Trade of Toolmaking	
Module 2:	Turning
Unit 2:	Facing, Parallel & Step Turning
	Phase 2

Published by

SOLAS
An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority

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Document Release History

Date	Version	Comments
25/09/2014	2.0	SOLAS transfer

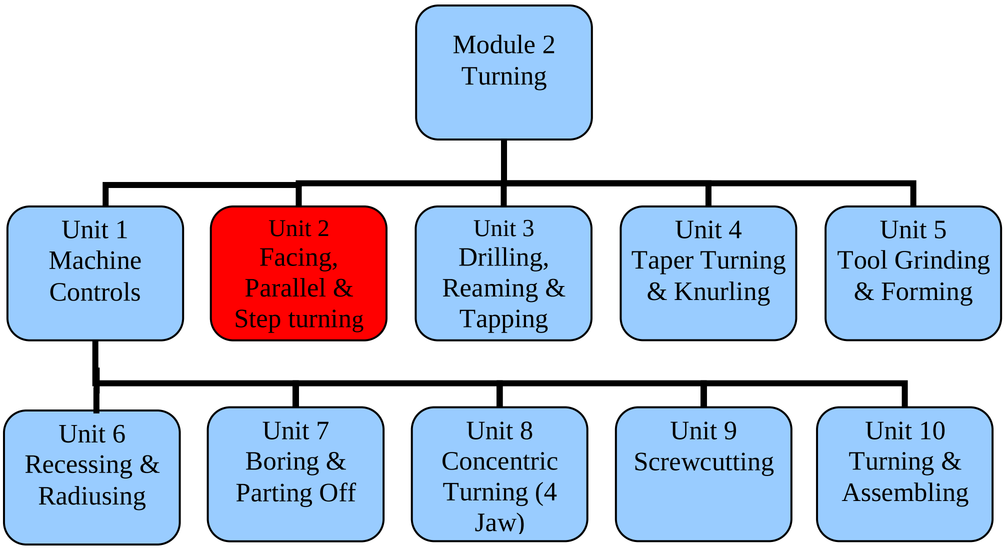
Unit Objective

On completion of this unit you will be able to read and interpret drawings, setup a 3-jaw chuck, calculate cutting speeds and perform turning and facing operations.

Introduction

Module two of this course covers turning. This is the second unit in module two and introduces the techniques associated with safely setting up a workpiece in a 3-jaw chuck. It also explains how to setup the cutting tool in the tool post and select the correct cutting speed. This unit also covers the turning, facing and centre drilling.

The speed of the chuck is measured in revolutions per minute (RPM), which is calculated by entering the cutting speed and the diameter of the material into a formula. The cutting speed refers to the distance covered by the tool across the material while machining. The cutting speeds for many common materials have already been determined and can be read from a data chart. Setting the correct cutting speeds is very important. Too high speed, the cutter will overheat and lose its cutting edge and produce a poor finish on the work piece. The cutter will eventually burn out. Too low a speed will also result in a poor finish and may cause the tool to break.



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

- Read and interpret basic first and third angle engineering drawings.
- Draw section views of individual components.
- Set up the workpiece securely in a 3-jaw chuck.
- Mount cutting/turning tool in tool holder/post and set tools on centre.
- Select and set correct spindle speed (RPM).
- Select and use coolants appropriate to material types.
- Face off workpiece ends (manual action).
- Centre drill workpieces.
- Machine components with parallel stepped turning and chamfering.

1.0 Reading And Interpreting Engineering Drawings

Key Learning Points

First and third angle projection, projection and assembly

1.1 First And Third Angle Projection, Projection And Assembly

Technical drawing is a method of communicating and exchanging design ideas in industry. Drawing sheets consist of a border, title block, views of the component, dimensions, symbols and notes. Multi-view orthographic projection is used in engineering drawing, working to BS 8888. There are two systems of projection, First Angle and Third Angle, which are based on a framework of planes at right angles. In first angle projection, each view shows what would be seen by looking on the far side of an adjacent view. In Third angle projection, each view shows what would be seen by looking on the near side of an adjacent view.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 4. *Principles of first and third angle orthographic projection*.

ISBN-13: 9780750651202

2.0 Drawing Section Views Of Individual Components

Key Learning Points

Sectional elevations, plans and end views.

2.1 Sectional Elevations, Plans And End Views

When a feature on a component is hidden or is inside the component and cannot be shown clearly on one of the projected views, then a sectioned view is taken through the part, showing the sectioned view at a right angle to the view.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 8, *Sections and sectional views*, p. 64.

ISBN-13: 9780750651202

3.0 Setting Up The Workpiece A 3-Jaw Chuck

Key Learning Points

Mounting of the workpiece on the 3-jaw chuck. Implication of changing work position for retention of concentricity.

3.1 Mounting Of The Workpiece On The 3-Jaw Chuck

The 3-jaw chuck is easy to use, as the work piece is self centred. The chuck can hold cylindrical and hexagonal bars. Internal and external jaws are available. The end face can easily be machined. A chuck key is used to tighten and loosen the jaws. From a safety point of view, it is important to remove the chuck key from the chuck immediately after use.

3.2 Implication Of Changing Work Position For Retention Of Concentricity

For parts that require a number of different diameters that need to be concentric, then turning should be performed in one setting without removing the part from the chuck. If a part is removed from a chuck and put back in again, then accuracy is lost. If a part needs to be aligned very accurately then it can be setup in a 4-jaw chuck and a dial indicator is used to centre it.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials,* 3rd edn, Elsevier Science & Technology, chapter 9, *Turning,* p. 151.

ISBN-13: 9780750660730

4.0 Mounting Turning Tool In Tool Post And Setting It On Centre

Key Learning Points

Setting up and mounting of tools and setting of the centre height. Composition and properties of HSS (high speed steel). Tool geometry: rake and clearance angles.

4.1 Setting Up And Mounting Of Tools And Setting Of The Centre Height

It is important to set the tool to the centre height of the work. If the tool is set too high it has the effect of reducing the clearance angle at the front of the tool and increasing the rake angle. When it is set too low it has the opposite effect. This can result in a poor surface finish on the turned surface. The correct tool height can be set by aligning it with the Tailstock Centre.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 8, *Turning*, p. 140.

ISBN-13: 9780750660730

4.2 Composition And Properties Of HSS (High Speed Steel)

One type of cutting tool commonly used is HSS (high speed steel), which is made of steel, tungsten, chromium and vanadium.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, p. 113.

ISBN-13: 9780750660730

4.3 Tool Geometry: Rake And Clearance Angles

Rake Angles: *Top Rake* is slope from the front tip of the tool towards the back. This can also be called the back rake. *Side Rake* is the slope from the side to side from the cutting edge. *True Rake* is a combination of *Top* and *Side Rake*.

Clearance Angle: The side and front of the tool is ground below the cutting edge to slope away from the workpiece. This provides clearance between the tool and the workpiece

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, p. 116.

ISBN-13: 9780750660730

5.0 Selecting And Setting Correct Spindle Speed (RPM)

Key Learning Points

Calculation of spindle speeds and feeds using formulae and charts

5.1 Calculation Of Spindle Speeds And Feeds Using Formulae And Charts

Cutting speed is expressed in metres per minute, which refers to the distance in metres that a tool may travel across the material being cut. The spindle speed is calculated by entering the cutting speed and the cutter diameter into the RPM formula, where the *Cutting Speed* is expressed in meters per minute. Charts are available that recommend the correct cutting speed for a particular material, e.g. a cutting speed of 30 meters/min is used for mild steel, and a cutting speed is 20 metres/min is used for tool steel. Therefore the spindle speed will be lower for the tool steel when compared to that of mild steel.

Recommended cutting speed in metres per minute:

Material	High Speed Steel (metres/min)	Carbide Cutter (metres/min)
Tool Steel	21 - 33	68 – 158
Mild Steel	33 – 42	98 – 188
Cast Iron	21 – 30	68 – 98
Brass	42 – 75	120 – 180
Aluminium	60 – 105	180 - 350
Plastic	60 - 450	unlimited

To find the correct RPM (revs per minute) setting of the spindle the following formula should be used;

$$\text{RPM} = \frac{\text{Cutting Speeds in metres per minute x 1000}}{\text{Circumference of material in millimetres}}$$

$$= \frac{S \times 1000}{\pi \times D}$$

For example, for a mild steel part a cutting speed of 30 m/min is chosen from the above table. If a Ø50mm bar is to be machined the RPM is calculated as follows:

$$\text{RPM} = \frac{30 \times 1000}{3.14 \times 50} = 190$$

Feed

Feed is the rate at which the cutting tool moves along or across the work. The feed is adjustable and can be slow (fine feed) or fast (coarse feed). For each single revolution of the workpiece of the workpiece, the tool will move along the work by a certain distance. This is referred to as the feed per revolution.

For a conventional lathe if a feed rate of 0.25mm is chosen, this means that the tool will move 0.25mm for one revolution, which would be a typical feed used on a conventional lathe.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials,* 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids,* p. 122.

ISBN-13: 9780750660730

6.0 Selection Of Coolant Appropriate To Material Type

Key Learning Points

Coolant: selection of and composition fof different materials. Hazards associated with coolants; use of barrier creams.

6.1 Coolant: Selection Of And Composition For Different Materials

Most machines are fitted with equipment for pumping coolant onto the tool. Turning can be done ‘wet’ or ‘dry’, but there are advantages to using coolant such as, higher cutting speeds, longer tool life, better surface finish and better swarf removal. There are four main types of coolant: soluble oil, mineral oil, synthetic and chemical. selection of and composition of different materials.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, p. 124.

ISBN-13: 9780750660730

6.2 Hazards Associated With Coolants; Use Of Barrier Creams

Barrier creams can be used to protect hands from any oil and chemicals that may be present in the coolant

7.0 Manually Facing Off Workpiece Ends

Key Learning Points

Centre lathe operation: facing.

7.1 Centre Lathe Operation: Facing

Facing: Facing is used to clean up and to square the sides of the turned workpiece. It is also used to and to bring the overall length to the size specified on the drawing. It can be performed by feeding the tool from the outer diameter to the centre of the workpiece. Manual or automatic feed can be used when feeding the tool.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 8, *Turning*, p. 140.

ISBN-13: 9780750660730

8.0 Centre Drilling Workpieces

Key Learning Points

Centre lathe operation: use of centre drills, drill chucks and morse tapers.

8.1 Centre Lathe Operation: Centre Drilling

Centre Drills: The centre drill can be used to drill a small tapered hole into the machined face. The purpose of using a centre drill is to provide an accurate pilot hole to guide the drill. It can also be used when the workpiece needs to be held between centres. Centre drills are available in various sizes. It is a drill and a countersink combined and should be drilled to halfway along the taper. The centre drill is normally held in a chuck, which has a Morse tapered shank. The chuck can then be locked into the Morse taper in the tailstock.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 8, *Turning*, p. 140.

ISBN-13: 9780750660730

9.0 Machining Stepped Components

Key Learning Points

Centre lathe operation: Turning diameters. Swarf handling and personel safety. Origins of the Vernier scales and applications. Professional attitude towards care and use of measuring instruments for quality assurance.

9.1 Centre lathe operation: Turning diameters

The largest diameter should be turned to size along the full length of the part. The step can be marked off using a vernier callipers and a scriber. A stop can be set, which will automatically stop the carriage. The step is turned to this line using the automatic feed. When the workpiece diameter is that as specified on the drawing, the cross slide is used to machine the face.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 8, *Turning*, p. 140.

ISBN-13: 9780750660730

9.2 Swarf Handling And Personal Safety

Keep hands away from swarf as the workpiece is being turned. Use a long handled rake to remove the swarf only when the chuck has stopped rotating.

9.3 Origins Of The Vernier Scales And Applications

All instruments using a vernier consist of two scales, one moving and the other fixed. The fixed scale is graduated in millimetres. The moving scale or the vernier scale is divided into 50 equal parts. The vernier scales are used in the vernier callipers, vernier height gauge and a vernier scale is used in a vernier protractor.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 6, *Vernier instruments*, p. 95.

ISBN-13: 9780750660730

9.4 Professional Attitude Towards Care And Use Of Measuring Instruments For Quality Assurance

Care should be taken when using measuring equipment, as they are delicate and can be easily damaged. Measuring instruments should be stored in a secure place and should be checked regularly and calibrated by the QA Dept.

Summary

Reading and interpreting engineering drawings: Technical drawing is a method of communicating and exchanging design ideas in industry. Drawing sheets consist of a border, title block, views of the component, dimensions, symbols and notes. Multi-view orthographic projection is used in engineering drawing working to BS 8888. There are two systems of projection, First Angle and Third Angle, which are based on a framework of planes at right angles. In first angle projection, each view shows what would be seen by looking on the far side of an adjacent view. In Third angle projection, each view shows what would be seen by looking on the near side of an adjacent view.

Drawing section views of individual components: When a feature on a component is hidden or is inside the component and cannot be shown clearly on one of the projected views, then a sectioned view is taken through the part, showing the sectioned view at a right angle to the view.

Setting up the workpiece a 3-jaw chuck: The 3-jaw chuck is easy to use, as the work piece is self centred. The chuck can hold cylindrical and hexagonal bars. Internal and external jaws are available. The end face can easily be machined. A chuck key is used to tighten and loosen the jaws. From a safety point of view, it is important to remove the chuck key from the chuck immediately after use.

Mounting turning tool in tool post and setting it on center: It is important to set the tool to the centre height of the work. If the tool is set too high it has the effect of reducing the clearance angle at the front of the tool and increasing the rake angle. When it is set too low it has the opposite effect. This can result in a poor surface finish on the turned surface. The correct tool height can be set by aligning it with the Tailstock Centre.

Selecting and setting correct spindle speed (RPM): Cutting speed is expressed in feet per minute or meters per minute. This refers to the distance covered by the tool across the material when machining. A data chart is available listing various materials and their corresponding cutting speeds. The revolutions per minute (RPM) is calculated by entering the cutting speed and the diameter of the material into the formula.

Selection of coolant appropriate to material type: Most machines are fitted with equipment for pumping coolant onto the tool. Turning can be done ‘wet’ or ‘dry’, but there are advantages to using coolant such as, higher cutting speeds, longer tool life, better surface finish and better swarf removal. 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.

Machining Stepped Components: The largest diameter should be turned to size along the full length of the part. The step can be marked off using a vernier callipers and a scriber. A stop can be set, which will automatically stop the carriage. The step is turned to this line using the automatic feed. When the workpiece diameter is that as specified on the drawing, the cross slide is used to machine the face.

Suggested Exercises

1. What is the most common work holding device used on the lathe.
2. What are the implications of changing the position of a workpiece when of using a 3-jaw chuck.
3. Explain why a turning tool needs to be setup on the same centre as the workpiece.
4. Setup a turning tool ‘on centre’ and then turn and face a workpiece.
5. Using the RPM formula, calculate the spindle speed for turning a Ø25mm mild steel bar with a HSS turning tool.

Questions

1. Why is important to set the turning tool to the centre height of the workpiece.
2. How is the correct tool height set?
3. What does HSS mean and list two other elements that are added to it.
4. Explain the following terms used for turning tools: Top Rake, Side, True Rake and Clearance Angles.
5. Calculate the spindle speed (RPM) when turning a 20mm mild steel bar.

Answers

1. If the tool is set too high it has the effect of reducing the clearance angle at the front of the tool and increasing the rake angle. When it is set too low it has the opposite effect. This can result in a poor surface finish on the turned surface.
2. The correct tool height can be set by aligning the cutting tip with the Tailstock Centre.
3. HSS means high speed steel, which is made of steel, tungsten, chromium and vanadium.
4. Top Rake is the slope from the front tip of the tool towards the back.
   - Side Rake is the slope from the side to side from the cutting edge.
   - True Rake is a combination of Top and Side Rake.
   - Clearance Angle: The side and front of the tool is ground below the cutting edge to slope away from the workpiece. This provides clearance between the tool and the workpiece
5. To find the correct RPM (revs per minute) setting of the spindle the following formula should be used:

$$\text{RPM} = \frac{\text{Cutting Speeds in metres per minute x 1000}}{\text{Circumference of material in millimetres}}$$

$$= \frac{\text{S x 1000}}{\text{л x D}}$$

Using a typical cutting speed of 30 meters/min for mild steel and 3.14 for л:

$$\text{RPM} = \frac{30 \text{ x } 1000}{3.14 \text{ x } 20}$$

$$= 477$$

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