Before you begin: Turn on the sound on your computer. There is audio to accompany this presentation.

Chapter 42
Thread and Gear Manufacturing

THREAD MANUFACTURING

Screw Thread
Ridge of uniform section in the form of a helix on the external or internal surface of a cylinder (straight thread) or in the form of a conical spiral on the frustum of a cone (taper thread).

SCREW THREAD STANDARDS

### SCREW THREAD STANDARDS

<table>
<thead>
<tr>
<th>Threads per Inch</th>
<th>Pitch Diameter</th>
<th>TPI = 1 / pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.33</td>
<td>3</td>
</tr>
</tbody>
</table>

### NOMENCLATURE

1. **Pitch**: distance from a point on one screw thread to the corresponding point on the next thread.

2. **Threads per Inch** \( TPI = 1 / \text{pitch} \)

3. **Pitch Diameter**: diameter at which thread form width equals thread form separation.

![Pitch Diagram](image1)

**Pitch Diameter**

- Minor Diameter
- Pitch Diameter
- Major Diameter

![Diagram](image2)

**Pitch Diameter**

- Pitch Diameter
- Pitch Line
- Pitch

![Diagram](image3)
NOMENCLATURE

4. Major Diameter:
   - External – crest
   - Internal – root

5. Minor Diameter:
   - External – root
   - Internal – crest

6. Lead $\Rightarrow$ axial advance of thread per revolution.
   - Lead = pitch for single lead thread.

7. Root $\Rightarrow$ usually radius to relieve stress.

8. Helix Angle $\Rightarrow$ angle of thread form from perpendicular to axis.

9. Thread Angle $\Rightarrow$ included angle of thread form.
10. Class → manufacturing tolerances:
   - Class 1 → special applications (ordnance)
   - Class 2 → normal production grade
   - Class 3 → minimum clearance

11. Designator:
   - A → external thread
   - B → internal thread

NOMENCLATURE

1. Coarse-thread series (UNC and NC) - general use.
2. Fine-thread series (UNF and NF) - automotive and aerospace.
3. Extra-fine-thread series (UNEF and NEF) - thin wall.
4. Eight-thread series (8UN and 8N) – pipe flanges, 1 to 6 inch diameter.
5. Twelve-thread series (12UN and 12N) - not used extensively, 1/2 to 6" diameter.
6. Sixteen-thread series (16UN and 16N) - fine thread applications, 3/4 to 6" diameter.
TYPES of SCREW THREADS

7. American Acme thread - used to transmit power and motion.
8. Buttress thread - used to transmit power and motion.
9. Square thread - used to transmit power and motion.
10. 29° Worm thread - used to transmit power and motion.

MANUFACTURING METHODS

External Threads
1. Single point threading on lathe → manual or CNC
2. Thread die → solid or solid-adjustable, usually hand threading
3. Die head → self-opening used on lathes and screw machines
MANUFACTURING METHODS

Figure 42-4: Cutting a screw thread on a lathe involves the method of supporting the work and the positioning of the tool on the work with the compound slide, and the tool face of the threading tool.

Figure 42-7: Top view of the machine of Fig. 42-6 shows an angle, and its relationship with the compound slide, and half-threaded angle tool, in compound slide.

Figure 42-10: Proper relationship of the threaded tool and workpiece connection (Chap. 42) with compound slide.

Figure 42-5: Correct instructions called G codes are sent on CNC lathes to produce threads.

- Z, specifies the absolute Z coordinate of the tool after each line.
- Z, specifies the absolute Z coordinate of the tool after the threading pass.
- Z, specifies the absolute Z coordinate of the tool after the threading pass.
- Z, specifies the absolute Z coordinate of the tool after the threading pass.
- Z, specifies the absolute Z coordinate of the tool after the threading pass.
External Threads (continued):

4. Thread milling ☑ CNC machines
5. Thread grinding ☑ single or multiple form wheels
6. Thread rolling ☑ cold forming process, flat or cylindrical dies
MANUFACTURING METHODS

Internal Thread Variations

1. Tapping ⇒ hand, drill press, lathe, and CNC equipment
   - Taper tap ⇒ (8) tapered (incomplete) threads for alignment.
   - Plug tap ⇒ (4) tapered threads.
   - Bottoming tap ⇒ (1 1/2) tapered threads.
   - Straight or spiral flute ⇒ Controls direction of chip flow.
   - Standard point or spiral point ⇒ Controls direction of chip flow.
Tapping Heads:

2. Collapsing taps $\Rightarrow$ similar to die head.
3. Single point threading on lathe $\Rightarrow$ boring bar.
4. Thread milling $\Rightarrow$ CNC machines.
5. Thread forming $\Rightarrow$ fluteless taps.
MANUFACTURING METHODS

Chapter 42 - 40

Tap Drill Calculation:

\[ TD = MD - \left[ 2(d) \times 0.75 \right] \]

where:
- \( TD \) = Tap Drill Diameter
- \( MD \) = Major Diameter
- \( d \) = Thread Depth = \( P \times 0.6134 \)
- \( P \) = Pitch = \( \frac{1}{TPI} \)
- \( TPI \) = #Threads per Inch

Example

Tap Drill Calculation: ¼-20 UNC-3B thread

\[ TD = MD - \left[ 2(d) \times 0.75 \right] \]

\[ d = P \times 0.6134 \]
\[ P = \frac{1}{TPI} \]

\[ TD = 0.250 - \left[ 2\left(\frac{1}{20}\right)\times 0.6134 \times 0.75 \right] \]

\[ TD = 0.204 \quad (#6 \text{ Drill}) \]
MANUFACTURING METHODS

\[ T_m = \frac{(L + A_L + A_R)n}{N} \]

\[ = \frac{\pi D (L + A_L + A_R)n}{12V} \]

Where:
- \( T_m \) = Cutting Time (min)
- \( L \) = Depth of Tapped Hole (in)
- \( n \) = Threads per Inch
- \( N \) = Spindle Speed (rpm)
- \( D \) = Tap Diameter (in)
- \( V \) = Cutting Speed (sfpm)
- \( A_L \) = Start Allowance (in)
- \( A_R \) = Withdraw Allowance (in)

Gear Manufacturing

INTRODUCTION

- Gears ⇒ Transmit power and motion mechanically.
- Size range ⇒ Microscopic to 30+ ft in diameter.
TYPES of GEARS
1. Spur Gears ⊳ straight teeth, parallel shafts.
2. Helical Gears ⊳ tooth form at angle to axis of rotation, parallel and nonparallel shafts.
3. Rack ⊳ gear with infinite radius, teeth lie on straight line.
4. Herringbone Gears ⊳ double helix angle.
   q Continuous ⊳ no center relief.
   q Modified ⊳ groove or gap between helix pairs.

5. Worm and Worm Gear ⊳ type of screw thread in mesh with special gear tooth form.
6. Bevel Gear ⊳ teeth form on conical form, straight or spiral-tooth.
7. Hypoid Gear ⊳ spiral bevel gear not requiring common intersecting axes.
8. Zerol Gear ⊳ bevel gear with teeth in circular arc.
1. Pitch Circle - corresponds to effective diameter of gear, controls angular velocity.
2. Pitch Diameter (PD) - pitch circle diameter.
3. Pitch Point - point of intersection between gears in mesh, should be on pitch circle.
5. Diametrical Pitch (DP) – number of teeth (N) per unit of pitch diameter (PD): \( DP = \frac{N}{PD} \)

6. Addendum – radial distance from PD to outside diameter: \( \text{Addendum} = \frac{1}{DP} \).

7. Dedendum – radial distance from PD to root circle.

8. Circular Pitch – distance between corresponding points on adjacent teeth. Circular Pitch = \( \pi/DP \)
NOMENCLATURE

9. Tooth Thickness - measured along pitch circle.
10. Face Width ⇒ length of teeth in axial plane.
11. Tooth Face ⇒ mating surface between pitch circle and addendum circle.
12. Tooth Flank ⇒ mating surface between pitch circle and root circle.

MANUFACTURING METHODS

1. Machining - multi-step process.
2. Cold-Forming - rolling process similar to thread method.
3. Extrusion
4. Casting - sand, die and investment casting used.
7. Plastic Molding
8. Forging
9. Flame Machining
MANUFACTURING SEQUENCE
1. Blanking – produces a semi-finished form ready for the gear cutting operation. Methods:
   - Turning.
   - Milling.
   - Grinding.

2. Gear Cutting – forms gear tooth form. Methods:
   - Hobbing – Generating process. Hob has one tooth form wrapped around cylinder to form helix. Most common gear manufacturing process.
   - Milling – Form cutters with tooth shape utilized. Stocking cutter used for roughing cuts. Helical gears milled using dividing head. Special milling machines available.

MANUFACTURING METHODS
HOBING
2. Gear Cutting (continued) – Methods:
   - Shaping – Generating process. Reciprocating cutter in form of tooth shape.
   - Broaching – Both internal and external gears.
   - Bevel Gear – Utilizes special machines.
   - Rolling – Cold-forming process.
   - Grinding – Wheels dressed into tooth form.
3. Heat Treatment – required for wear, through hardening and surface hardening used.

4. Finishing – Finalize geometry and accuracy. Methods:
   - Shaving – Gear run at high speed in contact with shaving tool. Minimal stock removed.
   - Roll Finishing – Cold-forming process for helical gears.
   - Grinding – Wheel dressed with tooth form or straight wheel with gear rolling past.
   - Lapping – Cast iron lapping gear.
MANUFACTURING METHODS

FINISHING

The End – See Oncourse for Videos