MET 33800 Manufacturing Processes

Chapter 23
Drilling and Hole-Making Processes

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

Materials Processing

Chapters 11-13
Chapters 20-27
Chapters 15-17
Chapters 30-33

Hole-Making Processes

FIGURE 22.24 Various types of drilling and reaming operations.
Hole-Making Process

Steps required to produce a hole that is:
✓ Sized accurately
✓ Geometrically accurate.
✓ Located correctly.

Drilling Process

1. Small hole formed by the web (Chisel edge).
2. Chips formed by the rotating cutting edges (lips).
3. Drill guided by margins that contact wall of hole.
4. Chips removed from hole by screw action of helical flutes.
Drilling Process
Drilling is a complex process:
- Two cutting edges.
- Cutting tool is relatively flexible.
- Cutting action inside workpiece.
- Chip removal must be along tool.
- Chip removal impedes cutting fluid.
- High levels of friction → chip formation, chip motion on tool, and tool on work.

Cutting Parameters

Spindle Speed ($N_s$)

$$N_s = \frac{12V}{\pi D}$$

$D = \text{drill diameter}$
$V = \text{cutting speed}$

Cutting Parameters

Feed ($f_r$) $\text{ipr} = \text{Amount of material removed per revolution.}$

Feed ($f_m$) $\text{ipm} = f_r \times N_s$

Depth of Cut ($t$) $= f_r / 2$
Cutting Parameters

Cutting Time ($T_m$)

$$T_m = \frac{L + A + A_p}{f_s N_s} = \frac{L + A + A_p}{f_m}$$

Allowance ($A$) = $D/2$ (text)

Length ($L$) = depth of effective diameter

$$A_p = \text{Allowance for drill point}$$

$$A_p = \frac{D}{2} \tan \left( \frac{90^\circ \cdot \text{Drill Included Angle}}{2} \right)$$

Cutting Parameters

Material Removal Rate (MRR)

$$MRR = \left( \pi \frac{D^2}{4} \right) f_r N_s \approx 3 D V f_r$$

$D$ = drill diameter (inch)

$N_s$ = spindle speed (RPM)

$V$ = cutting speed (sfpm)
**Example Problem**

Material: ASTM A296 Grade CA-15
Stainless Steel 300 BHN

Hole: 5/8 inch diameter x 2.0 deep

Data from Reference Handbook:

\[ V = 50 \text{ fpm} \]
\[ f_i = 0.0075 \text{ ipr} \]

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**Example Problem - Solution**

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Drill Nomenclature

1. Body:
   a. Flutes ⇒ Spiral or helical grooves.
   b. Lands ⇒ Area separating flutes.
   c. Margin ⇒ Area of land to support and guide drill.
   d. Web ⇒ Backbone between flutes. Relatively thin or narrow.
   e. Heel ⇒ Area of flute opposite side of land from margin.
Drill Web

Backbone between flutes. Relatively thin or narrow.

Drill Nomenclature

1. Body (continued):
   f. Helix Angle ⇒ Angle of flute to centerline.
      - 24° ⇒ Standard
      - 30° ⇒ used for deep holes and high feed rates.
      - 0 - 20° ⇒ used for soft materials (plastic, copper).
      - 0° ⇒ used for thin sheets or soft materials.

Helix Angle Variations

Type N – standard helix for steel and cast iron.
Type H – slow helix for brass and similar materials.
Type W – quick helix for aluminum and similar materials.
Length Variations

Drill Nomenclature

2. Point Cutting edges.
   a. Cone Angle \( \Rightarrow \) Included point angle.
      - Standard 118°
      - 90-118° used soft materials
      - 118-135° used for hard materials.

2. Point (continued)
   b. Back Rake Angle \( \Rightarrow \) determined by chisel edge, relief angle and helix angle.
   c. Chisel Edge \( \Rightarrow \) Formed by web and cone angle. Tendency to ‘walk’ due to chisel edge.
      - Split Point (crankshaft) \( \Rightarrow \) thinned web to reduce cutting force and improve
Drill Nomenclature

- Chisel edge: negative rake angle / high thrust force required.
- Cutting edge: positive rake angle / lower thrust force required.

Drill Nomenclature

3. Shank
   a. Straight Shank
   b. Taper Shank ➜ Tang for drill removal with drift and drive under heavy loads.
   c. Bit Shank ➜ Non-powered hand drills.

Drill Types

- Straight Flute
- Bi Shank Twist
- Taper Shank Twist
- Subland
- High-Helix Angle Twist
- Straight Shank Twist
- 3-Flute Core
**TWO FLUTE DRILL**

**DESCRIPTION:** A two-flute drill is the basic cutting tool for producing a single flute in a solid piece of material to remove chips, in particular for the production of holes in solid stock and for the excavation of a cutting blade.

**APPLICATIONS:** Two-flute drills are used for drilling single holes in a variety of materials, such as steel, cast iron, and some plastics. They are commonly used in industries such as manufacturing, automotive, and aerospace. The design allows for easy chip evacuation, making it suitable for materials that require efficient heat dissipation.

**UNITS:** Two-flute drills can be found in various sizes, ranging from small drills for precise work to large drills for heavy-duty applications. They are available in a variety of materials, including high-speed steel, carbide, and ceramic.

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**CORE DRILL**

**Also Applicable as Counterbore or Step Drill Styles**

**DESCRIPTION:** A core drill is typically used for drilling holes with a diameter close to the size of the drill bit. It is a multi-flute drill designed for drilling hard materials such as cast iron, steel, and other metals. Core drills are used in applications where high-precision drilling is required.

**APPLICATIONS:** Core drills are used in various applications, including manufacturing, automotive, and aerospace industries. They are particularly useful in applications where holes need to be drilled in high-density materials with minimal distortion. Core drills can also be used as counterbores or step drills to create a smooth surface.

**UNITS:** Core drills are available in a range of sizes, from small drills for light-duty applications to large drills for heavy-duty industrial uses. They are typically made from high-quality materials to ensure durability and performance.

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**STEP DRILL**

**DESCRIPTION:** A step drill is a single flute drill with two or more flutes, designed to drill a series of holes at different depths in a single operation. This design reduces the number of drilling steps required, making it more efficient and cost-effective.

**APPLICATIONS:** Step drills are commonly used in the automotive, aerospace, and manufacturing industries. They are particularly useful in applications where multiple holes need to be drilled in a single piece of material to create a stepped or tapered hole.

**UNITS:** Step drills are available in a variety of sizes and materials, including high-speed steel, carbide, and ceramic. The design allows for the creation of uniform and precise holes, ensuring consistent results in repetitive applications.
Drill Types

**Pivot Microdrill** – very small diameter holes.

**Spade Drill** – with and without coolant holes.
Deep hole drills are designed to drill to depths from 3x diameter to 12x diameter.

Most designs incorporate a parabolic flute for chip clearance and heavy web for rigidity.
Drill Types – Self-Advancing

Drill Type – BTA

BTA (Boring Trepanning Association) – Deep hole drills.

Horizontal Deep-Hole Drilling Machine

Drill Type Selection

Figure 23-14: Drill selection depends on hole diameter and hole depth.
Drill Type Selection

Drill Size Series

- Millimeter series: starting 0.015 mm in 0.01 to 0.50 mm increments.
- Number series: #80 (0.0135) to #1 (0.228).
- Letter series: A (0.234) to Z (0.413).
- Fractional series: 1/64 to 4.

Drill Size Series
Other Hole-Making Processes

1. Center Drilling ⇒ Used to locate hole accurately.
   a. Start (Center) Drill ⇒ center cutting drill which is short and stiff.
   b. Center Drill Countersink Combination ⇒ 60° angle for lathe centers.

2. Reaming ⇒ Accurate sizing and improved surface finish.
   a. Stock removal ⇒ 0.005 - 0.015"
   b. 45° corner chamfer typical
   c. Types: chucking, taper, adjustable
   d. Speed = 2/3 x drill speed
   e. Feed = up to 2 x drill feed
Reamers

Other Hole-Making Processes

3. Counterboring \(\Rightarrow\) Enlarge existing hole with flat bottom. Tools typically incorporate pilot for concentricity.

4. Spotfacing \(\Rightarrow\) Machine rough surface. Tools may or may not be piloted.

5. Countersinking \(\Rightarrow\) Enlarge existing hole with beveled section. Bevel self-centering so pilot not required.
Counterbores

Toolholders

1. Drill Chucks – for straight shank tools
2. Collet Holders – for straight shank tools.
3. Taper Shank Holders.

Cutting Fluids

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Cutting Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass and Copper</td>
<td>Molybdenum disulphide, graphite, cast iron, or ceramic, or a mixture of these materials.</td>
</tr>
<tr>
<td>Tungsten carbide</td>
<td>Molybdenum disulphide, graphite, cast iron, or ceramic, or a mixture of these materials.</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>Molybdenum disulphide, graphite, cast iron, or ceramic, or a mixture of these materials.</td>
</tr>
<tr>
<td>Cast iron</td>
<td>Molybdenum disulphide, graphite, cast iron, or ceramic, or a mixture of these materials.</td>
</tr>
<tr>
<td>Steel and tool steels</td>
<td>Molybdenum disulphide, graphite, cast iron, or ceramic, or a mixture of these materials.</td>
</tr>
<tr>
<td>Tool steels</td>
<td>Molybdenum disulphide, graphite, cast iron, or ceramic, or a mixture of these materials.</td>
</tr>
<tr>
<td>Tooling materials</td>
<td>Molybdenum disulphide, graphite, cast iron, or ceramic, or a mixture of these materials.</td>
</tr>
</tbody>
</table>
Machine Tools for Drilling

1. Bench drill presses.
   a. Plain
   b. Sensitive

2. Upright drill presses.
   a. Single spindle
   b. Turret
   c. CNC

CNC Drill Presses

Belt and Gear Drive
Upright Turret Type

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Machine Tools for Drilling

3. Radial drill presses.
   a. Plain ⊆ only vertical motion.
   b. Semi-universal ⊆ spindle pivots on vertical plane.
   c. Universal ⊆ radial arm also rotates.

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Machine Tools for Drilling

5. Multi-spindle drill presses.
7. Transfer machines.

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Gang Type Drill Presses

Multiple Spindle Types

Multiple Spindle Drill Heads
Gun Drill Type

The End – See Oncourse for Videos