

Trade of Toolmaking	
Module 4:	Grinding
Unit 6:	Grinding Angles
	Phase 2

Published by



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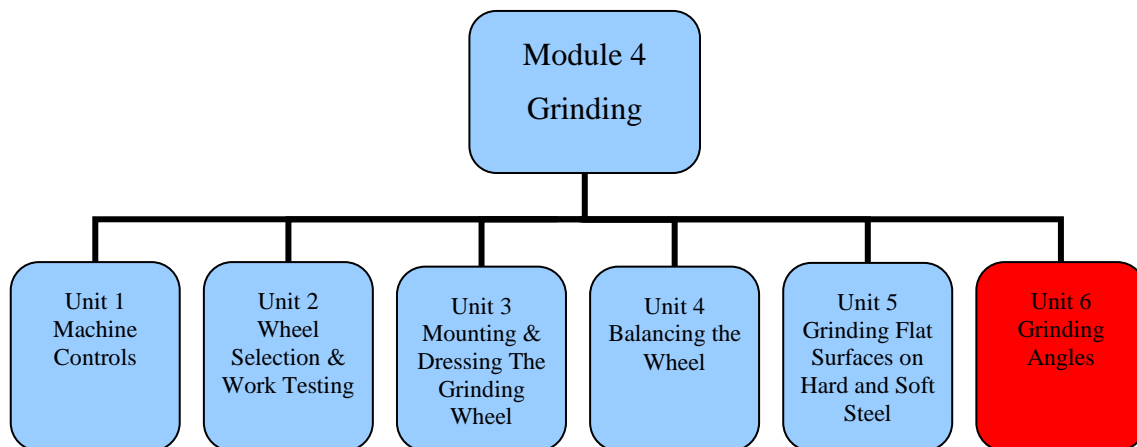
Unit Objective

On completion of this unit you will be able to calculate cutting speeds, select suitable work holding methods and setup the workpiece to grind at an angle.

Introduction

Module four of this course covers grinding. This is the sixth unit in module four and explains how to calculate angles using trigonometry. You should also understand the forces involved in grinding. The wheel should never be run beyond the maximum speed limit to that recommended by the manufacturer. Therefore it is important to understand the manufacturers data printed on the grinding wheel. Running the grinding wheel beyond the maximum speed limit could cause the wheel to disintegrate leading to serious injury.

When angles need to be ground on a workpieces, equipment needs to be used such as the adjustable angle plate, clamps and the grinding vice.



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

- Use trigonometrical functions to calculate angles
- Calculating speeds and feeds for grinding
- Select appropriate work holding method
- Setup sine bar/table/vice, angle plate and clamps
- Grind angles

1.0 Using Trigonometrical Functions To Calculate Angles

Key Learning Points

Trigonometry: solution to right angled triangles, use of trigonometric tables/calculator. Force, power, energy and calculations relating to grinding. Draw first and third angle projections of solids.

1.1 Trigonometry: Solution To Right Angled Triangles, Use Of Trigonometric Tables/Calculator

Trigonometry means the measurement of triangles. It deals with the ratio between the sides of a right angled triangle and provides a method of calculating unknown sides and angles. Three important trigonometrical ratios are sine, cosine and tangent, usually written as Sin, Cos and Tan and can be calculated using tables or the calculator.

Ref: Bird, John 2005, *Basic engineering mathematics*, 4th edn, Elsevier Science & Technology, chapter 19, *Introduction to trigonometry*, p. 142.
ISBN-13: 9780750665759

1.2 Force, Power And Energy

Force (F) = mass (m) x acceleration (a)

Where Force is measured in Newtons (N),

Mass is measured in kilograms (kg)

Acceleration is measured in meters per second squared (m/s^2)

Definition: Force (N) applied to 1 kilogram (kg) gives an acceleration of 1 metre per second every second (m/s^2).

Work Done (J) = force (N) x distance (m)

Where Work is measured in Joules (J),

Force is measured in Newton's (N),

Distance is measured in metres (m)

Definition: Work done is when a force 1 Newton (N) is exerted 1 metre (m)

Power (W) = Work Done (J)/time (s)

Where Power is measured in Watts (W)

Work Done is measured in Newton metres (Nm) or (J)

Time is measured in seconds (s)

Definition: Power is the rate of doing work. This the amount of work done or energy emitted per unit of time.

1.3 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. The Projection symbol must be added to the drawing to indicate which system has been used.

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 Calculating Speeds And Feeds For Grinding

Key Learning Points

Calculation of wheel speed and feed to grind components.

2.1 Calculation Of Wheel Speed And Feed To Grind Components

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:

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

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

$$\begin{aligned}\text{RPM} &= \frac{1820 \times 1000}{\pi \times 300} \\ &= 1930 \text{ rev/min}\end{aligned}$$

3.0 Selecting Appropriate Workholding Methods

Key Learning Points

Safe use of clamping devices.

3.1 Safe Use Of Clamping Devices

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. The angle plate is magnetic and sits directly onto the table. The workpiece can then be clamped onto the angle plate using toolmakers clamps.

4.0 Setting Up Sine Bar/Table/Vice, Angle Plate And Clamps

Key Learning Points

Setup the equipment necessary for the various tasks, Sine/vice table (chuck), Sine bar, Angle plate, Adjustable angle plate. Use and care of slip gauges including protector slips. Use of dial test indicator. Use of precision measuring equipment e.g. external micrometer, vernier callipers, depth micrometer and vernier protractor.

4.1 Setup The Equipment Necessary For The Various Tasks, Sine/Vice Table (Chuck), Sine Bar, Angle Plate, Adjustable Angle Plate

If the workpiece needs to be setup at an angle, then it can be placed on a sine bar with slip gauges placed at one end. When the sine bar has been setup at the required angle, the workpiece is placed on top and is then clamped onto the side of the angle plate as explained above. The sine bar is a steel block, which has a roller bars fixed at each end. One roller is placed on the table and the other on a set of slip gauges, which causes the sine bar to offset at the required angle. The slip gauge height can be calculated by using trigonometry. For a right angled triangle, if two values are known then the third value can be determined. In the case of the sine bar, the distance between the rollers is known and the offset angle is specified on the drawing, therefore the only unknown is the height of the slip gauges, which can easily be calculated. The adjustable angle plate can be used to offset the workpiece as the required angle.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 5, *Standards, measurement and gauging; The sine bar*, p. 77. ISBN-13: 9780750660730

4.2 Use And Care Of Slip Gauges Including Protector Slips

A set of slip gauges consist of a range of varying size blocks that can be built up to create the upper and lower limits of the slot to be checked. The polished surfaces allow the blocks to be 'wrung' together to form a stack. Slip gauges should be treated as delicate precision instruments. They can be damaged easily and should be stored in a secure place. Protector slips can be placed at either side of the pile, which are made from harder material and will protect the slip gauges from wear.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 5, *Standards, measurements and gauging*, p. 71. ISBN-13: 9780750660730

4.3 Use Of Dial Test Indicator

When aligning or clocking a workpiece, a dial indicator with a magnetic base is attachment onto the front of the column. The plunger or lever is positioned against the workpiece. The table is then be moved left and right until the workpiece is aligned.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 6, *Measuring equipment; Dial indicators*, p. 108. ISBN-13: 9780750660730

4.4 Use Of Precision Measuring Equipment E.G. External Micrometer, Vernier Callipers, Depth Micrometer And Vernier Protractor

There are many types of measuring instruments used in industry, such as the vernier callipers, the micrometer and the protractor. The vernier height is used for marking out. The accuracy of these instruments depends on how they are used and treated.

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

5.0 Grinding Angles

Key Learning Points

Production of 'vee block' according to the engineering drawing supplied. Dressing the wheel as required for the component and material to be machined. Importance of coolant when grinding.

5.1 Production Of 'Vee Block' According To The Engineering Drawing Supplied

When grinding a vee block, setup an adjustable angle block at 45° using a sine bar or a vernier protractor. Setup the vee block in a vice and clamp it onto the angle block. Grind one side of the vee and then rotate the vice 180° to grind the other side.

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

5.2 Dressing The Wheel As Required For The Component And Material To Be Machined

The grinding wheel is dressed by placing the diamond and its holder onto the magnetic chuck and lock in place. The centre of the wheel is positioned over diamond tip the then lowered slowly until it touches the diamond. Using the cross traverse hand wheel the diamond dresser is moved across the surface of the grinding wheel. The wheel is then lowered by a small amount and the process is repeated until the worn grains are removed and new ones exposed.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 10, *Surface grinding; Dressing*, p. 165.
ISBN-13: 9780750660730

5.3 Importance Of Coolant When Grinding

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. 7.5, *Cutting fluids*, p. 124.
ISBN-13: 9780750660730

Summary

Using trigonometrical functions to calculate angles: Trigonometry means the measurement of triangles. It deals with the ratio between the sides of a right angled triangle and provides a method of calculating unknown sides and angles. Three important trigonometrical ratios are sine, cosine and tangent, usually written as Sin, Cos and Tan and can be calculated using tables or the calculator.

Calculating speeds and feeds for grinding: 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).

Selecting appropriate workholding methods: 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. The angle plate is magnetic and sits directly onto the table. The workpiece can then be clamped onto the angle plate using toolmakers clamps.

Setting up sine bar/table/vice, angle plate and clamps: If the workpiece needs to be setup at an angle, then it can be placed on a sine bar with slip gauges placed at one end. When the sine bar has been setup at the required angle, the workpiece is placed on top and is then clamped onto the side of the angle plate as explained above. The sine bar is a steel block, which has a roller bars fixed at each end. One roller is placed on the table and the other on a set of slip gauges, which causes the sine bar to offset at the required angle. The slip gauge height can be calculated by using trigonometry. For a right angled triangle, if two values are known then the third value can be determined. In the case of the sine bar, the distance between the rollers is known and the offset angle is specified on the drawing, therefore the only unknown is the height of the slip gauges, which can easily be calculated.

Grinding angles: When grinding a vee block, setup an adjustable angle block at 45° using a sine bar or a vernier protractor. Setup the vee block in a vice and clamp it onto the angle block. Grind one side of the vee and then rotate the vice 180° to grind the other side.

Suggested Exercises

1. The magnetic chuck is mainly used when grinding, list other workholding devices that can be used.
2. What is the definition of force?
3. Calculate the slip gauge height required to setup a sine bar at an angle of 35° . Assume that the distance between the rollers is 100mm.
4. Wring a stack of slip gauges to the height calculated above.
5. What are the advantages of using coolant when grinding.

Questions

1. Calculate the RPM for a Ø250mm grinding wheel to run at 1520 m/min.
2. What units is Force and Power measured in?
3. What device can be used to offset a workpiece at an angle?
4. Describe a Sine Bar and explain briefly how it is used to offset a workpiece at the required angle.
5. Explain how a workpiece is aligned using a dial indicator.

Answers

1. The spindle speed is calculated by using the following formula:

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

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

$$\begin{aligned}\text{RPM} &= \frac{1520 \times 1000}{\pi \times 250} \\ &= 1935 \text{ rev/min}\end{aligned}$$

2. Force is measured in Newtons (N) and Power is measured in Watts.
3. The Sine Bar can be used to offset a workpiece at the required angle?
4. The Sine Bar is a long steel block, which has a roller bars fixed at each end. One roller is placed on the table and the other on a set of slip gauges, which causes the sine bar to offset at the required angle. The slip gauge height can be calculated by using trigonometry. The workpiece is then placed on the Sine Bar and clamped to an Angle Plate with Toolmakers Clamps.
5. When aligning or clocking a workpiece, a dial indicator with a magnetic base is attachment onto the front of the column. The plunger or lever is positioned against the workpiece. The table is then moved left and right and the workpiece is adjusted until the workpiece is aligned.

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.

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