

Machine Tools

A power-driven machine that performs a machining operation, including grinding

- ▶ Functions in machining:
 - Holds workpart
 - Positions tool relative to work
 - Provides power at speed, feed, and depth that have been set
- ▶ The term is also applied to machines that perform metal forming operations

Mechanics of Metal Cutting

- ✚ Tool must be sharp (what do you mean by sharp?)
- ✚ Relative velocity
- ✚ Interference
- ✚ Tool material shall be harder than the work piece material

Physical Phenomenon in Machining

- ✚ Plastic flow
- ✚ Fracture
- ✚ Friction
- ✚ Heat
- ✚ Molecular diffusion
- ✚ Chatter

At extreme condition

- Sticking friction at tip
- Deformation at high strain and strain rate
- Nascent surface exposed after deformation is very active

Objectives During Machining

- + High Material Removal Rate (MRR)
- + Good accuracy and Surface finish
- + Long tool life

Cost

Contradicting

Processing Parameters in Machining

Cutter Related

Material
Geometry
Mounting

Machine Related

Cutting fluid type and application method
Depth and Width of cut
Spindle speed
Feed rate

Workpiece Related

Material (composition, homogeneity)
Geometry (bar, block, casting etc.)
Depth of cut
Spindle speed
Feed rate

Others

Cutting fluid type and application method
Depth and Width of cut
Spindle speed
Feed rate

Effects of Processing Parameters

- ✚ Cutting forces and
- ✚ Torques and power
- ✚ Tool temperature
- ✚ Frictional effects on tool face
- ✚ Built up edge
- ✚ Formation
- ✚ Chatter, noise and
- ✚ Vibrations

- ✚ Work hardening
- ✚ Thermal softening
- ✚ Hot spots on the machined surface
- ✚ Deflection and diameter variations
- ✚ Tool life
- ✚ Surface finish

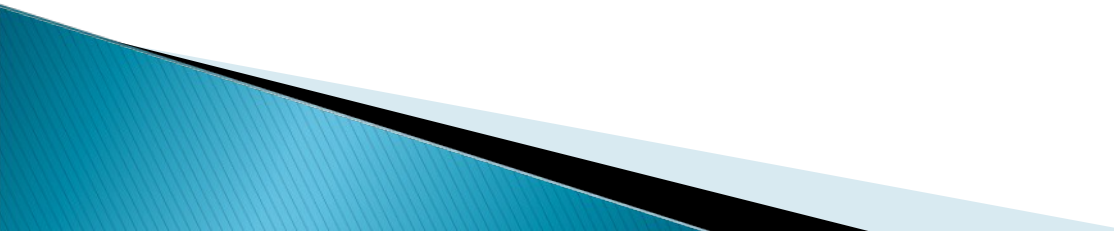
Cutting Conditions in Machining

- ▶ Three dimensions of a machining process:
 - Cutting speed v – primary motion
 - Feed f – secondary motion
 - Depth of cut d – penetration of tool below original work surface
- ▶ For certain operations, material removal rate can be computed as

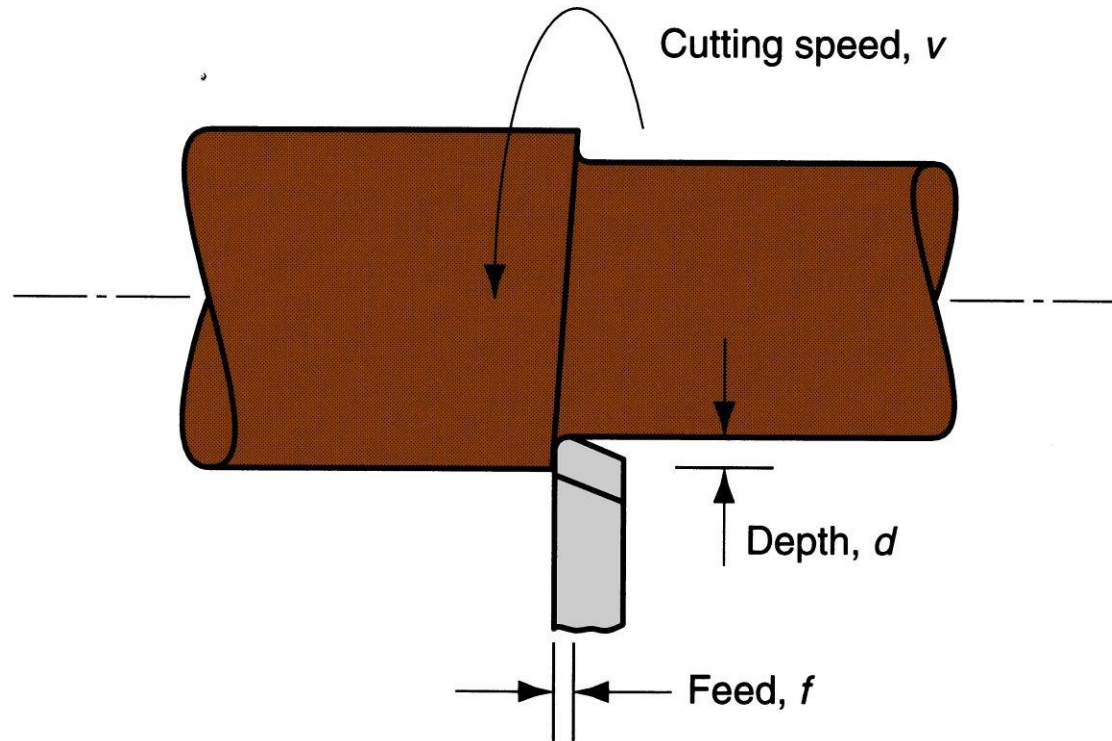
$$R_{MR} = v f d$$

where v = cutting speed; f = feed; d = depth of cut

Speed and Feed

- ▶ **Speed** is the relative movement between tool and w/p, which **produces** a **cut**
 - ▶ **Feed** is the relative movement between tool and w/p, which **spreads** the **cut**
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Cutting Conditions for Turning



Speed, feed, and depth of cut in turning.

Difficulties in Machining Mechanics studies

- ✚ Several physical phenomenon such as plastic flow, fracture, friction, heat, molecular diffusion and chatter are involved. Some of them occur in extrême conditions
- ✚ Friction – sticking; deformation – high strain and strain rate; nascent surface exposed after deformation is very active causing diffusion
- ✚ The cutting zone is covered by chips and coolant.

Typical machining is oblique, i.e., forces, torques and deflections exist in all 3 directions.

Difficulties in Machining Mechanics studies

- ✚ The typical machining operations are too short and the stock (depth and width of cut) keeps changing.
- ✚ Furthermore, velocity also may change along the cutting edge as well as over time. These changes further compound the difficulties to observe the process carefully.
- ✚ **Orthogonal cutting experiments were developed to overcome these difficulties.**