

# Metal Cutting Physics and Calculation of Speeds and Feeds

# Variables that we control

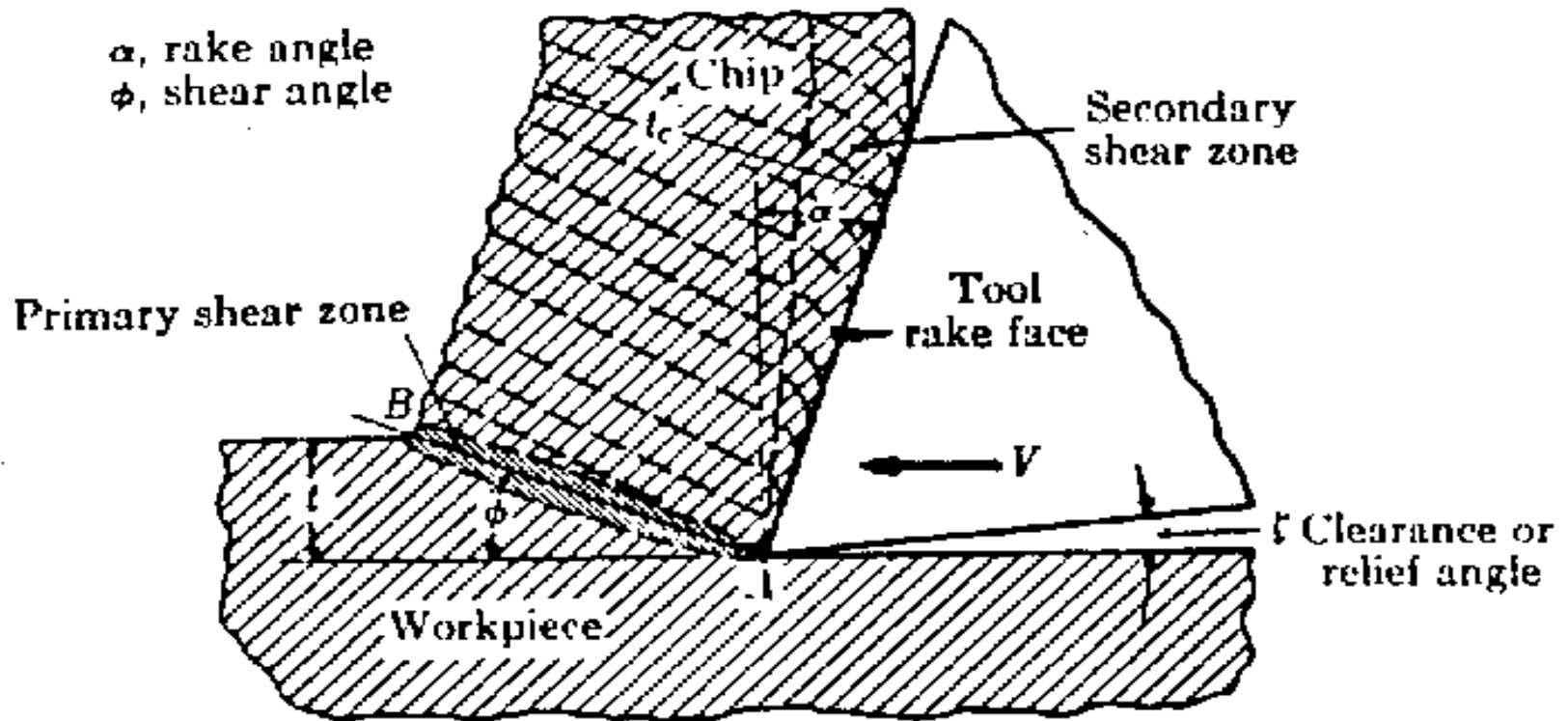
- We have control over a few variables when machining:
  - The contact velocity between the part and the cutting tool. This is the **SPEED** and is controlled by the RPM of the spindle.
  - The rate at which the tool moves through the workpiece – the **FEED RATE**.
  - The type of cutting tool (material, # cutting edges)
  - The type and quantity of the coolant or lubricant



# What we know

- Experimental about the machinability of materials is published. *Machinery's Handbook* is a good reference. Suppliers of unusual alloys usually provide machinability data for their products. This data include:
  - Recommended cutting tools and fluids
  - Recommended cutting velocity and chip load (chip thickness)

# Mechanics



# Surface Velocity – Determining RPM

- Material properties of the workpiece and the cutting tool determine the maximum velocity at the cutting tool.
- The velocity and the RPM are related by

$$CS = RPM * \pi D \quad (1)$$

$$RPM = CS / \pi D \quad (2)$$

For CS in FPM and D in inches

$$RPM = 4 * CS / D \quad (3)$$

# Mills



# Determining RPM - Examples

- Example cutting speeds with HSS tools:
  - Aluminum            250 SFM
  - Steel                 25 SFM
- For a .25" dia. tool cutting aluminum  
$$\text{RPM} = 4 * \text{CS} / \text{D} = 4 * 250 / .25 = 4,000 \text{ RPM}$$
- For a 1" dia. tool cutting steel  
$$\text{RPM} = 4 * \text{CS} / \text{D} = 4 * 25 / 1 = 100 \text{ RPM}$$
- For a 1" dia. high speed insert cutting aluminum  
$$\text{RPM} = 4 * \text{CS} / \text{D} = 4 * 9000 / 1 = 36,000 \text{ RPM}$$

# Feed Rate

- The optimum thickness of the chip formed by the cutting tool depends on the material properties of the workpiece and the cutting tool.

$$\text{Feed} = \text{RPM} * T * N$$

Feed =( inches/minute)

T = chip thickness (inches)

N = # cutting surfaces

# Feed Rate Examples

- Typical chip loads:
  - Aluminum .005"/tooth
  - Steel .003"/tooth
- Turning steel on the lathe – 1" dia. workpiece
$$\text{RPM} = 4 * \text{CS} / D = 4 * 25 / 1 = 100 \text{ RPM}$$
$$\text{Feed} = \text{RPM} * T * N = 100 * .003 = 0.3 \text{ in/min}$$
- High speed milling with 4 tooth 2" diameter cutter
$$\text{RPM} = 4 * \text{CS} / D = 4 * 9000 / 2 = 18,000 \text{ RPM}$$
$$\text{FEED} = \text{RPM} * T * N = 9000 * .005 * 4 = 180 \text{ in/min}$$

# Summary

- Find surface velocity and chip load data for your workpiece and cutting tool materials. Machinery's Handbook is a good reference.
- Calculate RPM for your cutting tool diameter (mill) or workpiece diameter (lathe)
- Calculate feed rate using the chip load and # of cutting teeth.