accurately locate the plates together and allow the plates to be assembled and disassembled without loosing their original position. Accurate location using dowels is essential in moulds, presstools machine parts etc.



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

- Plan the sequence of operations for the safe assembly of mating components.
- Mark out a series of toleranced mating components to produce an assembled unit using datum edges or referenced surfaces.
- Locate from datum edges, mark out, drill, ream and countersink reamed holes to the specifications on the supplied drawings.
- Locate and assemble the mating components using screws to hold the surfaces in place for reaming.
- Insert dowels in position to the required fit to locate the component permanently.

1.0 Planning The Sequence Of Operations

Key Learning Points

Layout and organisation of tools and materials in a neat and logical order. Planning assembly procedures and assembly work.

1.1 Layout And Organisation Of Tools

In order to assemble mating components together it is important to plan the sequence of operations. Tools and materials should be laid out and organised in a neat and logical order prior to starting the work.

1.2 Planning Assembly Procedures And Assembly Work

Job planning is important prior to starting any task. The drawing should first be studied and understood. A vernier height gauge will be needed for marking out the metal plates to the dimensions specified on the drawing. The scribed lines should be marked from the same datum edge as specified on the drawing. Toolmakers clamps will be required for holding the plates together when drilling the holes for the screws. The Zeus book can be used to determine the tapping drill and the clearance drills.

2.0 Marking Out Component To Produce An Assembly

Key Learning Points

Marking out of components with associated dimensions using the vernier height gauge. Use of datum edges to locate hole centres.

2.1 Marking Out Of Components With Associated Dimensions Using The Vernier Height Gauge

The workpiece is marked with a vernier height gauge to the dimensions specified on the drawing. The scribed lines should be marked from the same datum edge as specified on the drawing.

2.2 Use Of Datum Edges To Locate Hole Centres

The *datum* is described as a reference edge or a point from which measurements are made. For scribing hole centres, mark out the centre hole with the vernier height gauge and punch the centre point.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out*, p. 44.

ISBN-13: 9780750660730

3.0 Marking Out, Drilling, Reaming And Countersinking

Key Learning Points

Reaming allowances, parallel and taper reamers. Lubricants and coolants: lubrication and thermal properties. Calculating reaming speeds and feeds. Conversion of fractions to decimals and visa versa.

3.1 Reaming Allowances, Parallel And Taper Reamers

A drilled hole does not always produce a bore to the accuracy and finish as specified on the drawing, therefore a reamer is used for this purpose. The purpose of a reamer is to produce a hole of high accuracy and to a good finish. The holes are drilled to a diameter, which is slightly less then the finished dimension required, e.g. for up to Ø10mm holes the amount of stock that needs to be removed by the reamer is approximately 0.3mm.

The standard Machine Reamer is normally used, but Hand Reamers are also available. The start of the reamer is tapered and this allows the reamer to fit into the drilled hole and helps to align it prior to performing the hand reaming operation. Reamers are available as Parallel, as mentioned above, or Tapered. When a tapered hole is required, then a Tapered reamer is used. The hole is predrilled in steps using various sized drills. A tapered hole is used when for example a tapered pin is been used.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 8, *Drilling*, sec. 8.4 *Reamer*, p. 53.

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3.2 Calculating Reaming Speeds And Feeds

As a general rule the cutting speed for the reamer should be 50% of the drilling speed and the feed rate should be double. The reamer needs to be fed into the workpiece with a constant feed and it is important to use coolant.

3.3 Lubricants And Coolants: Lubrication And Thermal Properties

There are four main types of coolant: soluble oil, mineral oil, synthetic and chemical. Barrier creams can be used to protect hands from any oil and chemicals that may be present in the coolant. Coolant removes the heat generated by the cutting tool due to friction. The advantages of using coolant are: better surface finish, better swarf removal and increased tool life.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, sec. 7.5 *Cutting fluids*, p. 53.

ISBN-13: 9780750660730

4.0 The Assembly Of Components For Reaming

Key Learning Points

Assembly techniques: clamping and location for drilling and reaming.

4.1 Assembly Techniques: Clamping And Location For Drilling And Reaming

Prior to performing the reaming operations the metal plates will already have been drilled, counterbored, countersunk, tapped and then screwed together, as explained in previous units. In order to accurately align the plates prior to reaming, the sides of plates are placed on the marking out table and the screws lightly tightened. The plates can be gently tapped down onto the table, which will align the side walls. When the plates are aligned, the screws are then tightened. The assembled plates are then ready for marking out prior to drilling and reaming. A toolmakers clamp can also be used to clamp and align the plates.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out*, sec. *Clamps*, p. 53.

ISBN-13: 9780750660730

5.0 The Use Of Dowels For Permanent Location

Key Learning Points

Surface finish on reamed parts. Typical Ra, N and CLA values, examples using surface roughness comparators. Use of coated extractable dowels.

5.1 Surface Finish On Reamed Parts

For many applications the assembly of components with screws may be adequate, but if more precision is required then dowels need to be used, which will result in a more accurate hole and a better surface finish. The dowels accurately locate the plates together and allow the plates to be assembled and disassembled without loosing their original position.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 8, *Drilling*, p. 92.

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5.2 Typical Ra, N And CLA values, Examples Using Surface Roughness Comparators

As mentioned above, the purpose of a reamer is to produce a hole of high accuracy and to a good finish. A surface roughness comparator chart can be used to compare the reamed surface, or indeed any machined surface, to that of a standard reamed sample. The comparator chart consists of a range or machined samples and the corresponding Ra valve.

The *Ra* value is the average height of the peaks and valleys on a metal surface, at the micro scale (0.001mm).

Ra surface measurement is the most common system used, but other systems can also be used. The table below shows the approximate conversion between the different measuring systems:

Ra = CLA (CLA means centre line average. It is used in Britain and is identical to Ra)		**Roughness Grade No's (N)**
µm	**µin**	
0.40	15.7	N5
0.80	31.4	N6
1.6	63.0	N7
3.2	126.0	N8
6.3	247.0	N9
12.5	485.0	N10

Note: µm = micro metre, µin = micro inch

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 5, *Standards, measurements and gauging*, sec. 5.8 *Surface roughness*, p. 92.

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5.3 Use Of Coated Extractable Dowels

Dowels can be manufactured from various materials such as hardened steel, stainless steel of from chrome plated medium carbon steel. Some dowels have internal threads to allow them to be extracted from an assembly if required.

5.4 Determination Of Matter, Mass, Density And Volume

Matter is anything which occupies space and can be a solid, liquid or gas. *Mass* is more commonly referred to as *Weight*, but in physics and engineering weight means the pull of gravity on an object. Mass is measured in kilograms and weight is measured in Newtons (kgm/s^2). *Density* is mass per unit volume. It is the ratio of the amount of matter in an object compared to its volume, e.g. a small, heavy object, such as a block of steel, is denser than a larger object of the same mass, such as a block of wood. The *Volume* of an irregular object can be determined by filling a glass with water and immerse the object in it and collect the displaced water. The volume of water displaced is equal to the volume of the object.

5.5 Conversion Of Fractions To Decimals And Visa Versa

Bird, John Basic 2005, *Engineering mathematics*, 4th edn, Elsevier Science & Technology, chapter 2, *Fractions, decimals and percentages*, pp. 6-9.

ISBN-13: 9780750665759

Summary

Planning the sequence of operations: In order to assemble mating components together it is important to plan the sequence of operations. Tools and materials should be laid out and organised in a neat and logical order.

Marking out: When the plates have been aligned and screwed together, then the locations for the dowel holes are marked out to the dimensions specified on the drawing. The assembled plates are marked out using a vernier height gauge and are supported with an angle plate. The hole centres are then punch marked prior to drilling.

Drilling, reaming and countersinking: A drilled hole does not always produce a bore to the accuracy and finish as specified on the drawing, therefore a reamer is used for this purpose. The purpose of a reamer is to produce a hole of high accuracy and to a good finish. The holes are drilled to a diameter, which is slightly less then the finished dimension required, e.g. for up to Ø10mm holes the amount of stock that needs to be removed by the reamer is approximately 0.3mm. As a general rule the cutting speed for the reamer should be 50% of the drilling speed and the feed rate should be double. The reamer needs to be fed into the workpiece with a constant feed and it is important to use coolant. A countersink tool is used to chamfer the reamed holes, which will remove burrs and allow an easier insertion of the dowels.

The standard Machine Reamer is normally used, but Hand Reamers are also available. The start of the reamer is tapered and this allows the reamer to fit into the drilled hole and helps to align it prior to performing the hand reaming operation. Reamers are available as Parallel, as mentioned above, or Tapered. When a tapered hole is required, then a Tapered reamer is used. The hole is predrilled in steps using various sized drills. A tapered hole is used when for example a tapered pin is been used.

Assembly of components: Prior to performing the reaming operations the metal plates will already have been drilled, counterbored, countersunk, tapped and then screwed together, as explained in previous units. In order to accurately align the plates prior to reaming, the sides of plates are placed on the marking out table and the screws lightly tightened. The plates can be gently pushed onto the table, which will align the side walls. A toolmakers clamp can also be used to clamp and align the sides of the plates. When the plates are aligned, the screws are then tightened. The assembled plates are then ready for marking out prior to drilling and reaming.

Use of dowels for permanent location: For many applications in industry the assembly of components with screws may be adequate, but if more precision is required then dowels need to be used. The dowels accurately locate the plates together and allow the plates to be assembled and disassembled without loosing their original position.

As mentioned above, the purpose of a reamer is to produce a hole of high accuracy and to a good finish. A surface roughness comparator chart can be used to compare the reamed surface to that of a standard reamed sample. The comparator consists of a range or machined samples and the corresponding Ra valve. The Ra value is the measurement, at the micro scale (0.001mm), of the peaks and valleys on a metal surface.

Definitions: *Matter* is anything which occupies space and can be a solid, liquid or gas. *Mass* is more commonly referred to as *Weight*, but in physics and engineering weight means the pull of gravity on an object. Mass is measured in kilograms and weight is measured in Newtons (kgm/s^2). *Density* is mass per unit volume. It is the ratio of the amount of matter in an object compared to its volume, e.g. a small, heavy object, such as a block of steel, is

denser than a larger object of the same mass, such as a block of wood. The *Volume* of an irregular object can be determined by filling a glass with water and immerse the object in it and collect the displaced water. The volume of water displaced is equal to the volume of the object.

Suggested Exercises

1. State the purpose of using a reamer.
2. What size drill is used prior to reaming a Ø10mm hole.
3. Calculate the spindle speed for reaming a Ø10mm hole.
4. Machine two Ø10mm holes, drill one of the holes and ream the other. Note the difference in the surface finish between the two holes.
5. Measure the two holes using a vernier callipers and comment on the accuracy of their diameters.

Questions

1. What instrument is used to accurately mark out a workpiece?
2. Explain the term ‘datum’.
3. What tool is used to machine a hole to a high degree of accuracy and finish?
4. Explain the techniques of using a reamer to produce an accurate Ø10mm bore.
5. What speed and feed rates are used when using a reamer?

Answers

1. The workpiece is marked with a Vernier Height Gauge to the dimensions specified on the drawing. The scribed lines should be marked from the same datum edge as specified on the drawing.
2. The Datum is described as a reference edge or a point from which measurements are made.
3. The reamer is used to produce a hole of high accuracy and a good surface finish.
4. The holes are drilled to a diameter, which is slightly less then the finished dimension required, e.g. for up to Ø10mm holes the amount of stock that needs to be removed by the reamer is approximately 0.3mm. Therefore for a Ø10mm bore the hole is drilled to Ø 9.7mm prior to using the reamer.
5. As a general rule the cutting speed for the reamer should be 50% of the drilling speed and the feed rate should be double. The reamer needs to be fed into the workpiece with a constant feed and it is important to use coolant.

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

Bird, John 2005, *Basic engineering mathematics*, 4th edn, Elsevier Science & Technology.

ISBN-13: 9780750665759

Zeus Precision Charts Ltd. 2007, *Zeus precision data charts and reference tables for drawing office, toolroom & workshop*, 2007 edn, Zeus Precision Charts Ltd.

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