Trade of Toolmaking	
Module 2:	Turning
Unit 4:	Taper Turning and Knurling
	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

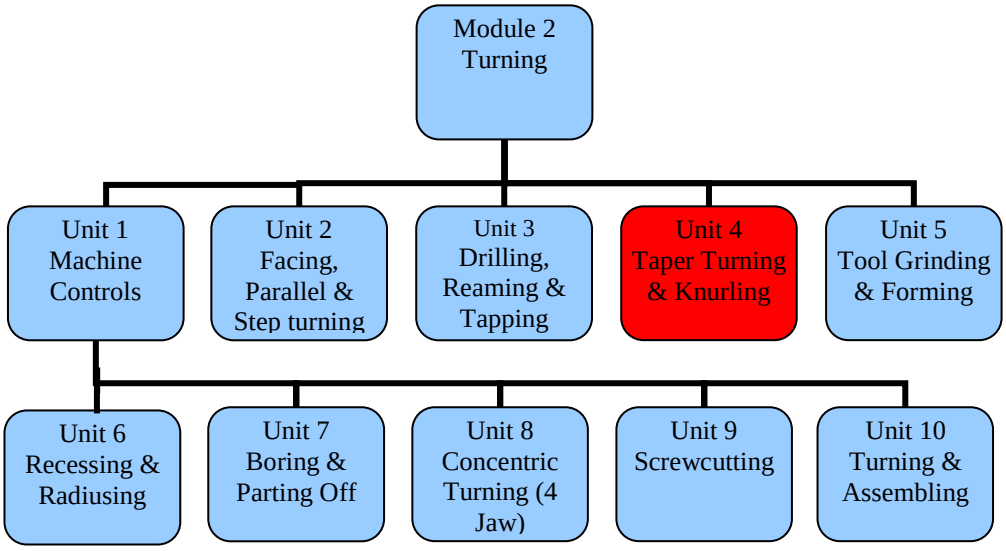
On completion of this unit you will be able to describe the function of a knurled surface and set up the lathe for knurling and for taper turning.

Introduction

Module two of this course covers turning. This is the fourth unit in module two and explains how to set up a knurling tool and perform knurling operations. Knurling is used on cylindrical components to provide hand or finger grip, which can be used on tools and machine parts. The knurled finish also improves the appearance of the part. Two patterns can be produced, Diamond and Straight, which can be knurled in fine, medium or coarse grades.

This unit also explains how to set up and perform taper turning using three different methods. These methods are used in industry to produce one-off and low volume components. For higher volume components CNC machines are mainly used nowadays.

This unit also explains how to interpret technical drawing requirement for knurling and tapers.



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

- Describe the function of a knurled surface.
- Correctly setup a knurling tool, and describe the forces under which a knurling tool operations.
- Knurl workpiece surfaces to produce the correct profile using the correct spindle speed and feed.
- Intepret technical drawings and calculate the angle to which the topside will be set to turn a taper.
- Taper turn to dimensions using topslide offset.

1.0 The Function Of A Knurled Surface

Key Learning Points

Function of a knurl: provides grip, finish, drive wheels. Parallel and Diamond knurling: fine, medium and coarse knurls

1.1 Function Of A Knurl

Knurling is used to provide hand or finger grip for various tools and machine parts. The knurled finish also improves the appearance or the part.

1.2 Parallel And Diamond Knurling: Fine, Medium And Coarse Knurls

Two patterns can be produced, Diamond and Straight, which can be knurled in fine, medium or coarse grades.

2.0 Knurling Tool Setup And The Forces Involved

Key Learning Points

Deformation of material, knurl types and applications. Parallelogram of forces (forces acting on cutting tools).

2.1 Deformation Of Material, Knurl Types And Applications

Knurling is an operation of impressing a raised diamond or straight line pattern on the surface of a cylinder. The **diamond** knurl is formed by two hardened steel rolls, one having a right hand and the other having a left hand helix. These rolls produce overlapping impressions to create a diamond shaped pattern. The **straight line** knurl is formed by two hardened steel rolls with straight grooves cut around the circumference. These rolls produce overlapping impressions to create a diamond shaped pattern.

2.2 Parallelogram Of Forces (Forces Acting On Cutting Tools)

When using tools on a lathe, three forces act on the tool, (i) the vertical or tangential force, (ii) the feed force and (iii) and radial force that tends to push the tool away from the workpiece. If the vertical and feed forces are known, they can be drawn to scale and lines drawn parallel to create a parallelogram. The diagonal line can be measured to determine the resultant or the radial force.

3.0 Knurling Using Correct Spindle Speed And Feed

Key Learning Points

Set up of the knurling tool: speeds and feeds and feeds for knurling, use of automatic feed, depth of penetration of the knurl. Turning diameters to suit the finished knurled size. Knurling techniques, cleaning of the knurling tool prior to application. Use of coolants.

3.1 Set Up Of The Knurling Tool: Speeds And Feeds And Feeds For Knurling, Use Of Automatic Feed, Depth Of Penetration Of The Knurl

The knurling tool needs to be aligned at 90º to the workpiece. The spindle can be run at 15m/min, with a feed rate of 0.5mm/rev. When the pattern has been formed then the automatic feed is used to traverse the knurling tool slowly across the work until a knurled pattern is created.

3.2 Turning Diameters To Suit The Finished Knurled Size

The outer surface of the workpiece is turned prior to performing the knurling operation. It is important to note that the knurled surface will increase in size due to the surface being deformed. Therefore if a particular outside diameter is required, then the surface to be knurled needs to be turned under size.

3.3 Knurling Techniques, Cleaning Of The Knurling Tool Prior To Application

When the spindle is rotating, the knurling tool should be fed manually into the workpiece with some force and then the automatic feed is used to traverse slowly across the work until a knurled pattern is created. If the diamond pattern is not deep enough or if it is irregular, not enough pressure is being applied. Ensure that the tool is clean prior to use and add oil to the roller pins.

3.4 Use Of Coolants

Clean oil can be added to the work to lubricate the workpiece and to keep the tool cool.

4.0 Interpreting Technical Drawings For Taper Turning

Key Learning Points

Drawing symbols for knurling using BS 8888 drawing standards. Designation of angles on engineering drawing. Units of angular measurements, included angles of tapers.

4.1 Drawing Symbols For Knurling Using BS 8888 Drawing Standards

Orthographic projection is used in engineering drawing to represent component parts, with the views in first or third angle and in accordance with BS 8888. A diamond pattern knurl is represented on a drawing by adding a diamond pattern to a small area of the feature to be knurled.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing,* 2nd edn, Elsevier Science & Technology, chapter 7, *Drawing layouts and simplified methods*, p. 59.

ISBN-13: 9780750651202

4.2 Designation Of Angles On Engineering Drawing

One method of dimensioning a tapered feature is to define the angle, the diameter of one end of the taper and the length of the feature.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing,* 2nd edn, Elsevier Science & Technology, chapter 14, *Dimensioning principles*, p. 105.

ISBN-13: 9780750651202

4.3 Units Of Angular Measurements, Included Angles Of Tapers

On engineering drawings angular dimensions are written in degrees, minutes and seconds. A tapered component is normally dimensioned with an included angle.

5.0 Taper Turning Using The Topslide

Key Learning Points

Methods of producing tapers on a centre lathe. Top slide offsetting. Offset tailstock. Taper turning attachment.

5.1 Methods Of Producing Tapers On A Centre Lathe

Taper turning involves the tool moving in a path that is inclined at a given angle to the workpiece axis. Three methods of producing a tapers are (i) Top Slide taper turning (ii) Off-set Tailstock and (iii) Taper Turning Attachment.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 8, *Turning*, p. 155.

ISBN-13: 9780750660730

5.2 Top Slide Offsetting

This is the easiest method, which involves adjusting the top slide by using the graduated scale at its base. The top slide and tool is then traversed along the workpiece by rotating the hand wheel. When using the hand wheel it is important to maintain a constant feed by using the hand over hand method. This will result in more uniform surface finish.

5.3 Offset Tailstock

The body of the tailstock, which houses the centre, can be offset by means of adjusting screws located at the side of the tailstock.

5.4 Taper Turning Attachment

This device can be attached to the back of the bed and linked onto the cross-slide. It supports an adjustable guide bar and slide block, which is linked to the cross-slide. When the guide bar is set to the required angle, it will cause the cross-slide, toolpost and tool to travel at the set angle when turning the workpiece.

Summary

The function of a knurled surface: Knurling is used to provide hand or finger grip for various tools and machine parts. The knurled finish also improves the appearance or the part. Two patterns can be produced, Diamond and Straight, which can be knurled in fine, medium or coarse grades.

Knurling tool setup and the forces involved: Knurling is an operation of impressing a raised diamond or straight line pattern on the surface of a cylinder. The **diamond** knurl is formed by two hardened steel rolls, one having a right hand and the other having a left hand helix. These rolls produce overlapping impressions to create a diamond shaped pattern. The **straight line** knurl is formed by two hardened steel rolls with straight grooves cut around the circumference. These rolls produce overlapping impressions to create a diamond shaped pattern.

When using tools on a lathe, three forces act on the tool, (i) the vertical or tangential force, (ii) the feed force and (iii) and radial force that tends to push the tool away from the workpiece. If the vertical and feed forces are known, they can be drawn to scale and lines drawn parallel to create a parallelogram. The diagonal line can be measured to determine the resultant or the radial force.

Knurling using correct spindle speed and feed: The outer surface of the workpiece is turned prior to performing the Knurling operation. It is important to note that the knurled surface will increase in size due to the surface being deformed. The knurling tool needs to be aligned at 90º to the workpiece. The spindle can be run at 15m/min, with a feed rate of 0.5mm/rev. Ensure that the tool is clean prior to use and add oil to the roller pins.

When the spindle is rotating, the knurling tool should be fed manually into the workpiece with some force and then traversed slowly across the work until a knurled pattern is created. If the diamond pattern is not deep enough or if it is irregular, not enough pressure is being applied. Add clean oil to the work to lubricate and to keep the tool cool.

Interpreting technical drawings for taper turning: Technical drawing is a method of communicating and exchanging design ideas in industry. Orthographic projection is used in engineering drawing to represent component parts, with the views in first or third angle and in accordance with BS 8888. A diamond pattern knurl is represented on a drawing by adding a diamond pattern to a small area of the feature to be knurled.

Taper turning using the topslide: Taper turning involves the tool moving in a path that is inclined at a given angle to the workpiece axis. There are three methods of producing a taper: Top Slide taper turning, (ii) Off-set Tailstock and (iii) Taper Turning attachment.

Suggested Exercises

1. What are the main functions of a knurled surface.
2. Setup a workpiece and knurl a diamond pattern onto its outer surface.
3. Measure the workpiece diameter before and after knurling and note the difference between the diameters.
4. State the three methods of turning a taper on a workpiece.
5. Setup a workpiece and turn a 15º taper by 20mm long using the topslide method.

Questions

1. What is the reason for knurling components?
2. What are the two knurling types?
3. Explain the procedure for knurling a workpiece.
4. Explain the techniques used to knurl a workpiece.
5. Explain how to turn a taper using the Top Slide Offset method.

Answers

1. Knurling is used to provide hand or finger grip for various tools and machine parts. The knurled finish also improves the appearance or the part.
2. The diamond knurl is formed by two hardened steel rolls, one having a right hand and the other having a left hand helix. These rolls produce overlapping impressions to create a diamond shaped pattern. The straight line knurl is formed by two hardened steel rolls with straight grooves cut around the circumference. These rolls produce overlapping impressions to create a diamond shaped pattern.
3. The knurling tool is aligned at 90º to the workpiece. The recommended spindle speed should be 15m/min, with a feed rate of 0.5mm/rev. When the pattern has been formed then the automatic feed is used to traverse the knurling tool slowly across the work until a knurled pattern is created.
4. When the spindle is rotating, the knurling tool should be fed manually into the workpiece with some force and then the automatic feed is used to traverse slowly across the work until a knurled pattern is created. If the diamond pattern is not deep enough or if it is irregular, not enough pressure is being applied.
5. This involves adjusting the top slide by using the graduated scale at its base. The top slide and tool is then traversed along the workpiece by rotating the hand wheel. When using the hand wheel it is important to maintain a constant feed by using the hand over hand method. This will result in more uniform surface finish.

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