Drilling is a widely used manufacturing process for hole making.

Although it seems to be a relatively simple process, substantial difficulties are encountered due to poor heat and chip removal.

There are also difficulties in feeding the coolant to the cutting zone.


Drilling can also be made by using a **lathe**, or **boring machine**.
1. **Twist Drill**

The most common types of drills are twist drills. They are made from HSS. They have three basic parts, namely the **body**, **point** and **shank**.

The body contains two or more spiral grooves, called **flutes**, and solid sections called **lands**, in the form of a **helix**.

![Diagram of Twist Drill](image)
The lands terminate in the point, with the leading edge of each land forming a cutting edge.
To reduce friction between the drill and the hole, each land is reduced in diameter except of the leading edge, leaving a narrow **margin** of full diameter to aid in supporting and guiding the drill and thus aiding in obtaining an accurate hole.
The **helix angle** of most drills is 24°, but drills with other helix angles (0 to 40°) are available.

**For steel and cast iron, drills with helix angles between 24 - 33° are used.**

**Low helix angle drills:**

Helix angles ranging from 0 to 20° are used for soft materials, such as plastics and copper (and alloys).

A lower than normal helix angle (15 - 20°) is sometimes useful to prevent the tool from ‘running ahead’ or ‘grabbing’ when drilling brass and plastics.
**High helix angle drills** (35 - 40°) improve cutting efficiency but weakens the drill body. They are used for cutting materials that can be drilled very rapidly, thus resulting in a large volume of chips, like aluminum and other **low strength** materials.

**Straight-flute drills** (zero rake and helix angles) are also available, and used for drilling of **thin** sheets of soft materials.
Cone (point) angle affects the direction of flow of chips across the tool face and into the flute.

The 118° cone angle that is used most often is an arbitrary one that has been found to provide good cutting conditions and reasonable tool life for mild steel, thus making it suitable for general-purpose drilling.

Plastics (soft materials): 60 - 90°

Brittle materials: 90° - 118° (e.g. Gray cast iron, magnesium alloys)

Ductile materials: 118° - 135° (e.g. Aluminum)
The two most common types are the **straight** and **taper** shanks.

**Taper shank** drills are held in a female Morse taper in the end of the machine tool spindle.
2. **Deep Hole Drill**

Deep hole drills contain passages (e.g. a central hole) through which coolant is forced to the cutting edges which also aids in pushing chips back out of the hole.
The oldest deep-hole drilling technique is gundrilling. The gundrill is a single-lipped tool, and its major feature is the delivery of coolant through the tool at extremely high pressures.

The original gundrills were very likely half-round drills, with an axially drilled coolant hole to deliver the cutting fluid to the cutting edge.
Types of Drills - **Trepanning (Hole) Cutter**

3. **Trepanning (Hole) Cutter**

Used to make *large diameter holes in thin material*.

The main hole is produced by the thin, cylindrical cutter or saw which forms the main body of the cutter.
4. **Center Drill and Countersink**

*Used to start a hole accurately.*

*Has a short body to provide rigidity.*
If accuracy in these respects is desired, it is necessary to follow **center drilling** and **drilling** by **boring** and **reaming**.

**Boring** trues the hole alignment, whereas **reaming** brings the hole to accurate size and improves the surface finish.
Boring is **enlargement** of an existing hole.

Therefore, before boring, the hole must be made by using one of the hole making methods (e.g. drilling).

Boring **trues** (corrects) the hole alignment.

Makes hole **concentric** with the axis of rotation of the workpiece.

Surface quality of the hole is improved.
Counterboring, Countersinking, and Spotfacing

Drilling often is followed by counterboring, countersinking, or spotfacing, to provide a bearing surface at one end of a drilled hole.

**Counterbore** provides a bearing surface for a bolt head or a nut, while **countersink** provides a bearing surface for a flat-head screw or rivet.

**Spotfacing** is done to provide a smooth bearing area on an otherwise rough surface at the opening of a hole.
7. **Indexable Drill**

Carbide-tipped drills and drills with indexable inserts are available with one or two inserts. They produce a hole four times faster than a spade drill.

They run at high speeds and low feeds.
Basic components of a typical drilling machine are, base, column, power head, spindle, and worktable.
Work that is to be drilled is held in a **vise** or special **jig** or **fixture**, which is placed on the table.

Work that is too large to be held in a vise can be clamped directly to the machine table, using suitable bolts and clamps and the slots or holes in the table.
Jigs and fixtures are workholding devices.

They are critical for repeated manufacturing with high degrees of accuracy and precision.

They hold one or multiple parts to provide stability and repeatable alignment of the part.

Jigs are mainly used during drilling. They hold the workpiece and guide the drill, so that locations of the drilled holes are correct wrt. the workpiece and positioning is repeatable.

Usage of CNC machine tools decrease the need for jigs because of providing excellent positioning.
**Jig** is a special device which, through built-in features, determines location dimensions that are produced by machining or fastening operations.

Location dimensions are the dimensions that determine the position or location of the geometrical shapes with respect to each other.

**Jig** for drilling
Jig

Bushing

Drill

Work

Plate jig

Channel jig

Diameter jig

Leaf jig

Ring jig (top view)

Sectional A-A' of ring jig

Box jig
Fixture is a special device that holds the workpieces during machining or assembly operations.
Fixture - Milling

Clamp → Work → Fixture

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Drilling Machines - Bench Type

1. Bench-Type Drilling Machines

Used for drilling of relatively small diameter (up to 13 mm diameter) holes in small workpieces.

There are two types of bench-type drilling machines.

- **Plain Bench-Type Drilling Machines (Drill Press)**
- **Sensitive Bench-Type Drilling Machines**

  Same as plain bench-type machines except that they usually are smaller and provided with more accurate spindles and bearings, and operate at higher speeds (up to 30 000 rpm), for drilling of very small diameter holes (less than 1 mm).
Bench Type Drilling Machines

Plain Bench Type Drilling Machine

Sensitive Bench Type Drilling Machine
2. Upright Drilling Machines

Similar to bench type machines but they are larger. Used for drilling of larger diameter holes in larger workpieces.

Mostly have a geared transmission to provide the range of speeds and feeds.

Generally equipped with a cutting fluid circulation system.

Generally have power feeding for feeding of the drill.
3. **Gang Drilling Machines**

Consist of independent columns, heads and spindles mounted on a common base.

Were used in mass production where related operations, such as holes of different sizes, reaming, or counterboring, must be done on a single part.

Replaced by turret-type drilling machines.
4. **Turret-Type Drilling Machines**

They have a *turret* which is capable of holding and indexing a number of tools. Used where a series of holes of different size, or series of operations (such as center drilling, drilling, reaming, and spotfacing) must be done repeatedly in succession.
5. **Radial Drilling Machines**

Used when holes are to be drilled at different locations on large workpieces which can not be easily moved and clamped on upright drilling machines.

Have a large, heavy, round, vertical column supported on a large base.

\[ \Leftrightarrow : \text{Plain} \]
\[ \Leftrightarrow + \Leftrightarrow : \text{Semiuniversal} \]
\[ \Leftrightarrow + \Leftrightarrow + \Leftrightarrow : \text{Universal} \]
6. Multiple Spindle Drilling Machines

Used if a number of parallel holes must be drilled in a part.

These are mass production machines with many spindles driven by a single powerhead and fed simultaneously into the work.

Two or more powerheads frequently are combined in a single machine.
Drilling Machines - Deep Hole

7. Deep-Hole Drilling Machines

As the depth of the hole increases (e.g. holes in rifle barrels, connecting rods, long spindles), it becomes very difficult to support the workpiece and the drill properly.

Also, chips must be rapidly removed to insure the proper operation and accuracy.

Rotational speeds and feeds must be carefully determined since there is a great possibility of deflection.

To overcome these problems, deep-hole drilling machines have been developed.
Deep-Hole Drilling Machines

Usually the workpiece is rotated in a chuck and stationary drill is fed into the workpiece.
Drilling Time

To include the additional distance traveled by the drill for approach (a) and overtravel (o), an approximate value of 1/2 hole (drill) diameter is added to the hole depth.
*** MACHINING/basic hole making (SME/Wiley’s video)***