IME 601 - FUNDAMENTALS OF MFG. ENG.

MACHINING PROCESSES — BASIC CLASS NOTES

Reading Review and Class Preparation

This should be filled out prior to class.

Key Concepts to Be Discussed in Class:

Questions About Subject Matter for Class Session:

So What Why Who Cares?

- Often We Need to Remove Material to Finish a Part

- Various Processes
  - Lathes
  - Milling
  - Drilling
  - Others

- Key Principles
  - Power and Energy Consumption
  - Tool Life and Productivity

Outline

- Key Principles

- Machining Processes

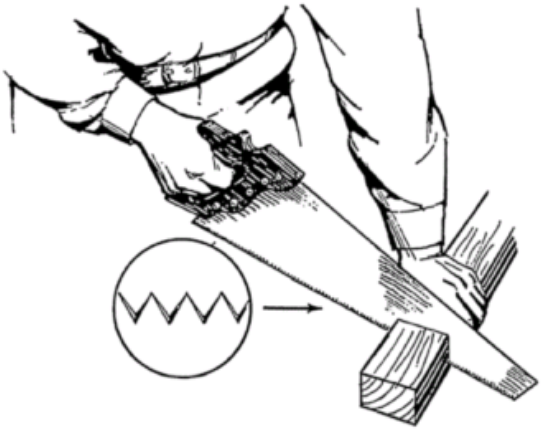
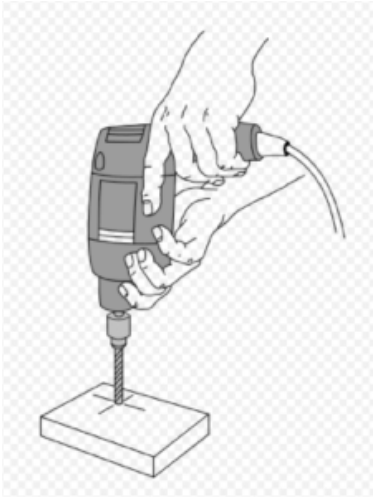
- Reference (Pictures)
  - Kalpakian S.: Manufacturing Engineering and Technology; Addison Wesley, © 1995
  - W. R. Riffe

Concept Question

- Write a Working Definition of Machining
- Apply this to the Processes to Be Discussed this Class Session
  - What Are They ?
  - How Are They Similar ?
  - How Are They Different ?

Sawing and Drilling

- Common Experience
  - Fix Work Piece and Move Tool

Sawing	Drilling
	
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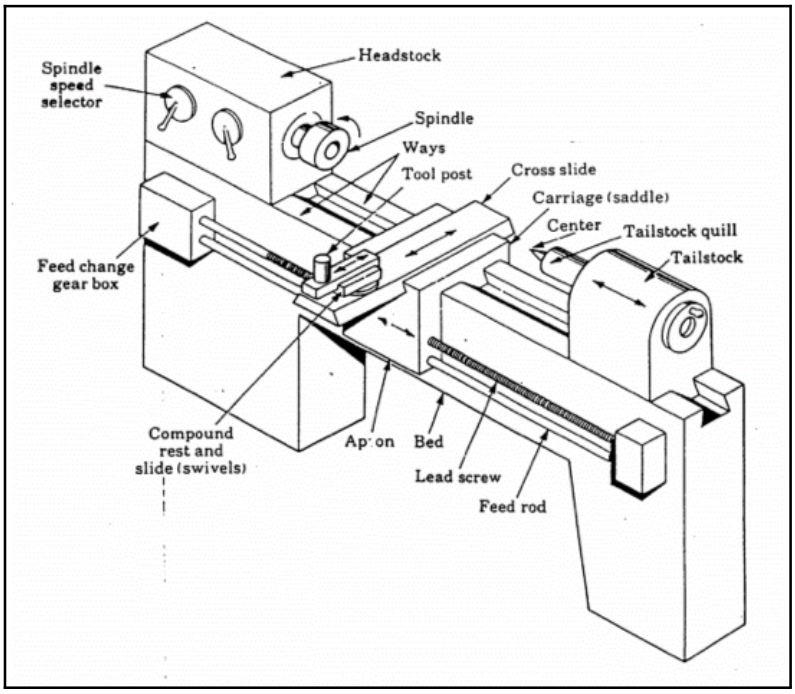
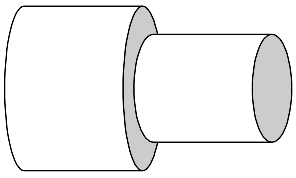
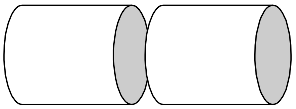
The Lathe

- Rotate Workpiece
  - Use Tools to Remove Material
  - Turning
  - Parting
  - Facing
  - Drilling
  - Boring

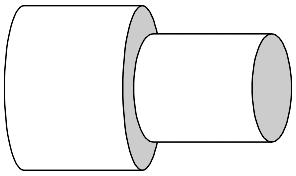


Lathe Operations

Turning	Parting	Facing
Remove Material From Surface	Separate Material	Remove Material From Face
		

Material Removal Rate

- Need to Calculate
  - Cutting Speed
  - Material Removal Rate
- Not Simply rpm (N)



Cutting Speed (V)	Material RR (Q)
$V = N\pi D$ D = Diameter	$Q = Vdf_r$ d = Depth of Cut f_r = feed rate (length /rev)

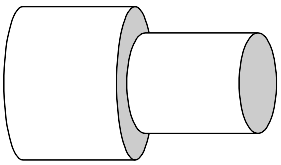
Energy Requirements

- Material Removal Requires Energy
  - Specific Energy (U) = Energy/Volume

$$P = UQ$$

Material	U (J/mm^3)
Al Alloys	0.4-1.1
Cu Alloys	1.4-3.3
Steel	2.7-9.3
Stainless Steel	3.0-5.2
Ni Alloys	4.9-6.8

Team Problem



- How Much Power is Required For the Following Operation on an Aluminum Part?
  - Operating Speed 800 rpm
  - Original Diameter 25mm
  - Depth of Cut 0.3mm
  - Feed Rate 1.5×10^{-3} mm/rev

- Determine Cutting Speed (V)

$$V = N\pi D$$

$$= \left(13.3\frac{rev}{s}\right)\pi(25mm)$$

$$= 1.0 \times 10^3 \frac{mm\ rev}{s}$$

- Determine Material Removal Rate (Q)

$$Q = Vdf_r$$

$$= \left(1.0 \times 10^3 \frac{mm\ rev}{s}\right)(3mm)\left(0.25\frac{mm}{rev}\right)$$

$$= 785\frac{mm^3}{s}$$

- Determine Required Power (P)

$$P = UQ$$

$$= \left(0.7\frac{J}{mm^3}\right)\left(785\frac{mm^3}{s}\right)$$

$$= 550W$$

Tooling

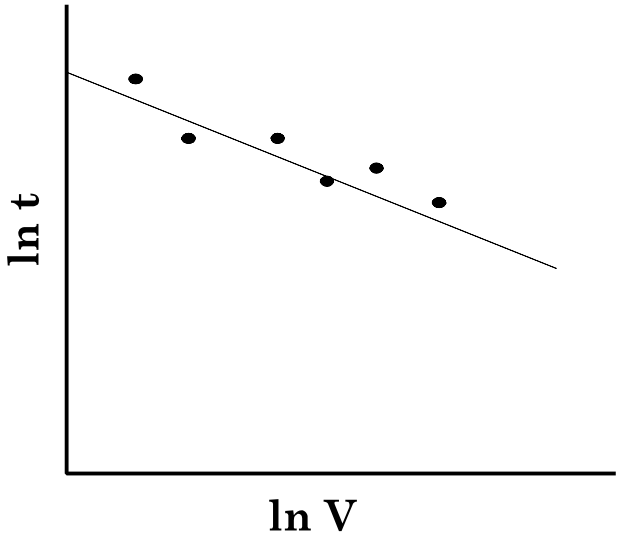
- Tools Usually Made From Hard Materials
  - High Speed Steel
  - Cemented Carbides
  - Ceramics

Material	Cost	Cut Speed	Wear
High Speed Steel	Low	Low	Poor
Cemented Carbide	Moderate	Moderate	Fair
Ceramics	High	High	Good

Tool Life

- Tools Will Wear Out
  - Taylor Equation

$$Vt^n = C$$



$$\ln t = \frac{1}{n}\ln C - \frac{1}{n}\ln V$$

Team Problem

- The Tool Has a Part Life of 8 hrs
  - If I Double the rpm the Part Life becomes 2 hrs
  - What if I Only Increase the rpm by 50%

- Importance of C

$$Vt^n = C$$

$$V_1 t_1^n = V_2 t_2^n$$

$$\left(\frac{t_1}{t_2}\right)^n = \frac{V_2}{V_1}$$

$$n = \ln\left[\frac{\frac{V_2}{V_1}}{\frac{t_1}{t_2}}\right] = \ln\left(\frac{2}{4}\right) = 0.7$$

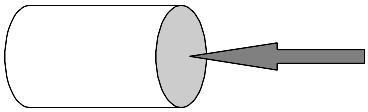
- Why Calculation of C is Not Required

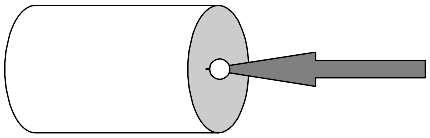
$$\left(\frac{t_1}{t_2}\right) = \sqrt[n]{\frac{V_2}{V_1}} = \sqrt[0.7]{1.5} = 1.8$$

- time = 4.4 hrs
  - So Doubling RPM Reduces Part Life from 8 hrs to 2 hrs
  - Raising RPM to 1.5x Original Reduces Part Life from 8 hrs to 4.4 hrs.

Drilling and Boring

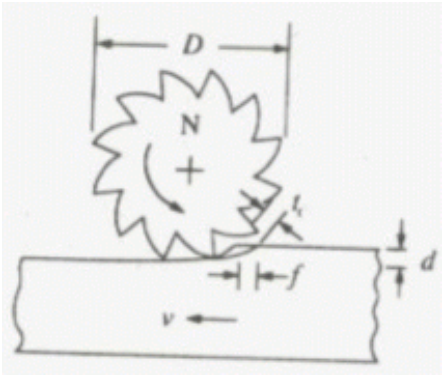
- Rotate Work Piece and Make Hole
  - Drilling - Make Hole
  - Boring - Expand Hole





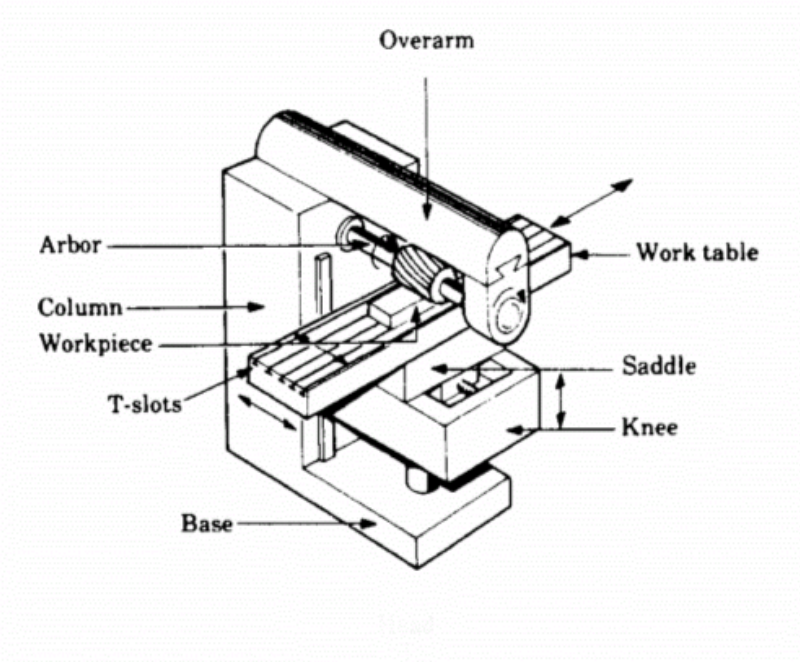
Milling

- One of the Most Widely Used Processes
  - Rotating Tool
  - Moving Tool or Workpiece
- Can Be Used to
  - Flatten Edge
  - Flatten Face
  - Cut Slit
- Milling Machines Often Have Other Features
  - Combined With Drills / Lathes



Horizontal Milling

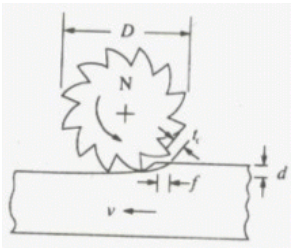
- Slab Milling Shown
  - Rotating Tool
  - Moving Work Piece
- Process
  - Depth of Cut (?)
  - Productivity

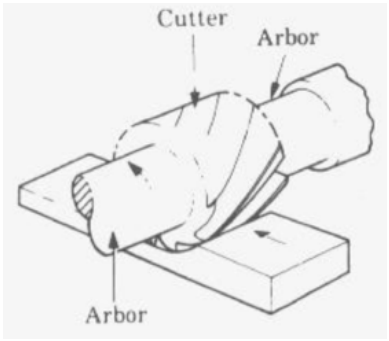
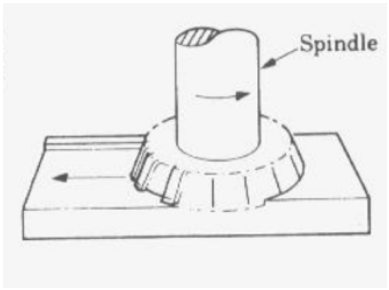
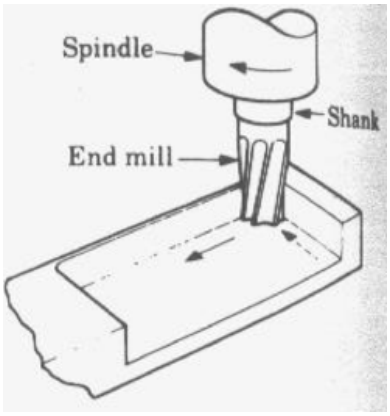


Ref. W. Riffe Slides

Basic Milling Operations

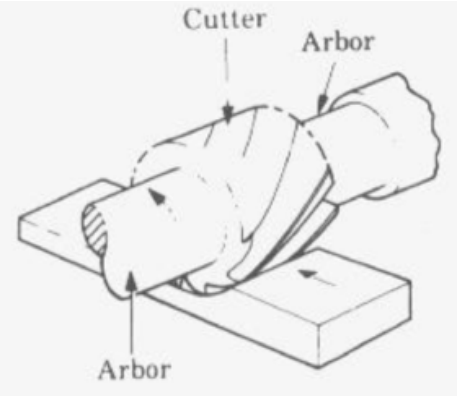
- Three Forms
  - Same Basic Principle



Slab Milling	Face Milling	End Milling
		

Milling Productivity

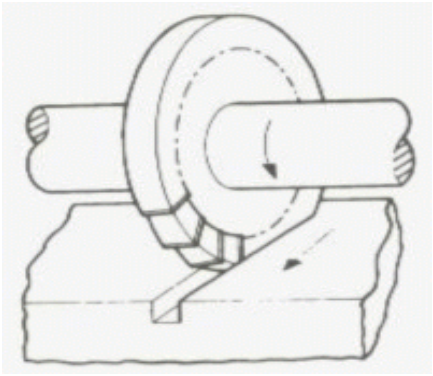
- Same Basic Parameters as Lathes
  - Cutting Speed (V)
  - Material Removal Rate (Q)
  - Power (P)
  - rpm (N)
  - Depth of Cut (d)
- Other Parameters
  - width of piece (w)
  - work piece velocity (v)



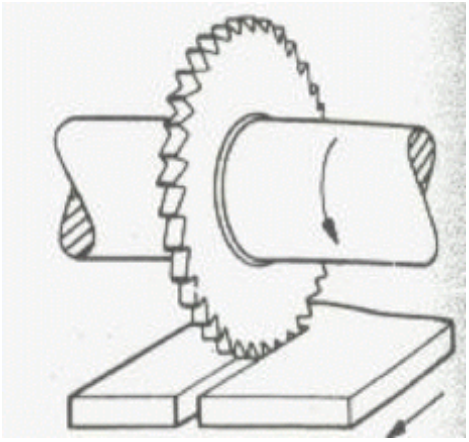
Cutting Speed	Material RR	Power
$V = \pi DN$	$Q = wdv$	$P = UQ$

Specialized Milling Processes

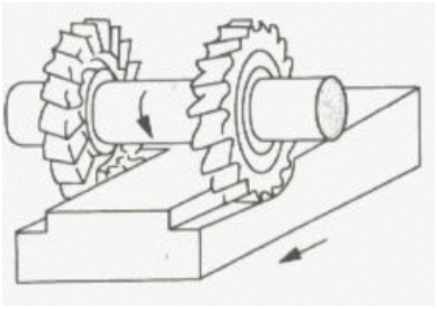
Slotting



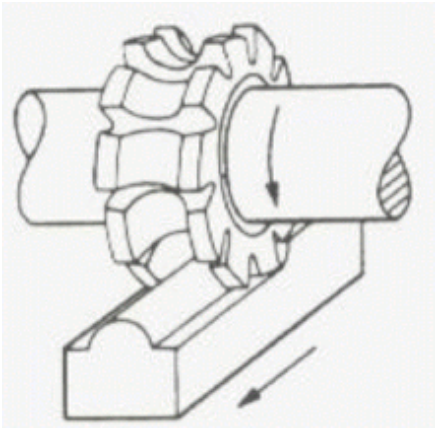
Slitting



Straddle Milling

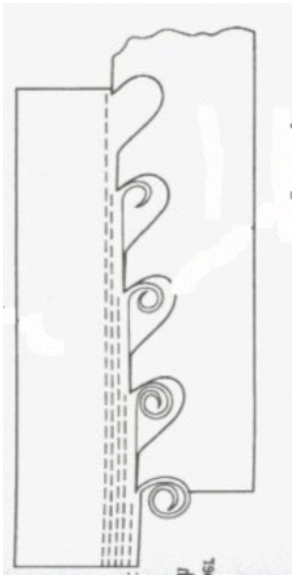


Form Milling



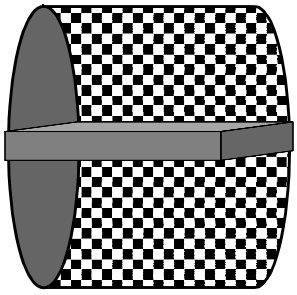
Team Problem
When Would You Use Each Milling Process in Manufacturing?

Broaching



- Milling and Lathes Are Not Always Practical
  - Internal Holes
  - Irregular Holes
  - Irregular Surfaces
- Broaching Tool
  - Successively Larger Teeth
  - Horizontal or Vertical

Grinding



- Abrasive Wheel Against Workpiece
  - High Tolerances
  - Surface Finish
- Abrasive
  - Grit Size
  - Hard Soft
- Safety
  - Hands / Eyes
  - Broken Wheels
- Same Productivity Terms

Advanced Machining Techniques

- Waterjet
  - High Pressure Water
  - Abrasive Water Jet
- Laser Beam
  - Very Precise
  - Expensive
  - Melt Material
- Electrochemical
  - Utilize a Chemical Reaction

Summary

- Machining Techniques
  - Sawing
  - Drilling
  - Lathes
  - Milling
  - Broaching
  - Grinding
  - Advanced
- Production / Cost Considerations
  - Material Removal Rate
  - Tool Life
  - Energy Costs