Trade of Toolmaking

Module 2:	Turning
Unit 5:	Tool Grinding & Forming
	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

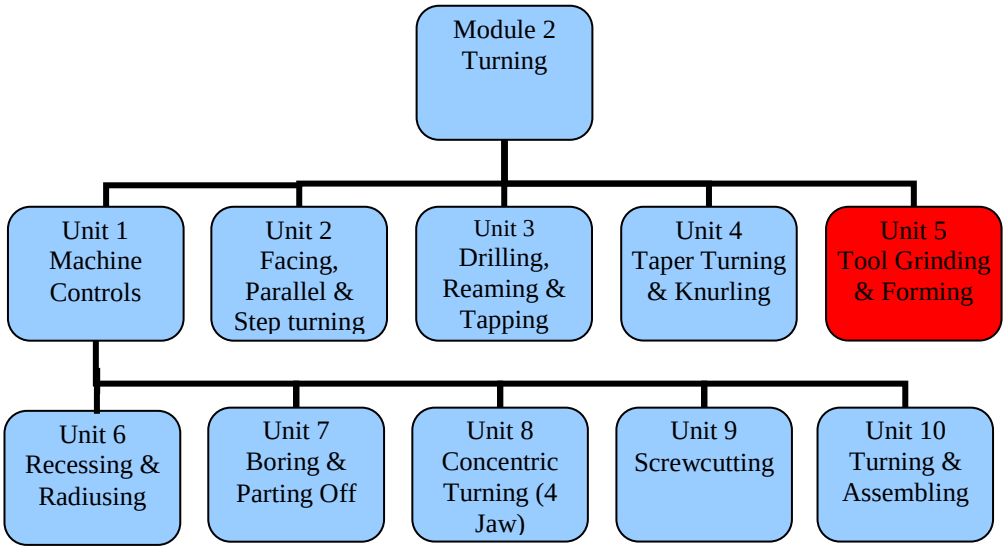
Unit Objective

On completion of this unit you will be safely able to grind turning tools to the required form and describe the function of a rake and clearance angles.

Introduction

Module two of this course covers turning. This is the fifth unit in module two and explains how to set-up and safely use a bench or pedestal grinding machine, which are used for grinding lathe tools, chisels and drills. Although the mounting of a grinding wheel is explained in this unit, it is recommended that this be carried out by a qualified person. Prior to grinding a turning tool it is important to understand the function of the rake and clearance angles. These forms are produced by supporting the tool or your hand on the work rest and by carefully controlling your hand movement, you learn over time and with instruction how to properly grind these tools.

For the majority of turning operations carried out in industry nowadays, disposable tungsten carbide tips are used, but it is still important to understand the basic principles of cutting tools and how to manufacture them. Also for non standard forms, where tungsten carbide tips are not available, experience in the hand grinding is important.



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

- Safely operate bench/pedestal grinder.
- Machine form to dimensions.
- Describe the function of a rake, clearance and wedge angles or turning tools.
- Grind HSS tools to machine internal and external radii and angular forms with the correct tool geometry.

1.0 Bench/Pedestal Grinding

Key Learning Points

Grinding wheel types/functions and set-up. Wheel safety checks/washers/ring test.
Wheel dressing techniques. Hazards associated with grinding, safety precautions to be taken

1.1 Grinding Wheel Types/Functions And Set-Up

There are two types of off-hand grinding machines, Bench and Pedestal. These machines are used where movement is controlled by hand such as grinding lathe tools, chisels, drills and punches. The grinding wheel is made up of grains of hard substances, which are held together by bonding agent. For grinding mild steel, the type of wheel that is normally used is aluminium oxide and a bond is vitrified clay. When grinding high carbon steel tools it is important not to over heat the tool, as this would reduce the hardness of the tool. When grinding soft metals, such as aluminium or copper, do not use a fine wheel as it will clog quickly. It is important to dress the wheel regularly in order to restore trueness and clear the clogged cavities.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 10, *Surface grinding*, p. 167.

ISBN-13: 9780750660730

1.2 Wheel Safety Checks/Washers/Ring Test

Prior to mounting a new grinding wheel it is important to check for (i) broken or chipped edges (ii) cracks (iii) damaged mounting bushes and (iv) damaged compressive washers. It may not be possible to see a crack, therefore the wheel should also be checked by suspending it on a string and gently tapping the wheel with a wooded handle at several points. A clear ring sound should be heard at all times. A dull sound means that the wheel is cracked and should not be used. When mounting the wheel, steel flanges of equal size should be used, with compressible washers between the wheel and the flanges. It is important not to over tighten the locking wheel.

1.3 Wheel Dressing Techniques

When the grinding wheel becomes clogged it needs to be dressed to expose new abrasives on the surface of the wheel. A star type dresser can be used to expose new abrasives. The wheel dresser also squares the surface and makes it concentric with the spindle axis.

The wheel is dressed as follows: Switch off the grinding machine and allow the wheels to stop. Move the work rest back and tighten. Locate the two lugs on the dressed behind the work rest. Ensure that there is a small gap between the wheel and the dresser. Pull the dresser back against the work rest and turn on the grinder. When the wheel has reached its full speed, push the dresser into the wheel while pivoting the lugs about the edge of the back rest. The wheel is now dressed and true.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, sec. 7.2, *Cutting tool maintenance*, p. 122.

ISBN-13: 9780750660730

1.4 Hazards Associated With Grinding, Safety Precautions To Be Taken

Always wear safety glasses when grinding. Adjustable work rests are provided for steadying and guiding the work. It is important to keep the rests close to the wheel in order to prevent the work from being pulled down between the rest and the wheel, which could cause and bad hand injury. The distance between the wheel and the work rest should never be less than 2mm. Ensure that the wheel guards are securely in position.

2.0 Machining Form To Dimensions

Key Learning Points

Surface finish – symbols/textures. The effects of surface finish on tool life.

2.1 Surface Finish – Symbols/Textures

When radii profiles are specified on drawings, they can be produced by grinding the HSS tool to the required dimensions. The tool is then set-up on the lathe and the workpiece turned to produce the required form. The drawing may also specify the surface finish requirements of the workpiece. The method used to determine the surface finish is to measure the average height of the peaks and valleys of the surface, using a surface measuring machine. The surface roughness is therefore expressed as surface roughness average (Ra) and is measured in micrometers (0.001mm). Surface roughness comparator sets are available and can be used to compare the machined surface of the workpiece and determine an approximate Ra value.

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

ISBN-13: 9780750660730

2.2 The Effects Of Surface Finish On Tool Life

A good surface finish on a tool cutting edge will prolong the tool life and produce a better surface on the workpiece.

3.0 The Function Of Rake And Clearance Angles

Key Learning Points

Function and definition of rake and clearance angles.

3.1 Function And Definition Of 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*, sec. 7.2, *Cutting tools*, p. 116.

ISBN-13: 9780750660730

4.0 Grinding HSS Tools

Key Learning Points

Use and care of measuring instruments. Tool grinding (right and left hand knife tools). Grinding rake and clearance angles on tools. Production of HSS tools with internal and external radii. Honing techniques to improve surface finish. Benefits of investment of time in tool sharpening in relation to tool life, and surface finish. Energy form and measurements, effect of heat on HSS tools.

4.1 Use And Care Of Measuring Instruments

Care should be taken when using measuring equipment. Treat measuring equipment as delicate precision instruments, as they can be easily damaged and should be stored in a secure place.

4.2 Tool Grinding (Right And Left Hand Knife Tools)

Single point tools are produced for right and left hand cutting. To determine which hand a tool is, it should be held with the cutting tip facing you. If the cutting edge is towards the right it is a right handed tool, if it is towards the left it is a left handed tool.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, sec. 7.2, *Cutting tools*, p. 120.

ISBN-13: 9780750660730

4.3 Grinding Rake And Clearance Angles On Tools

When grinding the *rake* angle it should slope from the front tip of the tool towards the back.

When grinding the clearance angle, the side and front of the tool is ground below the cutting edge to slope away from the workpiece.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, sec. 7.2, *Cutting tools*, p. 116.

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4.4 Production Of HSS Tools With Internal And External Radii

When internal and external radii need to be machined on turned parts, they can be produced accurately with form tools. Form tools are ground so that the contour of the cutting edge corresponds to the required shape. With experience the form tools can be produced by hand very accurately.

4.5 Honing Techniques To Improve Surface Finish

When the tool has been ground, the cutting edge can be improved by use a honing stick.

4.6 Benefits Of Investment Of Time In Tool Sharpening In Relation To Tool Life, And Surface Finish

A good surface finish on the cutting tip will produce a good surface finish on the turned part, e.g. a drive shaft. A poor surface finish in a corner radius could cause the drive shaft to fracture during use. Small scratches on a surface can propagate into cracks in areas where the shaft comes under high stresses.

4.7 Effect Of Heat On HSS Tools

It is important not to over heat the cutting tool and not to quench it in water, as this will result in small cracks.

Summary

Bench/pedestal grinding: There are two types of off-hand grinding machines, Bench and Pedestal. These machines are used where movement is controlled by hand such as grinding lathe tools, chisels, drills and punches. The grinding wheel is made up of grains of hard substances, which are held together by bonding agent. For grinding mild steel, the type of wheel that can be used is aluminium oxide and a bond is vitrified clay. When grinding high carbon steel tools it is important not to over heat the tool, as this would reduce the hardness of the tool. When grinding soft metals, such as aluminium or copper, do not use a fine wheel as it will clog quickly. It is important to dress the wheel regularly in order to restore trueness and clear the clogged cavities.

Always wear safety glasses when grinding. Adjustable work rests are provided for steadying and guiding the work. It is important to keep the rests close to the wheel, as this prevents work from being pulled down between the rest and the wheel and possible hand injury. Always ensure that wheel guards are in place.

Machining form to dimensions: When radii detailed profiles are specified on drawings, they can be produced by grinding the HSS tool to the required dimensions. The tool is then set-up on the lathe and the workpiece turned to produce the required form. The drawing may also specify the surface finish requirements of the workpiece. The method used to determine the surface finish is to measure the average height of the peaks and valleys of the surface, using a surface measuring machine. The surface roughness is therefore expressed as surface roughness average (Ra) and is measured in micrometers (0.001mm). Surface roughness comparator sets are available and can be used to compare the machined surface of the workpiece and determine an approximate Ra value.

The function of 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.

Grinding HSS tools: Grind HSS tools with the rake and clearance angles, as discussed above, are first ground to the required form. If a radius is required, this is checked with a radius gauge. It is important not to over heat the cutting tool and not to quench it in water, as this will result in small cracks. When the tool has been ground, the cutting edge can be improved by use a honing stick.

Suggested Exercises

1. What is the bench and pedestal grinding machine used for?
2. Obtain a grinding wheel and perform a ring test.
3. List the hazards associated with using a grinding machine?
4. In surface roughness measurement, what units is ‘Ra’ measured in?
5. Sketch a freehand isometric drawing of a HSS turning tool and label the rake and clearance angles.

Questions

1. What is the purpose of the grinding machine?
2. Give a brief description of the make-up of a grinding wheel.
3. What visual safety checks should be carried out prior to mounting a grinding wheel?
4. Explain how to dress a grinding wheel using a star type dresser.
5. How can you tell the difference between a right and left hand cutting tool?

Answers

1. These machines are used where movement is controlled by hand such as grinding lathe tools, chisels, drills and punches.
2. The grinding wheel is made up of grains of hard substances, which are held together by bonding agent.
3. Prior to mounting a new grinding wheel it is important to check for (i) broken or chipped edges (ii) cracks (iii) damaged mounting bushes and (iv) damaged compressive washers.
4. Move the work rest back and tighten. Locate the two lugs on the wheel dresser behind the work rest. Ensure that there is a small gap between the wheel and the dresser. Pull the dresser back against the work rest and turn on the grinder. When the wheel has reached its full speed, push the dresser into the wheel while pivoting the lugs about the edge of the back rest. The wheel is now dressed and true.
5. To determine which hand a tool is, it should be held with the cutting tip facing you. If the cutting edge is towards the right it is a right handed tool, if it is towards the left it is a left handed tool

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