Lecture 3-2: General-Purpose Machine Tools: Drilling Machines and Operations

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Drilling and Drilling Allied Operations

- **Drilling Operation**
- Drilling is a process used extensively by which through or blind holes are originated or enlarged in a WP.
- This process involves feeding a rotating cutting tool (drill) along its axis of rotation into a stationary WP (Figure 3.15).
- The axial feed rate f is usually very small when compared to the peripheral speed v.
- Drilling is considered a roughing operation and, therefore, the accuracy and surface finish in drilling are generally not of much concern.
- If high accuracy and good finish are required, drilling must be followed by some other operation such as reaming, boring, or grinding.

Drilling and Drilling Allied Operations

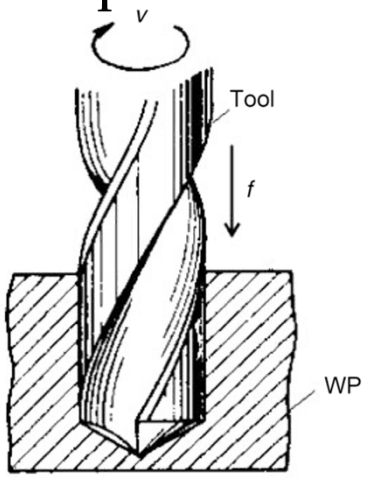


FIGURE 3.15 Drilling operation.

Drilling and Drilling Allied Operations

- The most commonly employed drilling tool is the twist drill, which is available in diameters ranging from 0.25 to 80 mm.
- A standard twist drill (Figure 3.16) is characterized by a geometry in which the normal rake and the velocity of the cutting edge are a function of their distance from the center of the drill.

Drilling and Drilling Allied Operations

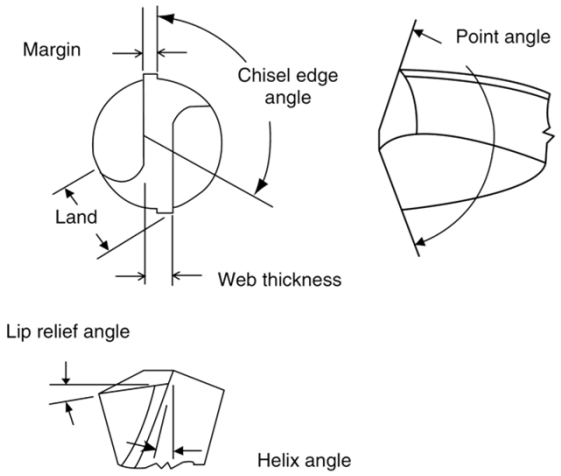
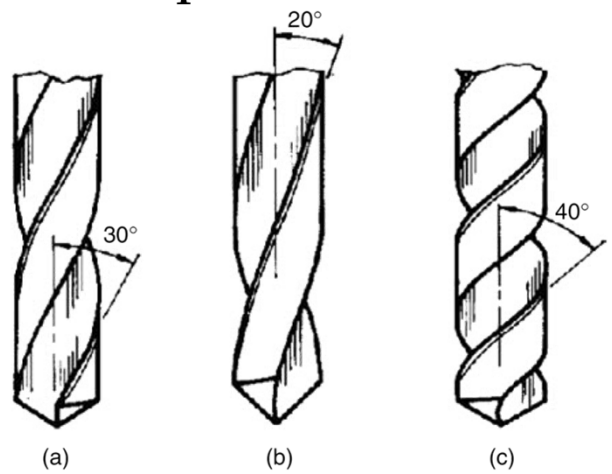


FIGURE 3.16 Terminology of a standard point twist drill.

Drilling and Drilling Allied Operations

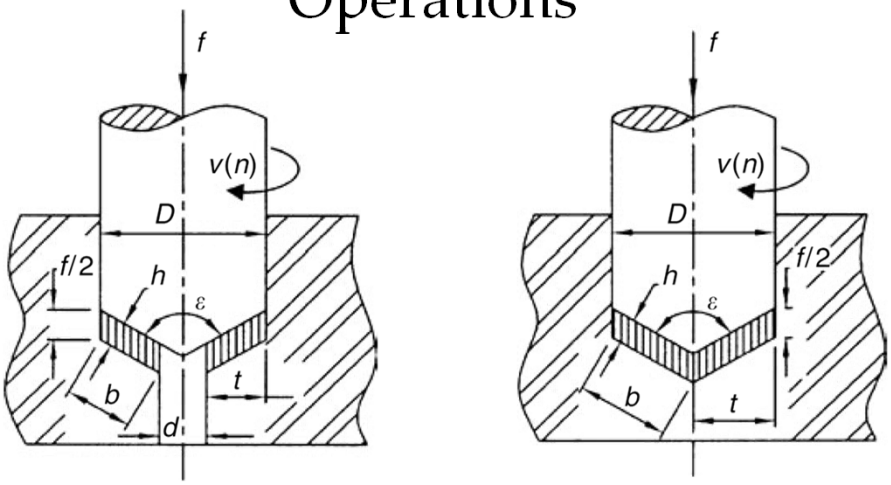
- Referring to the terminology of twist drill shown in Figure 3.17, the helix angle of the twist drill is the equivalent of the rake angle of other cutting tools.
- The standard helix is 30°, which, together with a point angle of 118°, is suitable for drilling steel and CI (Figure 3.17a).
- Drills with a helix angle of 20°, known as slow-helix drills, are available with a point of 118° for cutting brass and bronze (Figure 3.17b), and with a point of 90° for cutting plastics. Quick helix drills, with a helix angle of 40° and a point of 100°, are suitable for drilling softer materials such as aluminum alloys and copper (Figure 3.17c). Figure 3.18 visualizes the basic machining parameters in drilling and enlarging holes.

Drilling and Drilling Allied Operations



Helix drills of different helix angles: (a) Standard, (b) slow, (c) quick.

Drilling and Drilling Allied Operations



Basic machining parameters in drilling.

Drilling and Drilling Allied Operations

- **Drilling Allied Operations**
- Drilling allied or alternative operations such as core drilling, center drilling, counterboring, countersinking, spot facing, reaming, tapping, and other operations can also be performed on drilling machines as shown in Figure 3.19.
- Accordingly, the main and feed motion are the same as in drilling; that is, the drill rotates while it is fed into the stationary WP.
- In these processes, the tool shape and geometry depend upon the machining process to be performed.

Drilling and Drilling Allied Operations

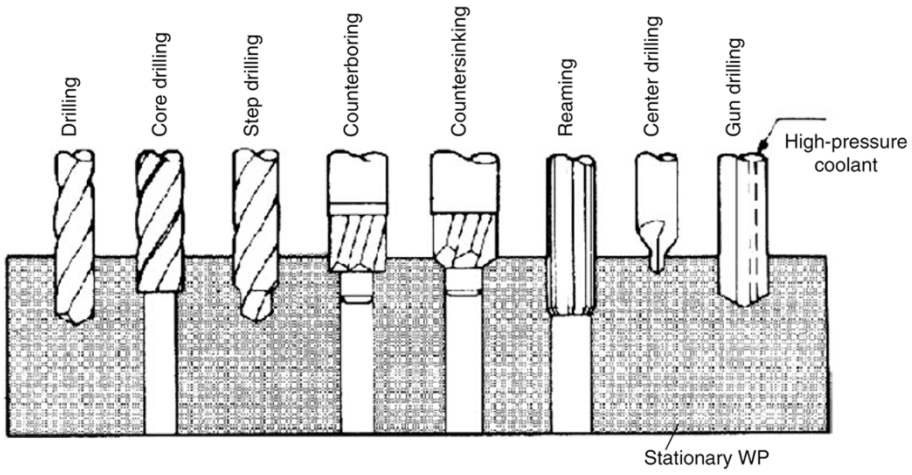


FIGURE 3.19 Drilling and drilling allied operations.

Drilling and Drilling Allied Operations

- The same operations can be accomplished in some other machine by holding the tool stationary and rotating the work. The most general example is performing these processes on a center lathe, in which the tool (drill, counterbore, reamer, tap, and so on) is held in the tailstock and the work is held and rotated by a chuck (Figure 3.20).

Drilling and Drilling Allied Operations

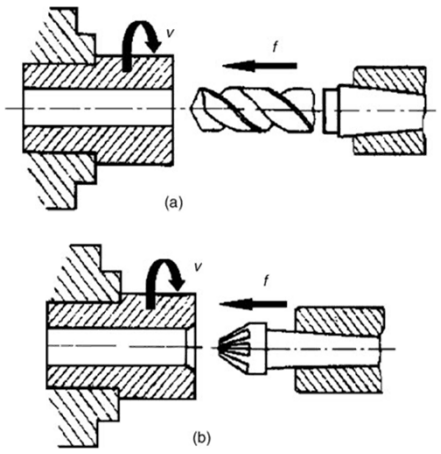
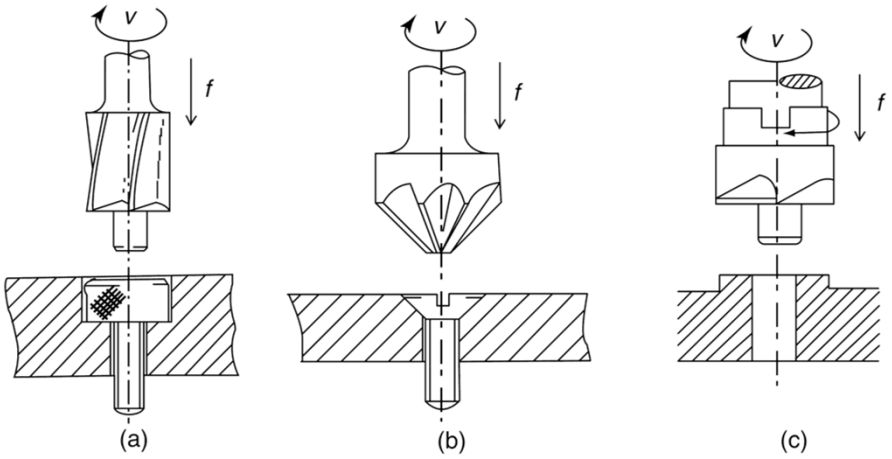


FIGURE 3.20 Drilling and drilling allied operations as performed on an engine lathe: (a) Drilling and (b) Countersinking.

Drilling and Drilling Allied Operations



Counterboring, countersinking, and spot facing operations.

GENERAL-PURPOSE DRILLING MACHINES

- The general-purpose drilling machines are classified as

1. Bench-type sensitive drill presses
2. Upright drill presses
3. Radial drills
4. Multispindle drilling machines
5. Horizontal drilling machines for drilling deep holes

- The most widely used in the general engineering industries are the upright drill presses and radial drills.

GENERAL-PURPOSE DRILLING MACHINES

- **Bench-Type Sensitive Drill Presses**
- These drill presses are used for machining small diameter holes of 0.25–12 mm diameter.
- Manual feeding characterizes this machine and that is why they are called “sensitive.”
- High speeds are typical for bench-type sensitive drill presses.

GENERAL-PURPOSE DRILLING MACHINES

- **Upright Drill Presses**
- These machines are used for machining holes up to 50 mm in diameter in relatively small-size work.
- It has a wide range of spindle speeds and feeds.
- Therefore, they are employed not only for drilling from solid material, but also for core drilling, reaming, and tapping operations.
- Figure 3.23 illustrates the gearing diagram of the machine.

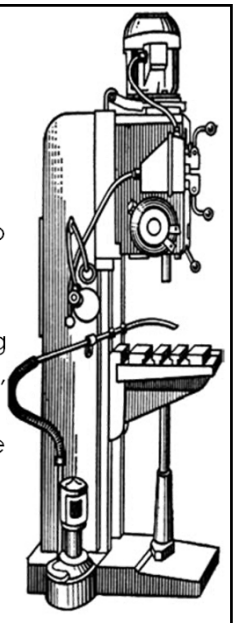


FIGURE 3.22 Typical upright drill press.

GENERAL-PURPOSE DRILLING MACHINES

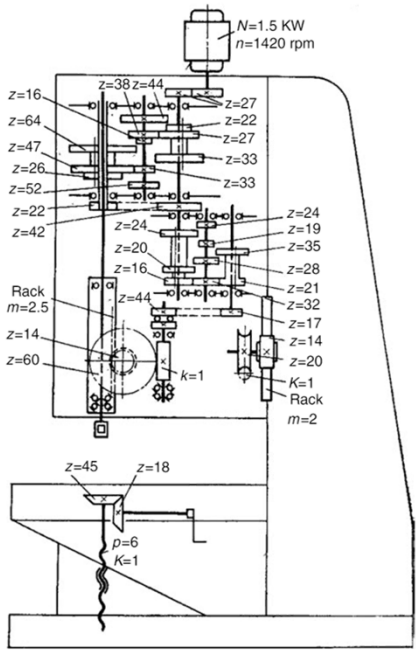


FIGURE 3.23 Kinematic diagram of an upright drill press.

GENERAL-PURPOSE DRILLING MACHINES

- **Cutting movements.**
- As shown in the gearing diagram (Figure 3.23), the kinematic chain equations for the maximum spindle speed and feed are given by

$$n_{\max} = 1420 \cdot \frac{27}{27} \cdot \frac{33}{33} \cdot \frac{52}{26} = 2840 \text{ rpm}$$

$$f_{\max} = 1 \cdot \frac{22}{42} \cdot \frac{24}{24} \cdot \frac{32}{21} \cdot \frac{17}{44} \cdot \frac{1}{60} \times \pi \times 2.5 \times 14 = 0.56 \text{ mm/rev}$$

GENERAL-PURPOSE DRILLING MACHINES

- **Auxiliary movements.**
- The drill head, housing the speed and feed gearboxes, moves along the machine column through the gear train: worm gearing 1/20-rack and pinion (z = 14, m = 2). The machine table can be moved vertically by hand through bevels 18/45 and an elevating screw driven by means of a handle (Figure 3.23).

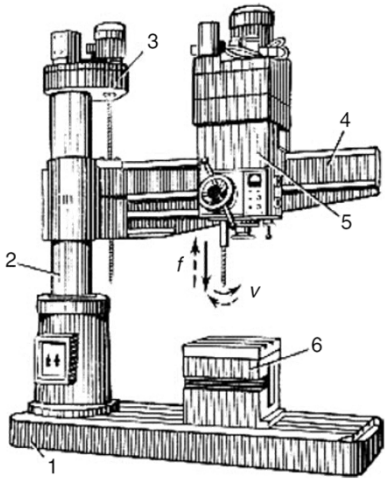
GENERAL-PURPOSE DRILLING MACHINES

- **Radial Drilling Machines.**
- These machines are especially designed for drilling, counterboring, countersinking, reaming, and tapping holes in heavy and bulky WPs that are inconvenient or impossible to machine on the upright drilling machines. They are suitable for multitool machining in individual and batch production.

GENERAL-PURPOSE DRILLING MACHINES

- Radial drilling machines (Figure 3.24) differ from upright drill presses in that the spindle axis is made to coincide with the axis of the hole being machined by moving the spindle in a system of polar coordinate to the hole, while the work is stationary.
- This is achieved by:
  1. Swinging the radial arm (4) about the rigid column (2)
  2. Raising or lowering the radial arm on the column by the arm-elevating and –clamping mechanism (3) to accommodate the WP height
  3. Moving the spindle head (5) along the guideways of the radial arm (4)

GENERAL-PURPOSE DRILLING MACHINES



Typical radial drilling machine.

GENERAL-PURPOSE DRILLING MACHINES

- Accordingly, the tool is located at any required point on the stationary WP, which is set either on detachable table (6) or directly on base (1).
- After the maneuvering tasks performed by the radial arm and spindle head, they are held in position using power-operated clamping devices.
- The spindle head gearing diagram of the radial drilling machine is very similar to that of the upright drill press.

GENERAL-PURPOSE DRILLING MACHINES

- **Multispindle Drilling Machines.**
- These are mainly used in lot production for machining WPs requiring simultaneous drilling, reaming, and tapping of a large number of holes in different planes of the WP.
- A single spindle drilling machine is not economical for such purposes, as not only a considerably large number of machines and operators are required but also the machining cycle is longer.

GENERAL-PURPOSE DRILLING MACHINES

- There are three types of multiplespindle drilling machines:

  a. Gang multispindle drilling machines.
  - The spindles (2–6) are arranged in a row, and each spindle is driven by its own motor.
  - The gang machine is in fact several upright drilling machines having a common base and single worktable (Figure 3.25). They are used for consecutive machining of different holes in one WP, or for the machining of a single hole with different cutting tools.

GENERAL-PURPOSE DRILLING MACHINES

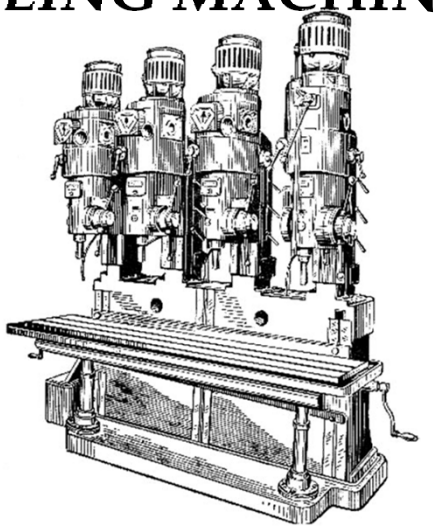


FIGURE 3.25 Gang, multiple-spindle drilling machine.

GENERAL-PURPOSE DRILLING MACHINES

b. Adjustable-center multispindle vertical drilling machines. These differ from gang-type machines in that they have a common drive for all working spindles.

The spindles are adjusted in the spindle head for drilling holes of varying diameters at random locations on the WP surface (Figure 3.26).

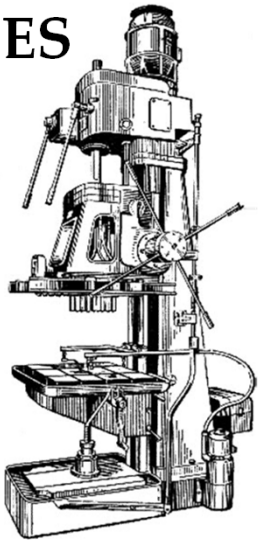


FIGURE 3.26 Multiple-spindle drilling machine.

GENERAL-PURPOSE DRILLING MACHINES

c. Unit-type multispindle drilling machines.

These are widely used in mass production.

They are, as a rule, chiefly built of standard units. Such machines are designed for machining a definite component held in a jig and are frequently built into an automatic transfer machine (Figure 3.27).

GENERAL-PURPOSE DRILLING MACHINES

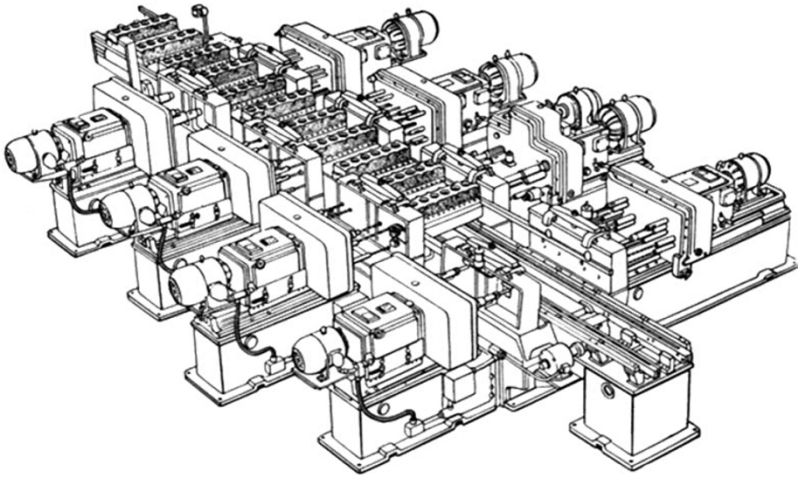


FIGURE 3.27 Unit-type multiple-spindle drilling machine.