Trade of Toolmaking

Module 4:	Grinding
Unit 5:	Grinding Flat Surfaces on Hard and Soft Steel
	Phase 2

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Unit Objective

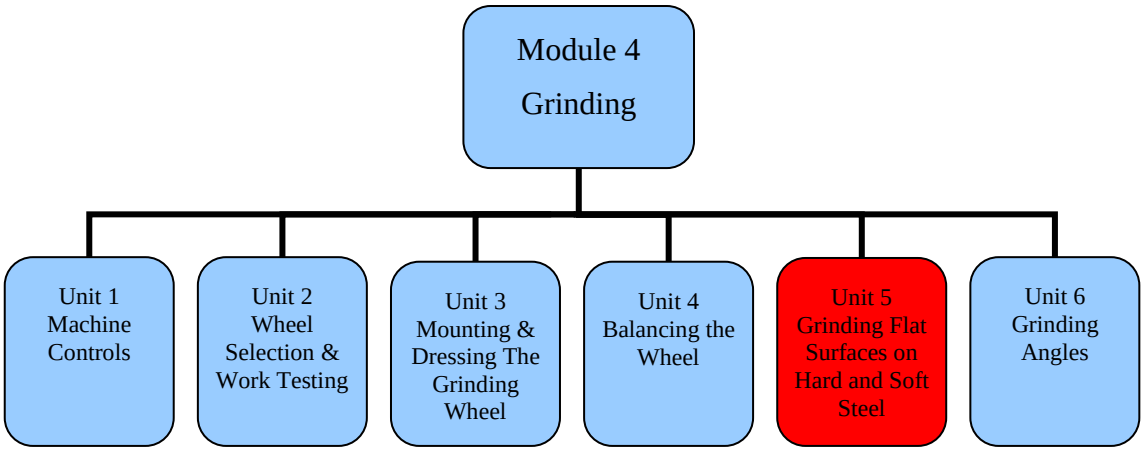
On completion of this unit you will be able to choose the correct wheel for the task in hand, learn how to calculate the correct speed for the grinding wheel and select appropriate workholding techniques for a range of components.

Introduction

Module four of this course covers grinding. This is the fifth unit in module four and explains how to read the external micrometer and vernier calipers.

It is important to use the correct wheel for the material being machined. A rough guide is to use a soft wheel for grinding hard materials and a hard wheel when grinding a soft material. The grinding wheel should never be run beyond the maximum speed limit to that recommended by the manufacturer. Running the grinding wheel past the maximum speed limit could cause the wheel to disintegrate leading to serious injury.

From an environmental and a safety point of view there is a tendency to move away from coolant to air cooling methods. Coolant has been used for many years and is still used today, but coolant contains oil and chemicals and the disposal of this waste is causing environmental issues. Also the oil and chemicals can be vaporised during grinding, which can cause problems for the operator. You will see further developments in this area over coming years.



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

- Read an external micrometer and vernier callipers
- Choose the correct wheel for the task in hand
- Calculate speeds and feeds for grinding
- Decide whether wet of dry grinding should be used
- Select appropriate workholding techniques for a range of components
- Precisely surface grind components to sizes specified on supplied drawing
- Demagnetise workpieces after holding on the magnetic table
- Draw first and third angle projections of solids

1.0 Reading An External Micrometer And Vernier Callipers

Key Learning Points

Use of precision measuring equipment e.g. micrometer and vernier callipers.

1.1 Use Of Precision Measuring Equipment E.g. Micrometer And Vernier Callipers

Both the vernier callipers and the external micrometer can be used to measure the outside diameter of a workpiece. They can also be used to measure the thickness and the length of a component. The micrometer is a more accurate instrument than the vernier callipers. The vernier calliper has one fixed jaw and a sliding jaw and the measurement is read from the vernier scale. The micrometer has U-shaped frame with a fixed cylindrical face on one side and an adjustable spindle on the other side. The thimble is rotated to take a reading, which is read from the sleeve.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 6, *Measuring equipment*, p. 95.
ISBN-13: 9780750660730

2.0 Choose The Correct Wheel For The Task In Hand

Key Learning Points

Wheel characteristics and selection: soft bond to grind hard material, hard bond to grind soft material, hard brittle abrasive on low resistance material, tough abrasive on high resistance material.

2.1 Wheel Characteristics And Selection

The selection of a grinding wheel depends on the type of material being machined. As a general rule, a wheel with a soft bond is used to grind a hard material and a wheel with a hard bond is used to grind a soft material. Also a hard brittle abrasive such as Silicon Carbide is recommended for material with a low hardness and toughness and a tough abrasive such as Aluminium Oxide is recommended for material with a high hardness and toughness.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 10, *Surface grinding*; *Types of cutting fluids*, p. 170.
ISBN-13: 9780750660730

3.0 Calculate Speeds And Feeds For Grinding

Key Learning Points

Feeds and speeds for grinding.

3.1 Feeds And Speeds For Grinding

It is important that the grinding wheel is not run beyond the maximum speed limit to that recommended by the manufacturer. Running the grinding wheel past the maximum speed limit could cause the wheel to disintegrate leading to serious injury. It is important therefore to check the recommended speed limits of the grinding wheel before mounting the wheel.

The average recommended wheel speed is expressed in surface metres per minute, which is taken from a data chart. This data along with the wheel diameter are entered into a formula to calculate the wheel speed in revolutions per minute (RPM).

For example, the RPM for a Ø300mm grinding wheel to run at 1820 m/min (value taken from data chart) is calculated as follows:

$$RPM = \frac{S \times 1000}{л \times D}$$

where S = surface speed (m/min) and D = diameter of grinding wheel

$$RPM = \frac{1820 \times 1000}{л \times 300}$$

$$= 1930 \text{ rev/min.}$$

4.0 Decide Whether Wet Of Dry Grinding Should Be Used

Key Learning Points

Types of grinding fluid used. Purpose of, and application of, grinding fluid. Advantages and disadvantages of dry grinding. Use of air jet when dry grinding.

4.1 Types Of Grinding Fluid Used

Types of grinding fluid that can be used are as follows: Synthetic cutting fluids, semi-synthetic cutting fluid and emulsion type cutting fluids. The synthetic cutting fluids are the most common used for grinding.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, sec.7.6, *Types of cutting fluids*, p. 125.
ISBN-13: 9780750660730

4.2 Purpose Of, And Application Of, Grinding Fluid

The use of coolant reduces frictional forces, cools the wheel and the workpiece thus preventing thermal damage, cleans the wheel and the workpiece, prolongs wheel life and improves surface finish.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, sec.7.6, *Types of cutting fluids*, p. 125.
ISBN-13: 9780750660730

4.3 Advantages And Disadvantages Of Dry Grinding

The advantages of dry grinding are few: but the work area remains dry, less cleaning up and waste coolant does not need to be disposed off. The disadvantages of dry grinding are: reduced wheel life, reduced feed rates, workpiece will heat up, less control over dimensional accuracy, the wheel will clog up quicker, it washes away the waste material and surface finish will not be as good.

4.4 Use Of Air Jet When Dry Grinding

The use of air jets instead of coolant is a recent development and if used with a mist of biodegradable lubricant, it can adequately cool the workpiece and wheel. The advantage of this system is that it is environmentally friendly as there is no waste product like that produced when using coolant.

5.0 Select Appropriate Workholding Techniques For A Range Of Components

Key Learning Points

Magnetic and non-magnetic materials. Safe use of magnetic chuck (table). Secure flat work; plates, blocks, thin work or short work. Nesting for short work. Logical and careful sequence of planning and clear understanding of hazards associated with securing work for grinding.

5.1 Magnetic And Non-Magnetic Materials

Materials such as mild steel, tool steel and some stainless steels are known as ferrous materials and are magnetic due to their iron content. These materials can be held successfully on the magnetic chuck. Many other materials that are commonly used in industry are non-magnetic and will therefore need to be held in a grinding vice, angle plate or fixture. Some of these non-magnetic materials are as follows: Aluminium, Copper, Brass, Bronze, Lead and some Stainless Steels.

5.2 Safe Use Of Magnetic Chuck (Table)

The magnetic chuck (table) can be used to hold magnetic workpieces such as steel components, but it will not hold components made from materials such as aluminium, brass and some stainless steels. These non-magnetic materials can be held in a vice, angle plate or on the table using double backed tape.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 10, *Surface grinding*, sec.10.3, *Workholding*, p. 163.
ISBN-13: 9780750660730

5.3 Secure Flat Work; Plates, Blocks, Thin Work Or Short Work

When grinding a magnetic workpiece, first grind the sides with the biggest surface area, by placing it directly onto the magnetic table and turn the magnet on. The sides can then be ground by holding the workpiece in a vice or clamping it onto an angle plate. Long thin workpieces should be held lengthways along the magnetic table.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 10, *Surface grinding*, sec.10.5, *Surface-grinding operations*, p. 171.
ISBN-13: 9780750660730

5.4 Nesting For Short Work

Small short parts can be grouped together and a thin parallel can be placed in front of the parts to prevent them slipping.

5.5 Logical And Careful Sequence Of Planning And Clear Understanding Of Hazards Associated With Securing Work For Grinding

Job planning is important prior to starting any task. The drawing should first be studied and understood. The sequence of operations should be planned so as to minimise the number of setups on the magnetic chuck, angle plate or the grinding vice.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 10, *Surface grinding*, sec.10.5, *Surface-grinding operations*, p. 171.
ISBN-13: 9780750660730

6.0 Precisely Surface Grind Components To Sizes Specified On Supplied Drawing

Key Learning Points

Grinding broad/narrow surfaces. Grinding of a flat surface to given dimensions, squareness and parallelism. Awareness of bending irregular/distortion created by hardening process. Removal of burrs from chuck (table) with an oil stone. Removal of burrs and sharp edges from workpieces. Touch on techniques e.g. 'Spark the Work', setting depth of cut. Use graduations on hand wheels. Plunge and traverse grinding.

6.1 Grinding Broad/Narrow Surfaces

To grind a broad magnetic workpiece, place it directly onto the magnetic table and turn the magnet on. To grind a narrow magnetic workpiece, place it length ways along the magnetic table and turn the magnet on. This will ensure that the narrow workpiece will be held securely by an adequate number of magnetic inserts in the magnetic chuck.

6.2 Grinding Of A Flat Surface To Given Dimensions, Squareness And Parallelism

When grinding a mild steel plate, place one of the surfaces with the biggest surface area directly on the magnetic chuck and grind. Then turn it over and place on the magnetic table to grind the other side to size. The sides will now be parallel with each other. The narrow sides can then be ground by holding the workpiece in a grinding vice or clamp it onto an angle plate. Gently tap down the plate with a soft mallet. The previously ground surfaces should now be square with the narrow sides. It is important to remove burrs and clean the workpiece between setups.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 10, *Surface grinding*, sec.10.5, *Surface-grinding operations*, p. 171.
ISBN-13: 9780750660730

6.3 Awareness Of Bending Irregular/Distortion Created By Hardening Process

The workpiece is normally machined on a milling machine prior to grinding, ensuring that an adequate grinding allowance is left on all the surfaces of the workpiece. The workpiece is then heat treated in order to harden it. Sometimes the workpiece may distort slightly during the heat treating process. This can be checked with an engineer's square. The surface may not be flat enough to be safely held on the magnetic chuck, it will therefore need to be first held in a grinding vice and ground until the surface is completely cleaned up. This ground surface can then be placed directly onto the magnetic chuck to grind the other side.

6.4 Removal Of Burrs From Chuck (Table) With An Oil Stone

The chuck may become damaged over time, which may be due to a workpiece being dropped onto it. The high points of this burr or dent can be removed by carefully using an oil stone and oil.

6.5 Removal Of Burrs And Sharp Edges From Workpieces

It is important to remove all burrs and sharp edges between setups. This will ensure that the workpiece lies flat on the magnetic chuck or vice. It will also ensure that the burr does not damage the chuck. The burrs can be removed by using needle files or a honing stone.

6.6 Touch On Techniques E.G. 'Spark The Work', Setting Depth Of Cut

When starting to grind a workpiece, turn on the grinding wheel and using the hand wheel, lower the grinding wheel down towards the workpiece. Slow down the hand feed as the grinding wheel comes close to the workpiece. Stop the down feed when the grind wheel is a millimetre or so away from the workpiece. Start the automatic feed, which will cause the table to reciprocate from side to side. The grinding wheel can then be lowered more slowly towards the surface of the workpiece by using the fine adjustment on the hand wheel. As the grinding wheel just touches the workpiece, a small number of sparks will be seen as the highest peaks on the surface come into contact with the abrasive grains on the wheel. At this stage the coolant can be turned on and the graduations on the hand wheel can be set to zero in order to set the depth of cut.

6.7 Use Graduations On Hand Wheels

As explained above, the hand wheel is used to lower the grinding wheel close to the workpiece, the fine adjustment on the hand wheel is used to touch the wheel off the workpiece. The graduations are then set to zero and the required cut can be taken.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 10, *Surface grinding*, sec.10.2, *Controls*, p. 163.
ISBN-13: 9780750660730

6.8 Plunge And Traverse Grinding

Plunge grinding means feeding the grinding downwards into the workpiece. Traverse grinding means that as the table is reciprocating from side to side, it also feeds back and forth along the Y axis

7.0 Demagnetise Workpieces After Holding On The Magnetic Table

Key Learning Points

Demagnetisation of components when necessary.

7.1 Demagnetisation Of Components When Necessary

Ferrous metals such as mild steel can become magnetised when held on the magnetic table. The workpiece should be removed, cleaned and placed on the demagnetiser and demagnetised.

8.0 Draw First And Third Angle Projections Of Solids

Key Learning Points

First and third angle projection of solids: plan, elevation and end view according to BS 8888.

8.1 First And Third Angle Projection Of Solids: Plan, Elevation And End View According 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*, p. 33, chapter 7, *Drawing layouts and simplified methods*, p. 54. *ISBN-13: 9780750651202*

Summary

Reading an external micrometer and vernier callipers: Both the vernier callipers and the external micrometer can be used to measure the outside diameter of a workpiece. They can also be used to measure the thickness and the length of a component. The micrometer is a more accurate instrument than the vernier callipers. The vernier callipers has one fixed jaw and a sliding jaw and the measurement is read from the vernier scale. The micrometer has U-shaped frame with a fixed cylindrical face on one side and an adjustable spindle on the other side. The thimble is rotated to take a reading, which is read from the sleeve.

Choose the correct wheel for the task in hand: The selection of a grinding wheel depends on the type of material being machined. As a general rule, a wheel with a soft bond is used to grind a hard material and a wheel with a hard bond is used to grind a soft material. Also a hard brittle abrasive such as Silicon Carbide is recommended for material with a low hardness and toughness and a tough abrasive such as Aluminium Oxide is recommended for material with a high hardness and toughness.

Calculate speeds and feeds for grinding: It is important that the grinding wheel is not run beyond the maximum speed limit to that recommended by the manufacturer. The average recommended wheel speed is expressed in surface metres per minute, which is taken from a data chart. This data along with the wheel diameter are entered into a formula to calculate the wheel speed in revolutions per minute (RPM).

Decide whether wet of dry grinding should be used: The use of coolant reduces frictional forces, cools the wheel and the workpiece thus preventing thermal damage, cleans the wheel and the workpiece, prolongs wheel life and improves surface finish. Types of grinding fluid that can be used are as follows: Synthetic cutting fluids, semi-synthetic cutting fluid and emulsion type cutting fluids. The synthetic cutting fluids are the most common used for grinding. The use of air jets instead of coolant is a recent development and if used with a mist of biodegradable lubricant, it can adequately cool the workpiece and wheel. The advantage of this system is that it is environmentally friendly as there is no waste product like that produced when using coolant.

Select appropriate workholding techniques for a range of components: The magnetic chuck (table) can be used to hold magnetic workpieces such as steel components, but it will not hold components made from materials such as aluminium, brass and some stainless steels. These non-magnetic materials can be held in a vice, angle plate or on the table using double backed tape.

Demagnetise workpieces after holding on the magnetic table: Ferrous metals such as mild steel can become magnetised when held on the magnetic table. The workpiece should be removed, cleaned and placed on the demagnetiser and demagnetised

Draw first and third angle projections of solids: 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.

Suggested Exercises

1. When grinding a hard material what type of bond should the wheel have?
2. When grinding a soft material what type of bond should the wheel have?
3. Calculate the RPM for a Ø250mm grinding wheel to run at 1520 m/min.
4. What is the purpose of using grinding fluid when grinding.
5. Prepare a list of magnetic and non-magnetic metals.

Questions

1. What measuring instruments are used to measure the thickness of a ground mild steel plate and state which one is more accurate?
2. With the aid of a sketch, briefly describe a vernier callipers and a micrometer.
3. What type of bond should the grinding wheel have when grinding a hard or soft material?
4. Why is it important to remove burrs when one of the surfaces of a workpiece has been ground?
5. Explain how magnetic and non-magnetic materials are securely held in place while they are been ground.

Answers

1. Both the vernier callipers and the external micrometer can be used to measure the outside diameter of a workpiece. They can also be used to measure the thickness and the length of a component. The micrometer is a more accurate instrument than the vernier callipers.
2. The vernier calliper has one fixed jaw and a sliding jaw and the measurement is read from the vernier scale. The micrometer has U-shaped frame with a fixed cylindrical face on one side and an adjustable spindle on the other side. The thimble is rotated to take a reading, which is read from the sleeve.
3. As a general rule, a wheel with a soft bond is used to grind a hard material and a wheel with a hard bond is used to grind a soft material.
4. It is important to remove all burrs and sharp edges between setups. This will ensure that the workpiece lies flat on the magnetic chuck or vice. It will also ensure that the burr does not damage the chuck. The burrs can be removed by using needle files or a honing stone.
5. The magnetic chuck (table) can be used to hold magnetic workpieces such as steel components, but it will not hold components made from materials such as aluminium, brass and some stainless steels. These non-magnetic materials can be held in a vice, angle plate or on the table using double backed tape.

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