Lecture 15

Chapter 23

Machining Processes Used to Produce Round Shapes

Turning

- Turning – part is rotating while it is being machined
- Typically performed on a lathe
  - Turning – produces straight, conical, curved, or grooved parts
  - Facing – produces flat surface perpendicular to turning axis
  - Cutting with form tools – produces axisymmetric shapes
  - Boring – enlarging cavities / producing internal grooves
  - Drilling – production of a hole
  - Parting – to cut a piece off from the end of a part
  - Threading – production of internal or external threads
  - Knurling – production of regularly shaped roughness

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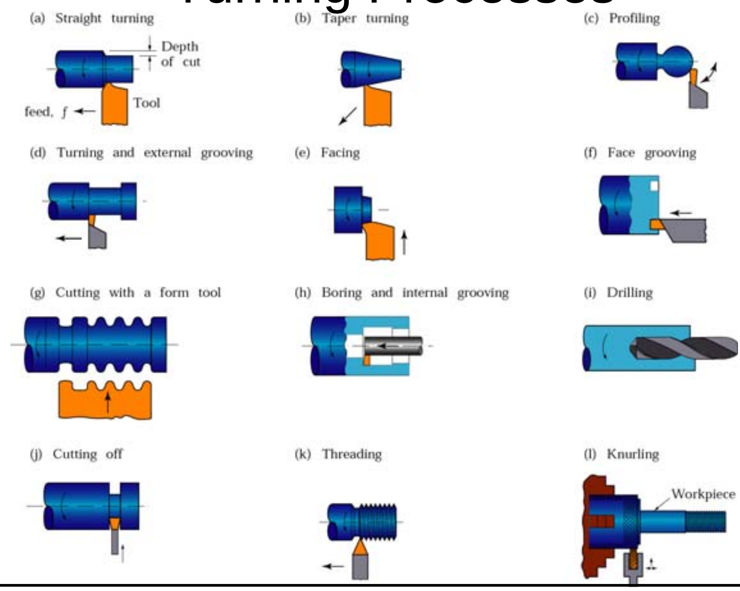
Turning Processes



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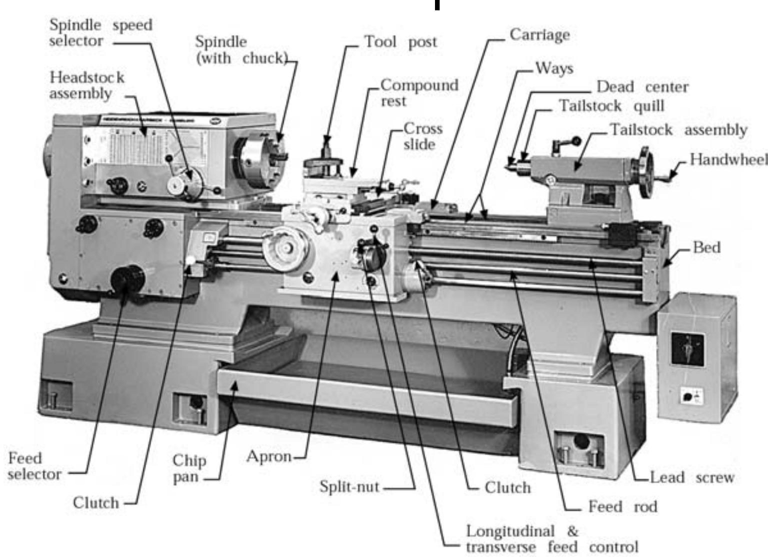
Lathe Components



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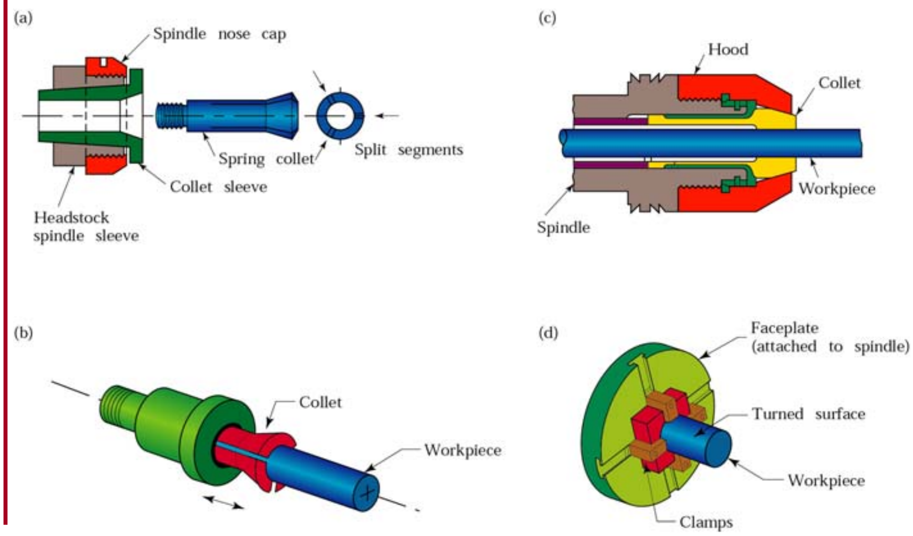
Collets



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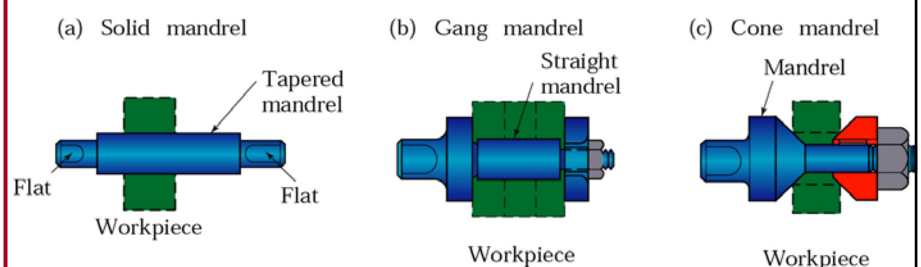
Mandrels



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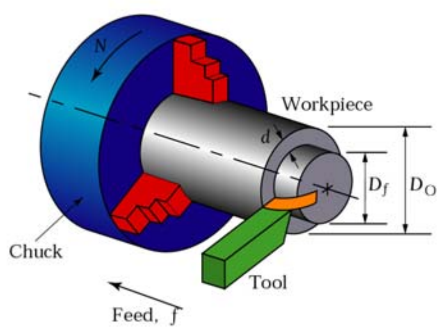
Turning Processes and Tolerances

TABLE 22.1 General Characteristics of Machining Processes Described in Chapters 22 and 23

Process	Characteristics	Commercial tolerances(±mm)
Turning	Turning and facing operations on all types of materials; uses single-point or form tools; requires skilled labor; low production rate, but medium to high with turret lathes and automatic machines, requiring less-skilled labor.	Fine: 0.05–0.13 Rough: 0.13 Skiving: 0.025–0.05
Boring	Internal surfaces or profiles, with characteristics similar to turning; stiffness of boring bar important to avoid chatter.	0.025
Drilling	Round holes of various sizes and depths; requires boring and reaming for improved accuracy; high production rate; labor skill required depends on hole location and accuracy specified.	0.075
Milling	Variety of shapes involving contours, flat surfaces, and slots; wide variety of tooling; versatile; low to medium production rate; requires skilled labor.	0.13–0.25
Planing	Flat surfaces and straight contour profiles on large surfaces; suitable for low-quantity production; labor skill required depends on part shape.	0.08–0.13
Shaping	Flat surfaces and straight contour profiles on relatively small workpieces; suitable for low-quantity production; labor skill required depends on part shape.	0.05–0.13
Broaching	External and internal flat surfaces, slots, and contours with good surface finish; costly tooling; high production rate; labor skill required depends on part shape.	0.025–0.15
Sawing	Straight and contour cuts on flat or structural shapes; not suitable for hard materials unless saw has carbide teeth or is coated with diamond; low production rate; requires only low labor skill.	0.8

Turning Variables

- Independent variables
  1. Rotational speed (N)
  2. Depths – of – Cut (d)
  3. Feeds (f)
  4. Material properties
     - Work-piece
     - Tool
- Dependent variables
  1. Surface finish
  2. Dimensional Accuracy



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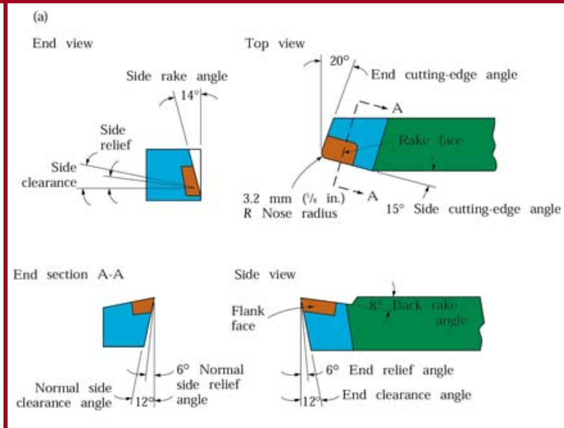
Designations for a Right Hand Cutting Tool



Tool Signature	Dimensions	Abbreviation
8	Back rake angle	BR
14	Side rake angle	SR
6	End relief angle	ER
12	End clearance angle	. . .
6	Side relief angle	SRF
12	Side clearance angle	. . .
20	End cutting-edge angle	ECEA
15	Side cutting-edge angle	SCEA
1/8	Nose radius	NR

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Designations for a Right Hand Cutting Tool

- Rake Angles
  - Side rake angle
  - Back rake angle
    - Controls flow of chip
  - Positive rake angle
    - Reduces forces and temperature
    - Smaller included angle – more apt to break
- Cutting edge angles
  - Chip formation
  - Tool strength
  - Cutting forces

Designations for a Right Hand Cutting Tool

- Relief angle
  - Controls interference / rubbing at the tool-work-piece
    - Too big – tool may chip off
    - Too small – flank wear
- Nose Radius
  - Small radii (Sharp tool) – rough surface finish
  - Large radii - chatter

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Tool Angles

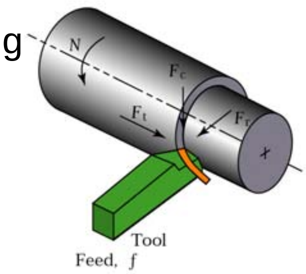
TABLE 22.2

	High-speed steel					Carbide (inserts)				
Material	Back rake	Side rake	End relief	Side relief	Side and end cutting edge	Back rake	Side rake	End relief	Side relief	Side and end cutting edge
Aluminum and magnesium alloys	20	15	12	10	5	0	5	5	5	15
Copper alloys	5	10	8	8	5	0	5	5	5	15
Steels	10	12	5	5	15	–5	–5	5	5	15
Stainless steels	5	8–10	5	5	15	–5–0	–5–5	5	5	15
High-temperature alloys	0	10	5	5	15	5	0	5	5	45
Refractory alloys	0	20	5	5	5	0	0	5	5	15
Titanium alloys	0	5	5	5	15	–5	–5	55	5	
Cast irons	5	10	5	5	15	–5	–5	5515		
Thermoplastics	0	0	20–30	15–20	10	0	0	20–30	15–20	10
Thermosets	0	0	20–30	15–20	10	0	15	5	5	15

- Trends
  - Compare Al – Steel - Plastics

Forces in Turning

- Three principle forces in turning
  - Cutting force (F_c)
    - Deflects tool tip downward
    - Deflects work-piece upward
    - Suggest a model?
  - Thrust force (F_t)
    - Acts longitudinally – pushes the tool away from the chuck
  - Radial force (F_r)
    - Pushes the tool away from the work-piece



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Turning Parameters and Formulas

TABLE 22.3

N = Rotational speed of the workpiece, rpm
f = Feed, mm/rev or in/rev
v = Feed rate, or linear speed of the tool along workpiece length, mm/min or in/min
= fN
V = Surface speed of workpiece, m/min or ft/min
= $\pi D_o N$ (for maximum speed)
= $\pi D_{avg} N$ (for average speed)
l = Length of cut, mm or in.
D_o = Original diameter of workpiece, mm or in.
D_f = Final diameter of workpiece, mm or in.
D_{avg} = Average diameter of workpiece, mm or in.
= $(D_o + D_f)/2$
d = Depth of cut, mm or in.
= $(D_o + D_f)/2$
t = Cutting time, s or min
= $l/f N$
MRR = mm^3/min or in^3/min
= $\pi D_{avg}\, d\, fN$
Torque = Nm or lb ft
= $(F_c)(D_{avg}/2)$
Power = kW or hp
= (Torque) (w , where w=2π radians/min

Note: The units given are those that are commonly used; however, appropriate units must be used and checked in the formulas.

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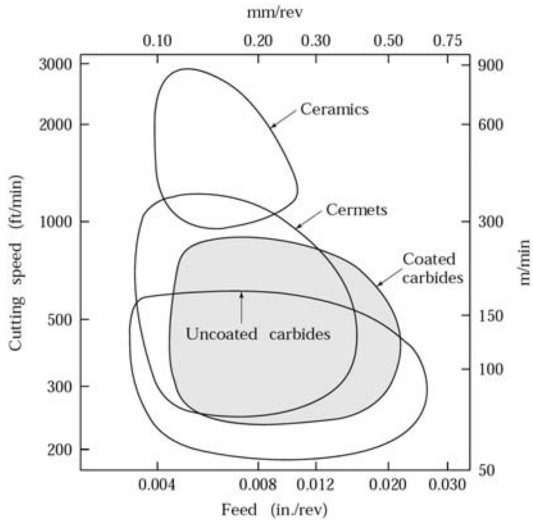
Ranges for Cutting Speeds and Feed Rates for Different Tooling Materials



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Types of Cutting Fluids for Turning

TABLE 22.5

Material	Type of fluid
Aluminum	D, MO, E, MO FO, CSN
Beryllium	MC, E, CSN
Copper	D, E, CSN, MO FO
Magnesium	D, MO, MO FO
Nickel	MC, E, CSN
Refractory	MC, E, EP
Steels (carbon and low alloy)	D, MO, E, CSN, EP
Steels (stainless)	D, MO, E, CSN
Titanium	CSN, EP, MO
Zinc	C, MC, E, CSN
Zirconium	D, E, CSN

Note: CSN, chemicals and synthetics; D, dry; E, emulsion; EP, extreme pressure; FO, fatty oil; and MO, mineral oil.

Turning Limitations

TABLE 22.6

Machine tool	Maximum dimension (m)	Power (kW)	Maximum rpm
Lathes (swing/length)			
Bench	0.3/1	<1	3000
Engine	3/5	70	4000
Turret	0.5/1.5	60	3000
Automatic screw	0.1/0.3	20	10,000
Boring machines (work diameter/length)			
Vertical spindle	4/3	200	300
Horizontal spindle 1.5/2	70	1000	
Drilling machines			
Bench and column (drill diameter)	0.1	10	12,000
Radial (column to spindle distance)	3	—	—
Numerical control (table travel)	4	—	—

Note: Larger capacities are available for special applications.