Trade of Toolmaking

Module 2:	Turning
Unit 9:	Screwcutting
	Phase 2

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Unit Objective

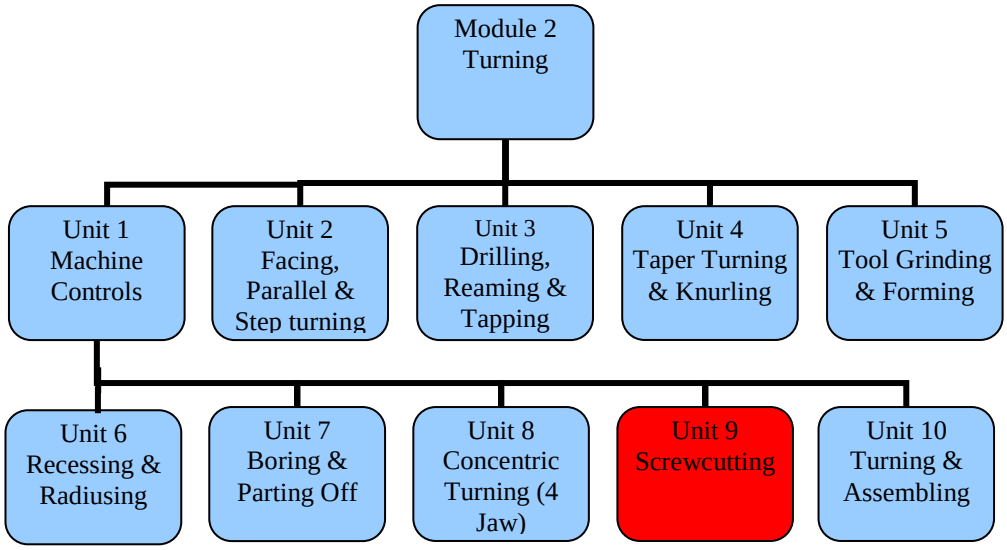
On completion of this unit you will be able to differentiate between thread forms, describe ISO metric thread forms and cut single start internal and external threads.

Introduction

Module two of this course covers turning. This is the ninth unit in module two and explains the differences between the thread forms. It introduces the techniques associated with cutting internal and external threads on a lathe.

The ISO Metric thread system is the most commonly used system and is used worldwide. The Imperial thread system is used mainly in the USA and is also used in parallel with the Metric system in other parts of the world, but is becoming less common. Both of these systems use a 60º thread form.

Screw cutting is usually the final lathe operation to be performed on the workpiece. Prior to cutting an external thread, the workpiece is turned to the major diameter of the thread and prior to cutting an internal thread, the workpiece is bored to the minor diameter of the thread. These diameters are determined using the Zeus book.



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

- Differentiate between thread forms and their functions.
- Describe the ISO metric thread forms and their proportions.
- Cut single start right hand vee threads (internal and external) to ISO form.

1.0 Differentiating Between Thread Forms And Their Functions

Key Learning Points

Multi-start, left hand, ACME and square threads.

1.2 Multi-Start, Left Hand, ACME And Square Threads

There are four main variations of screw threads:

- Vee threads(explained above): used for fastening devices,
- Square threads, which are used in screw jacks,
- Acme threads, which are used in lead screws of lathes and
- Buttress threads, used for quick release e.g. vices.

A *multi-start thread*, such as a double-start thread, is a screw thread in which the nut moves a distance or two pitches for one turn.

The majority of threads in use are *right handed* threads, but *left handed* threads are also available. The right handed threaded screw is tightened in a clockwise direction, whereas the left hand thread is tightened in a counter clockwise direction.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 15, p. 114.

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2.0 Description Of ISO Metric Thread Forms

Key Learning Points

Difference between the lead and pitch of a thread. ISO metric thread profile and associated terminology. Metric thread nomenclature: pitch, thread depth, flank angle, crest, root, root radius etc. Rake and clearance angles. Root diameters of threads and associated calculations.

2.1 Difference Between The Lead And Pitch Of A Thread

The lead is the distance a nut will travel on the thread in one full revolution. In a single start the lead is equal to the pitch. In a multi-start thread such as a double start thread, the nut moves a distance of two pitches in one turn.

2.1 ISO Metric Thread Profile And Associated Terminology

The ISO Metric thread system is the most common system and is used worldwide. The Imperial thread system is used mainly in the US, but is also used in parallel with the Metric system in other parts of the world, but is becoming less common. Both of these systems use a 60º thread form. The ISO Metric system has three thread series, coarse, fine and constant pitch series. The Imperial thread system has three series, UNC (Unified National Coarse), UNF (Unified National Fine) and UNS (Unified National Special).

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 15, p. 114.

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2.2 Metric Thread Nomenclature: Pitch, Thread Depth, Flank Angle, Crest, Root, Root Radius Etc

The screw thread is a helical grove of uniform cross-section wrapped around the surface of a cylinder. The distance between each thread is called the *pitch*. The crest of a thread is the flat land or top edge of a thread. The root is the bottom of the groove. The flank is the straight side between the crest and the root. The angle of a thread is the angle between the flanks. The major diameter of a thread is distance across the crests of an external thread or across the roots of an internal thread. The minor diameter is the distance across the roots of an external thread or across the crests of an internal thread.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 15, p. 114.

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2.3 Rake And Clearance Angles

Top Rake is a slope from the front tip of the tool towards the back. This can also be called the back 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.

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2.4 Root Diameters Of Threads And Associated Calculations

The basic form at the root of an ISO external thread (bolt) is flat. The formula for calculating the width of this flat is P/4. The formula for calculating the flat at the crest of the thread is P/8. (P is the pitch of the thread).

The basic form at the root of Unified threads (UNF and UNC) is a radius. The formula for calculating this radius is 0.144P. The formula for calculating the radius at the crest of the thread is 0.108P. (P is the pitch of the thread).

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, appendices, *Screw-thread forms*, appendix 1, *Basic form for ISO metric threads;* fig. A1, appendix 2, *Basic form for unified threads;* fig. A2.

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3.0 Cutting Internal And External ISO Threads

Key Learning Points

Tool setup: centre height and squareness. Permanent engagement of screwcutting tools. Threading dial engagement and disengagement method. Threading recesses: tool clearance on diameter and length..

3.1 Tool setup: Centre Height And Squareness

For cutting screw threads on the lathe, the relationship between the movement of the saddle and the turning of the workpiece needs to be controlled. This is done by the lead screw, which is driven by a train of gears from the spindle.

The tool used for cutting the thread is similar to a parting-off tool, with the end ground to the vee form of the thread and the tip rounded off to suit the radius at the bottom of the thread. When grinding the tool, a screw cutting gauge is used to check the angle. The tool tip should be aligned to the central axis of the workpiece. A screw cutting gauge can be used to position the threading tool perpendicular to the workpiece. A chart, which is displayed on the headstock of the lathe, shows a range of pitches and the corresponding setup codes. When the required pitch has been chosen, levers on the headstock can be positioned to the chosen code. The spindle is now connected to the correct gear train.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 9, *Turning*, sec. 9.6, *Screw-cutting*, p. 156.

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3.2 Permanent Engagement Of Screwcutting Tools

When the spindle is turned on the tool can be lightly touched off the work and the cross slide dial set to zero, which will allow the depth can now be controlled. Low spindle speeds are used and the coolant is turned on. Great care is required when cutting threads. As the tool reaches the end of the cut, the spindle must be stopped and the tool withdrawn. The spindle can now be reversed to traverse the tool back to its original position. The depth is reset to take a deeper cut.

A thread pitch gauge can be used to check that the correct pitch is being cut.

3.3 Threading Dial Engagement And Disengagement Method

A threading dial can also be used, which is connected to the leadscrew. This allows the leadscrew to be disengaged when the tool reaches its end position. The tool can be traversed back to its starting position and re-engaged with the leadscrew when the threading dial is at the required position.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 9, *Turning*, sec. 9.6, *Screw-cutting*, p. 157.

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3.4 Threading Recesses: Tool Clearance On Diameter And Length

When cutting internal threads, the minor diameter is bored out, as explained in Unit 7. The cutting tool is setup on the boring bar and the thread is cut using the same techniques as explained above**.**

Summary

Differentiating between thread forms and their functions: The ISO Metric thread system is the most common system and is used worldwide. The Imperial thread system is used mainly in the US, but is also used in parallel with the Metric system in other parts of the world, but is becoming less common. Both of these systems use a 60º thread form. The ISO Metric system has three thread series, coarse, fine and constant pitch series. The Imperial thread system has three series, UNC (Unified National Coarse), UNF (Unified National Fine) and UNS (Unified National Special). There are four main variations of screw threads, Vee threads(explained above): used for fastening devices, Square threads: used in screw jacks, Acme threads: used in lead screws of lathes and Buttress threads: for quick release e.g. vices.

Description of ISO metric thread forms: The screw thread is a helical grove of uniform cross-section wrapped around the surface of a cylinder. The distance between each thread is called the *pitch*. The crest of a thread is the flat land or top edge of a thread. The root is the bottom of the groove. The flank is the straight side between the crest and the root. The angle of a thread is the angle between the flanks. The major diameter of a thread is distance across the crests of an external thread or across the roots of an internal thread. The minor diameter is the distance across the roots of an external thread or across the crests of an internal thread.

A screw thread can also have a number of separate threads running around it. This is called a multi-start thread. For example, in a three start thread, the pitch is the distance between each thread, whereas the *lead* = 3 x pitch.

Cutting internal and external ISO threads: For cutting screw threads on the lathe, the relationship between the movement of the saddle and the turning of the workpiece needs to be controlled. This is done by the lead screw, which is driven by a train of gears from the spindle.

The tool used for cutting the thread is similar to a parting-off tool, with the end ground to the vee form of the thread and the tip rounded off to suit the radius at the bottom of the thread. When grinding the tool, a screw cutting gauge is used to check the angle. The tool tip should be aligned to the central axis of the workpiece. A screw cutting gauge can be used to position the threading tool perpendicular workpiece. A chart on the headstock of the lathe shows a number of pitches and the corresponding setup codes. When the required pitch has been chosen, levers on the headstock can now be positioned to the chosen code. The spindle is now connected to the correct gear train.

When the spindle is turned on the tool can be lightly touched off the work and the cross slide dial set to zero, which will allow the depth can now be controlled. Low spindle speeds are used and the coolant is turned on. Great care is required when cutting threads. As the tool reaches the end of the cut, the spindle must be stopped and the tool withdrawn. The spindle can now reversed to traverse the tool back to its original position. The depth is reset to take a deeper cut.

A thread pitch gauge can be used to check that the correct pitch is being cut.

When cutting internal threads, the minor diameter is bored out, as explained in Unit 7. The cutting tool is setup on the boring bar and the thread is cut using the same techniques as explained above.

Suggested Exercises

1. What is the most common screw thread system used worldwide?
2. List four variations of threads.
3. Draw a cross section of an external screw thread and label the following features: Pitch, Crest, Root, Flank, Angle, Minor and Major Diameters.
4. Calculate the width of the flat at the root of an external M5x0.8 ISO thread.
5. What is used to check there pitch if a threaded bar.

Questions

1. Where are Acme threads commonly used?
2. What is the angle of an ISO Metric thread form?
3. What method is used to position the threading tool perpendicular to the work?
4. What is the definition of a screw thread?
5. Explain the following terms used for screw threads: (i) Pitch, (ii) Crest, (iii) Root and (iv) Flank.

Answers

1. Acme threads are used in lead screws of lathes.
2. The ISO Metric system uses a 60º thread form.
3. A screw cutting gauge can be used to position the threading tool perpendicular to the workpiece.
4. The screw thread is a helical grove of uniform cross-section wrapped around the surface of a cylinder.
5. The Pitch is the distance between each thread.
   - The Crest of a thread is the flat land or top edge of a thread.
   - The Root is the bottom of the groove.
   - The Flank is the straight side between the crest and the root.

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