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## Document Release History

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## Unit Objective

On completion of this unit you will be able to safely operate the grinding machine, describe its functions and features, identify and safely operate all leavers and controls.

## Introduction

Module four of this course covers grinding. This is the first unit in module four and introduces the techniques associated with operating a grinding machine. The grinding machine can be used to remove material from a workpiece following the milling operation. It is ideal for removing metal from harder materials such as tool steel and tungsten carbide. Workpieces can be ground to a tighter tolerance band then that of the milling machine and with a better surface finish. The metal removal rate is less then that of a milling machine. Therefore if a workpiece needs to be produced to a high hardness value, then it is first machined on a milling machine, hardened and then finished ground on the grinding machine. It is important to leave a grinding allowance on the workpiece during the milling operation.


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

- Apply the appropriate safety precautions when operating the plain surface grinder.
- Identify and describe the function of the main parts and features of the plain surface grinder.
- Identify and safely operate all leavers and controls i.e. emergency stop and isolation switch.
- Mount/hold steel components to safely traverse the machine table.


### 1.0 Applying Safety Precautions When Operating The Plain Surface Grinder

## Key Learning Points

Safe operation of the machine and the hazards associated with surface grinding.

### 1.1 Safe Operation Of The Machine And The Hazards Associated With Surface Grinding

When using a grinding machine it is important to wear safety glasses at all times. No loose clothing should be worn and long hair should be tied back. The area around the grinding machine should be keep free of debris and oil and coolant spills should be cleaned up. It is important to check the grinding wheel before mounting it on the spindle and check that all machine guards are in place.

### 2.0 The Functions Of The Main Parts Of The Grinding Machine

## Key Learning Points

Identify and describe the main parts of the plain surface grinder. Labelling of machine axes. Knowledge and understanding of axes movements on the surface grinding machine and use of dial graduations. Use of digital readout. Characteristics and operation of the magnetic table (chuck). Principles of magnetism and the use of magnetic fields for table (chuck) operation.

### 2.1 Identify And Describe The Main Parts Of The Plain Surface Grinder

The most common surface grinding machine that is used in the Toolroom is the Horizontal Spindle with a Reciprocating Table. The grinding wheel is locked securely onto a horizontal spindle, which is housed in the vertical column positioned at the back of the machine. The table sits on guide rails on the saddle, which in turn sits on guide rails on the machine base. When grinding, the workpiece is held either on a flat magnetic table (chuck), in a vice or can be clamped to an angle plate.
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 10, Surface grinding, p. 161.
ISBN-13: 9780750660730

### 2.2 Labelling Of Machine Axes

The table reciprocates left and right along the X axis. The table can also be fed back and forth along the Y axis. The grinding wheel can move vertically up and downwards in the Z axis.

### 2.3 Knowledge And Understanding Of Axes Movements On The Surface Grinding Machine And Use Of Dial Graduations

The grinding wheel, which rotates at a very high speed, is feed vertically downwards in the Z axis onto the workpiece. The outer surface of the rotating grinding wheel is used to remove metal from the workpiece, while the table reciprocates left and right along the X axis. The table can also be fed back and forth along the Y axis, which feeds the work under the grinding wheel.
The vertical movement of the grinding wheel is controlled by rotating the hand wheel and the graduations on the dial are used for fine adjustment.

### 2.4 Use Of Digital Readout

A digital readout, if fitted, can be used instead of the dial graduations for adjusting the grinding wheel height in the Z axis or for adjusting the wheel on the Y axis when grinding the workpiece with the side of the wheel.

### 2.5 Characteristics And Operation Of The Magnetic Table (Chuck)

The magnetic table (chuck) is used to hold the metal workpiece in place while it is being ground. Permanent magnets are positioned underneath the top surface, which can be moved into position with a handle, which either turns the magnetic table 'on' or 'off'.
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 10, Surface grinding, sec.10.3, Workholding, p. 163.
ISBN-13: 9780750660730

### 2.6 Principles Of Magnetism And The Use Of Magnetic Fields For Table (Chuck) Operation

When matter is structured so that it has a north and south pole it is called a magnet. In magnetic materials like poles repel each other while unlike poles attract each other. Magnetic materials attract metal objects, but not all materials are capable of being magnetised. Some materials, when magnetised, hold their magnetism for a long time and are called Permanent Magnets. Magnets produce magnetic fields surrounding them that affect materials they come in contact with.

Magnetic force lines are sometimes called "Flux" and have the following characteristics:

- always form complete loops
- never cross one another
- have a definite direction, North to South external to the magnet
- try to contract as if they were stretched elastic threads
- repel one another when lying side-by-side in the same direction

The magnetic table (chuck) is used to hold the metal workpiece in place while it is being ground, but the workpiece has to be magnetic. Permanent magnets are positioned underneath the top surface, which can be moved into position with a handle, which either turns the magnetic table 'on' or 'off'.

### 3.0 Identifying And Safety Operating All Leavers And Controls

## Key Learning Points

Emergency shut down procedure and machine isolation.

### 3.1 Emergency Shut Down Procedure And Machine Isolation

In the event of an emergency press the red button on the control panel. The table movement and the grinding wheel will then come to a stop. When the wheel has stopped switch all levers to neutral and raise the wheel off the workpiece.

### 4.0 Mounting/Holding Steel Components To Safely Traverse The Machine Table

## Key Learning Points

Understanding of close tolerances associated with grinding. Safe mounting of magnetic materials on the magnetic table. Safe use of the precision grinding vice and need for adequate clamping force. Use if slip gauges to calculate angles. Job planning, sequencing, care of grinding wheels, tools and equipment.

### 4.1 Understanding Of Close Tolerances Associated With Grinding

Grinding is normally a finishing operation and is carried out on workpieces that have been hardened or need to be finished to a high degree of accuracy and a good surface finish.

### 4.2 Safe Mounting Of Magnetic Materials On The Magnetic Table

When grinding the workpiece, first grind the sides with the biggest surface area. Place it directly onto the magnetic table and turn the magnet on. In order to prevent the workpiece from slipping due to the forces of the rotating grinding wheel, it is advisable to position a smaller block or parallel against the left side of the workpiece and then lock the magnetic table. This is because the grinding wheel rotates in a clockwise direction and has a tendency to push the workpiece to the left. When the sides have been ground to size, the workpiece is removed, deburred and cleaned.
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 10, Surface grinding, sec.10.3, Workholding, p. 163.
ISBN-13: 9780750660730

### 4.3 Safe Use Of The Precision Grinding Vice And Need For Adequate Clamping Force

A grinding vice is placed on the magnetic table and the magnet turned on. The workpiece can then be held in the vice and the edges ground to size. This will also ensure that the edges are square with the ground side walls. Alternatively, depending on the shape of the workpiece, an angle plate can be setup on the magnetic table and the workpiece can be clamped onto the side of the plate with toolmakers clamps.
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 10, Surface grinding, sec.10.5, Surface-grinding operations, p. 171.

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### 4.4 Use If Slip Gauges To Calculate Angles

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.
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 5, Standards, measurement and gauging, p. 70. ISBN-13: 9780750660730

### 4.5 Job Planning, Sequencing, Care Of Grinding Wheels, Tools And Equipment

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 table, vice or angle plate. The workpiece is normally milled prior to grinding, therefore adequate grinding allowance needs to be left on the surfaces of the workpiece.

A grinding wheel is made up of small abrasive particles, which are held together with a bonding material. These wheels are very brittle and can crack or break if dropped. Therefore they should be handled with care and stored in a safe place. Other devices such as the grinding vice and angle plate are manufactured to a high degree of accuracy and should also be handled with care.

## Summary

Applying safety precautions when operating the plain surface grinder: Safety is important when using the grinding machine. Safety glasses should be worn at all times. No loose clothing should be worn and long hair should be tied back. The area around the grinding machine should be keep free of debris and oil and coolant spills should be cleaned up. It is important to check the grinding wheel before mounting it on the spindle and check that all machine guards are in place.
The functions of the main parts of the grinding machine: The most common surface grinding machine that is used in the Toolroom is the Horizontal Spindle with a Reciprocating Table. With this machine the grinding wheel is locked securely onto a horizontal spindle, while the workpiece is held on a flat magnetic table (chuck) or in a vice. The grinding wheel, which rotates at a very high speed, is feed vertically downwards in the Z axis onto the workpiece. The outer surface of the rotating grinding wheel is used to remove metal from the workpiece, while the table reciprocates left and right along the X axis. The table can also be fed back and forth along the Y axis, which feeds the work under the grinding wheel.

The vertical movement of the grinding wheel is controlled by rotating the hand wheel and the graduations on the dial are used for fine adjustment. A digital readout, if fitted, can be used instead of the dial graduations for adjusting the wheel height.

As explained above, the magnetic table (chuck) is used to hold the metal workpiece in place while it is being ground. Permanent magnets are positioned underneath the top surface, which can be moved into position with a handle, which either turns the magnetic table 'on' or 'off'.
Identifying and safety operating all leavers and controls: In the event of an emergency press the red button on the control panel, which will stop the table and the grinding wheel will slowly come to a stop.

Mounting/Holding steel components to safely traverse the machine table: When grinding the workpiece, first grind the sides with the biggest surface area. Place it directly onto the magnetic table and turn the magnet on. In order to prevent the workpiece from slipping due to the forces of the rotating grinding wheel, it is advisable to position a smaller block or parallel against the left side of the workpiece and then lock the magnetic table. This is because the grinding wheel rotates in a clockwise direction and has a tendency to push the workpiece to the left. When the sides have been ground to size, the workpiece is removed, deburred and cleaned. A grinding vice is then placed on the magnetic table and the magnet turned on. The workpiece can then be held in the vice and the edges ground to size. This will also ensure that the edges are square with the ground side walls. Alternatively, depending on the shape of the workpiece, an angel plate can be setup on the magnetic table and the workpiece can be clamped onto the side of the plate with toolmakers 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.

## Suggested Exercises

1. What safety precautions should be taken prior to using a grinding machine?
2. Sketch a surface grinding machine and label its main features.
3. Explain briefly how the magnetic chuck works.
4. What action do you take in the event of an emergency?
5. Under the supervision of your Instructor, place a mild steel plate on the magnetic chuck and turn on the magnet, then grind both sides of the workpiece.
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Trade of Toolmaking - Phase 2
Module 4
Unit 1
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## Questions

1. What is the most common surface grinder that is used in the Toolroom?
2. Explain briefly the main parts of the surface grinding machine and how they are connected to each other?
3. Explain the axis designations in the surface grinding machine.
4. Explain how the magnetic chuck is used to hold a workpiece.
5. Explain how material is removed from the workpiece on the surface grinding machine.

## Answers

1. The most common surface grinding machine that is used in the Toolroom is the Horizontal Spindle with a Reciprocating Table.
2. The grinding wheel is locked securely onto a horizontal spindle, which is housed in the vertical column positioned at the back of the machine. The table sits on guide rails on the saddle, which in turn sits on guide rails on the machine base. When grinding, the workpiece is held either on a flat magnetic table (chuck), in a vice or can be clamped to an angle plate.
3. The table reciprocates left and right along the X axis. The table can also be fed back and forth along the Y axis. The grinding wheel can move vertically up and downwards in the Z axis. The grinding wheel is fed downwards along the Z axis in order the take the required cut.
4. The magnetic table (chuck) is used to hold the metal workpiece in place while it is being ground. Permanent magnets are positioned underneath the top surface, which can be moved into position with a handle, which either turns the magnetic table 'on' or 'off'
5. The grinding wheel is switched on and is feed vertically downwards in the Z axis onto the workpiece. The abrasives on the outer surface of the rotating grinding wheel removes metal from the workpiece, while the table reciprocates left and right along the X axis. The table can also be fed back and forth along the Y axis, which feeds the work under the grinding wheel.

## Recommended Additional Resources

## Reference Books

Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology.
ISBN-13: 9780750660730
Simmons, Colin H \& Maguire, Dennis E 2004, Manual of engineering drawing, $2^{\text {nd }}$ edn, Elsevier Science \& Technology.

ISBN-13: 9780750651202
Bird, John 2005, Basic engineering mathematics, $4^{\text {th }}$ edn, Elsevier Science \& Technology. ISBN-13: 9780750665759

