MACHINING OPERATIONS
AND MACHINE TOOLS

1. Turning and Related Operations
2. Drilling and Related Operations
  3. Milling
4. Machining & Turning Centers
5. Other Machining Operations
6. Shape, Tolerance and Surface Finish
  7. Machinability
8. Selection of Cutting Conditions
9. Product Design Consideration
1. Turning & Related Operations

• Turning – a machining process in which a single-point tool remove material from the surface of a rotating work piece. (Lathe)

Rotational Speed: \[ N = \frac{v}{\pi D_o} \]

\[ D_o - D_f = 2d \]

Feed rate: \[ f_r = Nf \]

Time of machining: \[ T_m = \frac{L}{f_r} \]

Material Removal Rate: \[ MRR = vfd \]
Operations related to Turning

- Facing
- Taper turning
- Contour turning
- Form turning
- Chamfering
- Cutoff
- Threading
- Boring
- Drilling
- Knurling
Work Holding

- Mounting between two centers (Dog & Live center)
- Chuck
- Collet
- Face plate
Other Lathes & Turning Machine

• Toolroom Lathe and Speed Lathe
• Turret Lathe
  – The tailstock is replaced with a turret
• Chucking Machines – No tailstock
• Automatic Bar Machine – Similar to chuck machine but with a collet
  – A single- and multiple-spindle bar machines
• NC Lathe
Boring Machining

- Boring – Cutting is done inside diameter of the work material

Horizontal Boring Machining

Vertical Boring Machining
2. Drilling & Related Operations

• Geometry of Twist drill
  – Shank, Neck and Drill body
  – Helix angle, Point angle, Flute, cutting edge, Chisel edge, Margin

• Cutting conditions

  Spindle: \( N = \frac{v}{\pi D} \)
  Feed rate: \( f_r = N f \) \( \text{f(in/rev)} \)

  Metal Removal Rate: \( MRR = \frac{\pi D^2 f_r}{4} \)

  Machining time: \( T_m = \frac{t + A}{f} \) For a through hole

  \( T_m = \frac{d}{f_r} \) For a blind hole
Twist Drill and Drilling Operations

**Figure 8.49** Various types of drills and drilling operations.

From Kalpakjian and Schmid (2003)
Machine Tool for drilling

- Drill press
  - Upright drill
  - Bench drill
  - Radial drill
  - Gang drill - 2-6 drills together
  - NC drill

- Vice, Jig and fixture
3. Milling

- **Milling**
  - A machine operation in which a work part is fed past a rotating cylindrical tool with multiple edges. (milling machine)

- **Types**
  - **Peripheral milling**
    - Slab, slotting, side and straddle milling
    - Up Milling (Conventional) & down milling (Climb)
  - **Facing milling**
    - Conventional face, Partial face, End, Profile, Pocket & contour millings
Cutting conditions

• Milling cutters
  – Plain milling cutters
  – Form milling cutters
  – Face milling cutters
  – End milling cutters

• Cutting conditions
  Spindle rotation speed: \( N = \frac{v}{\pi D} \)
  Feed rate: \( f_r = Nn_tf \)
  Material Removal Rate: \( MRR = wdf_r \)
Milling Machines

- Knee-and-column Milling Machine
  - Horizontal and Vertical types
  - Universal and Ram types
- Bed-type Mill
- Planer-type Mills – the largest category
- Tracer (profile) Mill – reproduce an irregular part geometry
- CNC Milling machine
Machining Centers

• Machining center – highly automated machine tool capable of performing multiple machining operations under CNC control.
  – Automatic tool changer
  – Pallet shuttles
  – Automatic workpart positioning

• CNC turning center
A CNC mill-turn center

A series of operations without human interactions

Stock  Turning  Milling  Drilling

A part

From a round stock  From a casting  From another casting
5. Other Machining Operations

- Shaping and planing
  - A single-point tool moves linearly relative to the work part
  - Shaping - A tool moves
  - Planing - A workpart moves

- Broaching
  - Performed by a multiple-tooth cutting tool by moving linearly relative to the work in the direction of the tool axis.

- Sawing
  - Hacksawing, Bandsawing, and Circular sawing
Broaching

Semifinishing teeth

Finishing teeth

Roughing teeth

Cut per tooth
Sawing

Hacksaw - linear reciprocating motion

Bandsaw - linear continuous motion

Saw Blade (Straight & Undercut tooth or Straight & Raker sets)