Trade of Toolmaking

Module 1:	Induction & Bench Fitting
Unit 6:	Filing Internal & External Radii
	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

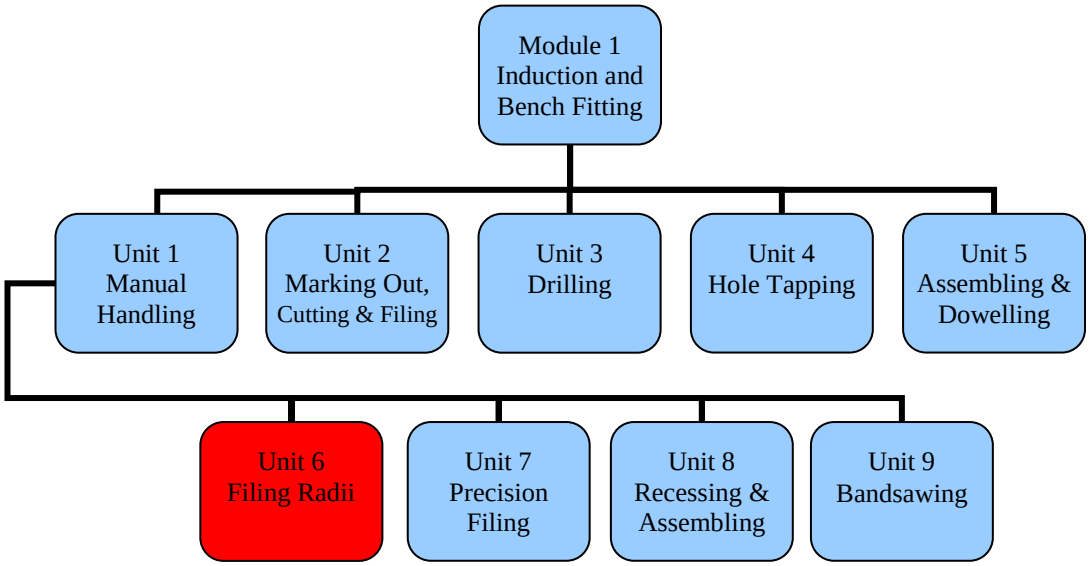
Unit Objective

On completion of this unit you will be able to mark out and file components with internal and external radii, slots and flats to the standard specified on the supplied drawing and use slip gauges to determine the limits of size of tolerances on components.

Introduction

Module one of this course covers induction and bench fitting. This is the sixth unit in module one and introduces the techniques associated with marking out, drilling, cutting and filing radii and slots to the required drawing specifications.

Marking out, cutting and filing are used to shape mild steel plates, although, manual and CNC machines are nowadays used for multiple parts, where greater precision and speed is required. It is important to be able to file metal plates accurately as it forms one of the basic fundamentals of metal shaping and fabrication. In industry, metal plates are generally marked out prior to machining and act as a guide to the operator and files are used to remove burrs and round corners.



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

- Accurately locate and mark out components with internal (concave) and external (convex) radii.
- Produce components containing internal and external radii, slots and flats to the standard specified on the supplied drawing.
- Apply a tolerance and calculate limits of size on component.
- Select, clean and wring slip gauges to determine the limits of size of tolerances on components.
- Plan the sequence of operations; mark out, produce a number of slots on a component.

1.0 Marking Out Internal And External Radii

Key Learning Points

Marking out of component with associated dimensions using the vernier height gauge. Datum edges, use of absolute and incremental dimensions. Line and end standards of measurement.

1.1 Marking Out Of Component With Associated Dimensions Using The Vernier Height Gauge

The components to be filed are first marked out using precision marking equipment such as; the Vernier Height Gauge Scriber, Dividers, Straight Edge, Protractor, Angle Block, Try Square, Vee-block and Marking-off table. Precision measuring equipment is used such as the; Rule, Vernier Caliper, Micrometer, Depth Micrometer, Try Square and the Protractor.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out*, sec. 3.3, *Marking out equipment*, p. 46.

ISBN-13: 9780750660730

1.2 Datum Edges, Use Of Absolute And Incremental Dimensions

The plates are marked out using the same datum edges as those specified on the drawing. When absolute dimensioning is used, it means that all features are marked out and measured from one end of the plate. Normally there are two datum edges, which are at right angles to each other. Absolute dimensioning is more accurate and can be marked out easily from the drawing, because all the features are measured from one edge. When incremental dimensioning is used, e.g. with a series of drilled holes, then each of the holes are dimensioned and measured from the previous hole. In incremental dimensioning the positions have to be calculated before marking out and measuring. Also as each hole, for example, has its own positional tolerance, then there can be a build up of tolerances and therefore is less accurate then absolute dimensioning.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out*, p. 44.

ISBN-13: 9780750660730

1.3 Line And End Standards Of Measurement

The distance between two lines is called line measurement, an example of this is the rule which can be used to measure a component. The distance between two faces is called end measurement, where callipers and micrometers can be used.

2.0 Creating Internal And External Radii, Slots And Flats

Key Learning Points

Tangent points between lines and arcs, arc to arc tangent points. Angles, bisection of angles, type of triangle, construction of triangles, Pythagoras theorem. Use of radius gauges. Precision filing techniques for producing radii. Location of holes and drilling. Surface finish. Use of the depth micrometer. Typical Ra, N, CLA values for filing, examples using surface roughness comparators, surface finish symbols.

2.1 Tangent Points Between Lines And Arcs, Arc To Arc Tangent Points

Horizontal and vertical lines are marked out using the vernier height gauge. The centres of the arcs and holes are marked with a punch. The dividers are used scribe the radii. Lines are scribed between the scribed radii using a rule and scriber, ensuring that the lines are tangent to the already scribed radii. To create angled edges the protractor can be used to scribe the required angle.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out*, p. 44.

ISBN-13: 9780750660730

2.2 Angles, Bisection Of Angles, Type Of Triangle, Construction Of Triangles

When drawing angled components, it is also important to be able to construct triangles and bisect angles.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 9, *Geometric constructions and tangency*, p 68

ISBN-13: 9780750651202

2.3 Pythagoras Theorem

Trigonometry means the measurement of triangles. The Pythagoras Theorem can be used to find the length of one side or a right angled triangle if the lengths of the other two sides are known. The theorem states that for a right angled triangle the square on the hypotenuse (longest side) is equal to the sum of the squares on the other two sides.

Ref: Bird, John 2005, *Basic Engineering mathematics*, 4th edn, Elsevier Science & Technology, chapter 19, *Introduction to trigonometry*, p142

ISBN-13: 9780750665759

2.4 Use Of Radius Gauges

Radius gauges are available in sets of various radii and are used to check the profile of a filed or machined part.

2.5 Precision Filing Techniques For Producing Radii

Filing has already been discussed in Unit 1, all the basic filing techniques are used for precision filing of radii. The hack saw is used to cut the metal close to the scribed line for external radii. Files are used to finish the radius. For a precision finish a smooth file is used. While filing it is important to continuously check the dimension and that the edges are square. For internal radii, holes can be drilled close to the scribed line, the excess material can be removed with a hack-saw or a chisel, prior to filing.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 2, *Hand processes*, p. 30.

ISBN-13: 9780750660730

2.6 Location Of Holes And Drilling

When two metal plates need to be screwed together, the top plate is first drilled. The bottom plate is then clamped to the drilled top plate with toolmakers clamps and the drilled holes are used to guide a drill of the same size to spot the bottom plate. The correct size tapping drill is then drilled through the bottom plate.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3 *Marking out*, sec. *Clamps*, p. 53.

ISBN-13: 9780750660730

2.7 Surface Finish, Typical Ra, N, Cla Values For Filing, Surface Roughness Comparators, Surface Finish Symbols

A surface roughness comparator chart can be used to compare the filed surface to that of a standard filed sample. The comparator chart consists of a range or machined samples and the corresponding Ra valve.

The Ra value is the average height of the peaks and valleys on a metal surface, at the micro scale (0.001mm).

Ra surface measurement is the most common system used, but other systems can also be used. The table below shows the approximate conversion between the different measuring systems:

Ra = CLA (CLA means centre line average. It is used in Britain and is identical to Ra)		**Roughness Grade No's (N)**
µm	**µin**	
0.40	**15.7**	**N5**
0.80	**31.4**	**N6**
1.6	**63.0**	**N7**
3.2	**126.0**	**N8**
6.3	**247.0**	**N9**
12.5	**485.0**	**N10**

Note: µm = micro metre, µin = micro inch

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

ISBN-13: 9780750660730

2.8 Use Of The Depth Micrometer

The depth micrometer is used for measuring features such as the depths of slots and holes.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Measuring equipment*, p. 105.

ISBN-13: 9780750660730

3.0 Calculating Of The Limits Of Size On A Component

Key Learning Points

Application and calculation of appropriate tolerance bands.

3.1 Application And Calculation Of Appropriate Tolerance Bands

Limits of size is the maximum and minimum values given for a specific dimension. The tolerance represents the total amount by which the dimension may vary.

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

4.0 The Correct Use Of Slip Gauges

Key Learning Points

Use and care of slip gauges. Gauging of upper and lower limits on slots using slip gauges.

4.1 Use And Care Of Slip Gauges

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 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.

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

4.2 Gauging Of Upper And Lower Limits On Slots Using Slip Gauges

The upper and lower limits can be determined from the drawing. The appropriate slip gauges are 'wrung' together to create two piles, which will be used to gauge the slot. To achieve the correct size slot, the lower limit set of slip gauges should easily fit into the slot, but the upper limit set of slip gauges should not fit or will be very tight. The gauges should never be forced into the slot.

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

5.0 Planning The Sequence Of Operations For Creating Slots

Key Learning Points

Reading of workshop drawings to plan the sequence of operations prior to manufacturing. Layout and organisation of tools and material in a neat and logical order.

5.1 Reading Of Workshop Drawings To Plan The Sequence Of Operations Prior To Manufacturing

Drawings should be read carefully prior to carrying out any task and it is important to plan the sequence of operations. Tools and material should be laid out and organised in a neat and logical order.

5.2 Layout And Organisation Of Tools And Material In A Neat And Logical Order

Prior to marking out and filing components it is important to plan the sequence of operations. Tools and materials should be laid out and organised in a neat and logical order.

Summary

Marking out internal and external radii: The components to be filed are first marked out using precision marking equipment such as; the Vernier Height Gauge Scriber, Dividers, Straight Edge, Protractor, Angle Block, Try Square, Vee-block and Marking-off table. Precision measuring equipment is used such as the; Rule, Vernier Caliper, Micrometer, Depth Micrometer, Try Square and the Protractor. See Unit 2 for detailed notes and illustrations regarding marking out.

The plates are marked out using the same datum edges as those specified on the drawing. When absolute dimensioning is used, it means that all features are marked out and measured from one end of the plate. Normally there are two datum edges, which are at right angles to each other.

Creating internal and external radii, slots and flats: Horizontal and vertical lines are marked out using the vernier height gauge. The centres of the arcs and holes are marked with a punch. The dividers are used scribe the radii. Lines are scribed between the scribed radii using a rule and scriber, ensuring that the lines are tangent to the already scribed radii. To create angled edges the protractor can be used to scribe the required angle. It is also important to be able to bisect angle and use the Pythagoras theorem.

Filing has already been discussed in Unit 1, all the basic filing techniques are used for precision filing of radii. The hack saw is used to cut the metal close to the scribed line for external radii. Files are used to finish the radius. For a precision finish a smooth or dead smooth file is used. While filing it is important to continuously check the dimension and that the edges are square. Radius gauges can be used to check the profile. For internal radii, holes can be drilled close to the scribed line, the excess material can be removed with a hack-saw or a chisel, prior to filing.

The limits of size on a component: Limits are the maximum and minimum values given for a specific dimension. The tolerance represents the total amount by which the dimension may vary.

The correct use of slip gauges: 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 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.

Planning the sequence of operations: Drawings should be read carefully prior to carrying out any task and it is important to plan the sequence of operations. Tools and material should be laid out and organised in a neat and logical order.

Suggested Exercises

1. Explain the difference between absolute and incremental dimensioning.
2. What is the function of an angle plate.
3. Explain how to check the width of a slot using slip gauges.
4. Explain the difference between line and end standard measurement.

Questions

1. State the Pythagoras Theorem.
2. What are the advantages of using absolute dimensioning over incremental dimensioning.
3. Give an example of line and end measurement?
4. What is a surface roughness comparator chart used for?
5. What is the meaning of the Ra value.

Answers

1. The theorem states that for a right angled triangle the square on the hypotenuse (longest side) is equal to the sum of the squares on the other two sides.
2. Absolute dimensioning is more accurate and can be marked out easily from the drawing, because all the features are measured from one edge. In incremental dimensioning the positions have to be calculated before marking out and measuring. Also as each hole, for example, has its own positional tolerance, then there can be a build up of tolerances and therefore is less accurate then absolute dimensioning.
3. An example of line measurement is the rule which can be used to measure a component. Examples of end measurement are the vernier calipers and micrometer.
4. A surface roughness comparator chart can be used to compare the surface of a workpiece to that of a standard sample. The comparator chart consists of a range or machined samples and the corresponding Ra value.
5. The Ra value is the average height of the peaks and valleys on a metal surface, at the micro scale (0.001mm).

Recommended Additional Resources

Reference Books

Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology.

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Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology.

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Bird, John 2005, *Basic engineering mathematics*, 4th edn, Elsevier Science & Technology.

ISBN-13: 9780750665759