Trade of Toolmaking			
Module 1:	Induction & Bench Fitting		
Unit 4:	Hole Tapping		
	Phase 2		

Published by



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# Unit Objective

On completion of this unit you will be able to differentiate between various types of screw thread forms, interpret and draw basic assembly drawings, select correct tapping drill sizes and perform thread tapping operations.

# Introduction

Module one of this course covers induction and bench fitting. This is the forth unit in module one and explains the difference between Metric, Imperial and BSP thread forms and tap sets. It explains the techniques associated with reading and interpreting technical drawings and how to draw sectioned views of assemblies to BS 8888. It explains how to spot and drill holes in one plate from existing holes in another plate and how to select the correct tapping drill sizes and taps required for performing the thread tapping operation.

As explained in Unit 3, drilling operations are used through out industry when, for example, metal plates need to be fastened together. In order to assemble the metal plates together, clearance holes for the screw threads are required in one of the metal plates, while the other plate requires threaded holes. The screws are used to secure the plates together. The threaded hole is produced by drilling a hole with a tapping drill and then using a series of taps to create the threaded hole.



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

- Differentiate between metric, imperial and BSP thread forms and tap sets.
- Create sectioned drawings of assembled components.
- Spot or locate and drill holes through existing holes on components or located from datum surfaces on components.
- Select appropriate drill sizes for tapping and drill from spotted or located holes.
- Select and use a range of taper, intermediate and plug taps to cut a range of threaded holes.
- Tap a range of holes on mild steel plate to match the specified thread sizes on the supplied drawings.

### 1.0 Metric, Imperial And BSP Thread Forms & Tap Sets

#### **Key Learning Points**

ISO Metric and imperial thread forms. ISO Metric and imperial taps and dies. Thread form and pitches: relationships between pitch and thread depth/thread gauges/cutting sequence. Nut/screw bolt types and identification marks. Screw head types and conformation. Types of washers: applications, selection, identification of different types of washers. Ratio of thread length to diameter, thread depth.

#### **1.1 ISO Metric And Imperial Thread Forms**

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 60° thread forms. 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). BSP (British Standard Pipe) thread form is used for pipes and can either be parallel or tapered. The thread form is 55° and is based on the Whitworth thread system, which was the world's first standard system, but is now obsolete.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3<sup>rd</sup> edn, Elsevier Science & Technology, chapter 12, *Joining methods*, p. 193.

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#### **1.2 ISO Metric And Imperial Taps And Dies**

Taps are used to cut an internal thread. The tapered end of the tap allows the tap to be entered in to the pre-drilled hole and makes it easier to start the thread. It is important use a suitable lubricant on the tap. A tap handle is used to rotate the tap to cut the thread and the centre held in the tailstock will help to keep the tap centred. It is important to reverse and withdraw the tap frequently in order to clear out and break the metal chips. The above steps are repeated with the Plug and Finishing taps until the required hole is tapped

The die is used to cut an external thread on a bar. The die is held in a die stock and the central screw is used for adjustment and side screws hold the die in place. The die has lead or chamfer to help the die to start cutting. The bar should also have a chamfer. The die handle is used to rotate the die which cuts the thread.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3<sup>rd</sup> edn, Elsevier Science & Technology, chapter 2, *Hand processes*, p. 39.

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#### 1.3 Thread Form And Pitches: Relationships Between Pitch And Thread Depth/Thread Gauges/Cutting Sequence

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. 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.

Thread gauges are available for checking the thread pitch.

Ref Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2<sup>nd</sup> edn, Elsevier Science & Technology, chapter 15, *Screw threads and conventional representations*, p.114.

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#### 1.4 Nut/Screw Bolt Types And Identification Marks

Hexagon head bolts and nuts are used where high strength is required. Bolts are threaded for only part of their length, where the unthreaded portion passes through the two plates being joined together. Some bolts have identification marks specifying the material type and grade.

#### 1.5 Types Of Washers: Applications, Selection, Identification Of Different Types Of Washers

Washers provide an increased bearing surface for the bolt heads and nuts, they distribute the load over a larger area, and prevents marring, it also prevents a bolt or nut from loosening under vibration. The washer is available in light, medium, heavy duty and extra heavy duty

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3<sup>rd</sup> edn, Elsevier Science & Technology, chapter 12, *Joining methods*, p. 190.

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#### **1.6** Ratio Of Thread Length to Diameter, Thread Depth

To calculate the tapping drill size, a formula that is easy to remember is:

 $\mathbf{T}=\mathbf{D}-\mathbf{P},$ 

where T = Tapping drill size

D = Screw thread diameter

P = screw pitch

E.g. the tapping drill size required for tapping an M5 x 0.8 screw thread is calculated as follows, using the above formula:

T =  $5 \times 0.8$ 

= 4.2

Therefore use a Ø4.2mm drill.

Ref: Zeus Precision Charts Ltd. 2007, Zeus precision data charts and reference tables for drawing office, toolroom & workshop, 2007 edn, Zeus Precision Charts Ltd.

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### 2.0 Sectioned Drawings Of Assembled Components

#### **Key Learning Points**

Reading and interpretation of simple assembly drawings from first and third projection to produce the components. Production of simple sectioned drawings of assembled components in accordance with BS 8888.

#### 2.1 Reading And Interpretation Of Simple Assembly Drawings From First And Third Projection To Produce The Components

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. The assembly drawing shows the components assembled together and may be sectioned to show internal parts. The individual parts are numbered on the drawing and a table lists the components, the individual single-part drawing number, the quantity required of each component.

Ref Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2<sup>nd</sup> edn, Elsevier Science & Technology, chapter 4, *Principles of first and third angle orthographic projection*, p. 33.

ISBN-13: 9780750651202

#### 2.2 Production Of Simple Sectioned Drawings Of Assembled Components In Accordance With BS 8888

The assembly drawing shows the components assembled together and may be sectioned to show internal parts. The individual parts are numbered on the drawing and a table lists the components, the individual single-part drawing number, the quantity required of each component.

Ref Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2<sup>nd</sup> edn, Elsevier Science & Technology, chapter 8, *Sections and sectional views*, p.64.

ISBN-13: 9780750651202

# **3.0** The Location And Drilling of Holes

#### **Key Learning Points**

Calculation of drill speeds and feeds. Alignment, clamping and 'spot through' existing holes.

#### 3.1 Calculation Of Drill Speeds And Feeds

In order to use the drilling machine efficiently it is important to calculate the correct cutting speeds and feeds using the relevant formulae and also to select the correct size drill, counterboring and countersink tools. The correct speeds and feeds will ensure more efficient machine operation and will result in reduced tool wear. When drilling using a bench or pillar drill, the feed rate is normally controlled by hand.

This is calculated by entering the cutting speed and the cutter diameter into the RPM formula, where the *Cutting Speed* is expressed in meters per minute. Charts are available that recommend the correct cutting speed for a particular material, e.g. for mild steel, a typical cutting speed of 30 meters/min is used and for tool steel the cutting speed is 20 metres/min. Therefore the spindle speed will be lower for the tool steel when compared to that of mild steel.

To find the correct RPM (revs per minute) setting of the spindle the following formula should be used;

RPM	=	Cutting Speeds in metres per minute x 1000	
		Circumference of cutter in millimetres	
	=	<u>S x 1000</u> л x D	

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3<sup>rd</sup> edn?, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*, p. 122.

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#### 3.2 Alignment, Clamping And 'Spot Through' Existing Holes

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.

# 4.0 The Selection Of Appropriate Tapping Drill Sizes

#### **Key Learning Points**

Determination of drilling sizes/tapping sizes from Zeus book or charts for tapping exercises.

#### 4.1 Determination Of Drilling Sizes/Tapping Sizes From Zeus Book Or Charts For Tapping Exercises

When all holes have been drilled, the taps with the aid of a tap wrench are used to thread the holes. Care must be taken to keep the tap square with the work and use the correct lubricant. It is important to calculate the correct cutting speeds prior to drilling and select the correct tapping drill, which can be found in the Zeus book.

Ref: Zeus Precision Charts Ltd. 2007, Zeus precision data charts and reference tables for drawing office, toolroom & workshop, 2007 edn, Zeus Precision Charts Ltd.

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# 5.0 The Selection And Use Of Taper, Intermediate And Plug Taps

#### **Key Learning Points**

Planning the sequence of tapping operations.

#### 5.1 Planning The Sequence Of Tapping Operations

In order to create the threaded hole, the correct size twist drill is used first to drill the tapping hole. Taps are then used to cut the threaded hole and need to be used in combination with the tap wrench. The taps are normally used in steps of three to allow for progressive cutting of the threads, where the tapered tap is used first, then the intermediate and finished by the plug tap.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3<sup>rd</sup> edn?, Elsevier Science & Technology, , chapter 2, *Hand processes*, p. 39.

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## 6.0 Tapping Of Holes in Mild Steel Plate As Per Drawing

#### **Key Learning Points**

Use of, and need for lubrication/cutting fluids. Workholding and machine operation. Application of the thread cutting sequence: taper, intermediate and plug taps. Techniques for tapping blind holes. Tap alignment during tapping.

#### 6.1 Use Of And Need For Lubrication/Cutting Fluids

It is important to keep the work area and the workshop clean and tidy. A tapping lubricant should be used when tapping the hole. This will remove heat due to friction and will lubricate the cutting edges.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3<sup>rd</sup> edn, Elsevier Science & Technology, chapter 7, *Cutting tools and cutting fluids*.

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#### 6.2 Workholding And Machining Operation

When drilling the holes prior to performing the tapping operation, the workpiece should be clamped to the table or held in a vice. Work should never be held by hand, as high forces are transmitted by the revolving tool and the work can be wrenched from your hand causing injury.

The workpiece is then clamped into the bench vise to perform the tapping operation.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3<sup>rd</sup> edn, Elsevier Science & Technology, chapter 8 *Drilling*, sec. 8.3 *Clamping*, p. 132.

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#### 6.3 Application Of The Thread Cutting Sequence: Taper, Intermediate And Plug Taps

Taps are normally used in sets of three, to allow for progressive cutting of the threads. The set consists of a taper, intermediate and a plug tap. The taps are used as follows:

- The taper tap is used first. The taper helps to align the tap square to the work. A blind hole may be too shallow to allow the tapered tap to be used.
- The intermediate is used next. Only the first three or four threads are tapered. If a through hole is being tapped, then this tap may complete the task.
- The plug tap is finally used. This tap is used to complete the thread to the correct depth in a blind hole.

#### 6.4 Techniques For Tapping Blind Holes

A blind hole cannot be tapped all the way to the bottom, therefore it is important to drill the hole deeper than the thread depth required. If the blind hole is shallow then the tapered tap cannot be used, therefore start with the intermediate tap. Care should be taken when the tap reaches the bottom, as the tap could easily break. One technique that can be used is to screw a nut onto the tap and ensure that the distance between the end of the tap and the nut is less than the drilled hole depth. Continue tapping until the nut reaches the top of the plate. The same technique is used for the plug tap.

#### 6.5 Tap Alignment During Tapping

- Lock the tapered tap into the tap wrench.
- Apply a tapping lubricant onto the tap and insert into the drilled hole.
- Keep the tap square to the work and cut a few threads by applying downward pressure.
- Check regularly with a rule or a square to ensure that the tap is square with the work.
- If the tap is not square it can be adjusted by applying greater pressure on one side.
- When the tap is square apply constant turning pressure on both handles.
- As a rule, for every complete turn reverse the tap by a quarter turn.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3<sup>rd</sup> edn, Elsevier Science & Technology, chapter 2, *Hand processes*, sec. 2.7 *Taps*, p. 39.

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# Summary

**Metric, imperial and BSP thread forms and tap sets:** 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 60° thread forms. 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). BSP (British Standard Pipe) thread form is used for pipes and can either be parallel or tapered. The thread form is 55° and is based on the Whitworth thread system, which was the worlds first standard system, but is now obsolete.

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. 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.

**Sectioned drawings of assembled components:** 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. The assembly drawing shows the components assembled together and may be sectioned to show internal parts. The individual parts are numbered on the drawing and a table lists the components, the individual single-part drawing number, the quantity required of each component.

**The location and drilling of holes:** 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 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.

**The selection of appropriate tapping drill sizes:** When all holes have been drilled, the taps with the aid of a tap wrench are used to thread the holes. Care must be taken to keep the tap square with the work and use the correct lubricant. It is important to calculate the correct cutting speeds prior to drilling and select the correct tapping drill, which can be found in the Zeus book.

**The selection and use of taper, intermediate and plug taps:** In order to create the threaded hole, the correct size twist drill is used first to drill the tapping hole. Taps are then used to cut the threaded hole and need to be used in combination with the tap wrench. The taps are normally used in steps of three to allow for progressive cutting of the threads.

**Tapping of holes in mild steel plate as per drawing:** The first tap to be used is the taper tap, next is the intermediate tap and finally the plug tap, which fully forms the threaded hole close to the bottom of the hole.

# **Suggested Exercises**

- 1. State the four main variations of screw threads and sketch a cross section of each.
- 2. State one use for each of the above thread forms.
- 3. Select the correct sized tapping drill for an M5 thread, using the Zeus book.
- 4. Name each tap in a set and explain where each one is used.
- 5. Drill and tap an M5 thread in a mild steel plate.

# Questions

- 1. What is the most common screw thread system used in industry?
- 2. What tool is used to cut an internal screw thread?
- 3. Explain how a set of taps are used to cut an internal screw thread.
- 4. Why is it important to use a tapping lubricant when tapping threads?
- 5. Explain how holes are safely drilled prior to performing a tapping operation.

### Answers

- 1. ISO Metric thread system is the most common system and is used worldwide.
- 2. Taps are used to cut an internal thread.
- 3. The taps are used as follows:
  - The taper tap is used first. The taper helps to align the tap square to the work. A blind hole may be too shallow to allow the tapered tap to be used.
  - The intermediate is used next. Only the first three or four threads are tapered. If a through hole is being tapped, then this tap may complete the task.
  - The plug tap is finally used. This tap is used to complete the thread to the correct depth in a blind hole.
- 4. A tapping lubricant will remove heat due to friction and will lubricate the cutting edges, thus reducing wear on the tap.
- 5. When drilling the holes prior to performing the tapping operation, the workpiece should be clamped to the table or held in a vice. Work should never be held by hand, as high forces are transmitted by the revolving tool and the work can be wrenched from your hand causing injury. The workpiece is then clamped into the bench vice to perform the tapping operation.

# **Recommended Additional Resources**

#### **Reference Books**

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

ISBN-13: 9780750660730

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

ISBN-13: 9780750651202

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

ISBN-13: 9780750665759

Zeus Precision Charts Ltd. 2007, Zeus precision data charts and reference tables for drawing office, toolroom & workshop, 2007 edn, Zeus Precision Charts Ltd.

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