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)

\[ N = \frac{v}{\pi D_d} \]
\[ D_o - D_i = 2D_d \]
\[ f_t = Nf \]
\[ T_m = \frac{L}{f_t} \]
\[ MRR = vfd \]

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: \[ f_r = \frac{N_f f_t}{f_r} \] (in/rev)
  - Metal Removal Rate: \[ MRR = \pi D f_r \]
  - Machining time: \[ t_m = \frac{f_t}{f_r} \] for a through hole
  - \[ t_m = \frac{D_r}{f_r} \] for a blind hole

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Twist Drill and Drilling Operations

- Drill press
  - Upright drill
  - Bench drill
  - Radial drill
  - Gang drill - 2-6 drills together
  - NC drill
- Vice, Jig and fixture

Machine Tool for drilling

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

4. 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

5. 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

6. 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

7. 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

8. 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

9. 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

10. 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

11. 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

12. 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: \[ f_r = \frac{N_f f_t}{f_r} \]
  - Material Removal Rate: \[ MRR = \pi D f_r \]
Milling Machines

- Knee-and-column Milling Machine (Fig. 22.22 and Fig. 22.23)
  - Horizontal and vertical types
  - Universal and Ram types
- Bed-type Mill (Fig. 22.24)
- 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

A part

- Stock
- Turning
- Milling
- Drilling

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 & Sawing

Hacksaw - linear reciprocating motion
Bandsaw - linear continuous motion