



INTRODUCTION TO PRODUCTION AND MANUFACTURING SYSTEMS

INDU 211

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Agenda

- Chapter 3 – Manufacturing Engineering

Manufacturing Engineering

- Designing the production process for a product
 - Everything related to the *process* of making a product, such as:
 - Evaluating the manufacturability of the product
 - Process selection and parameters
 - Cutting tool material, size, and shape
 - Cutting speed
 - Depth of cut
 - Designing work-holding devices (jigs and fixtures)
 - To control and secure the position of the work piece
 - Cost estimation
 - Quality of the part produced

Product - Production Design Interaction

- Product design: develop and evaluate the ability of the part to perform its function
 - Size, shape, strength, etc. using knowledge of physics, strength of material, etc.
- Manufacturing engineering: develop and evaluate the cost of producing the parts
 - Limitation and cost of various alternatives
- Interaction between product designers and manufacturing engineer from the very beginning
 - Designer opts for tight tolerances → high processing cost
 - The manufacturing engineer opts for the largest possible tolerance

Product - Production Design Interaction

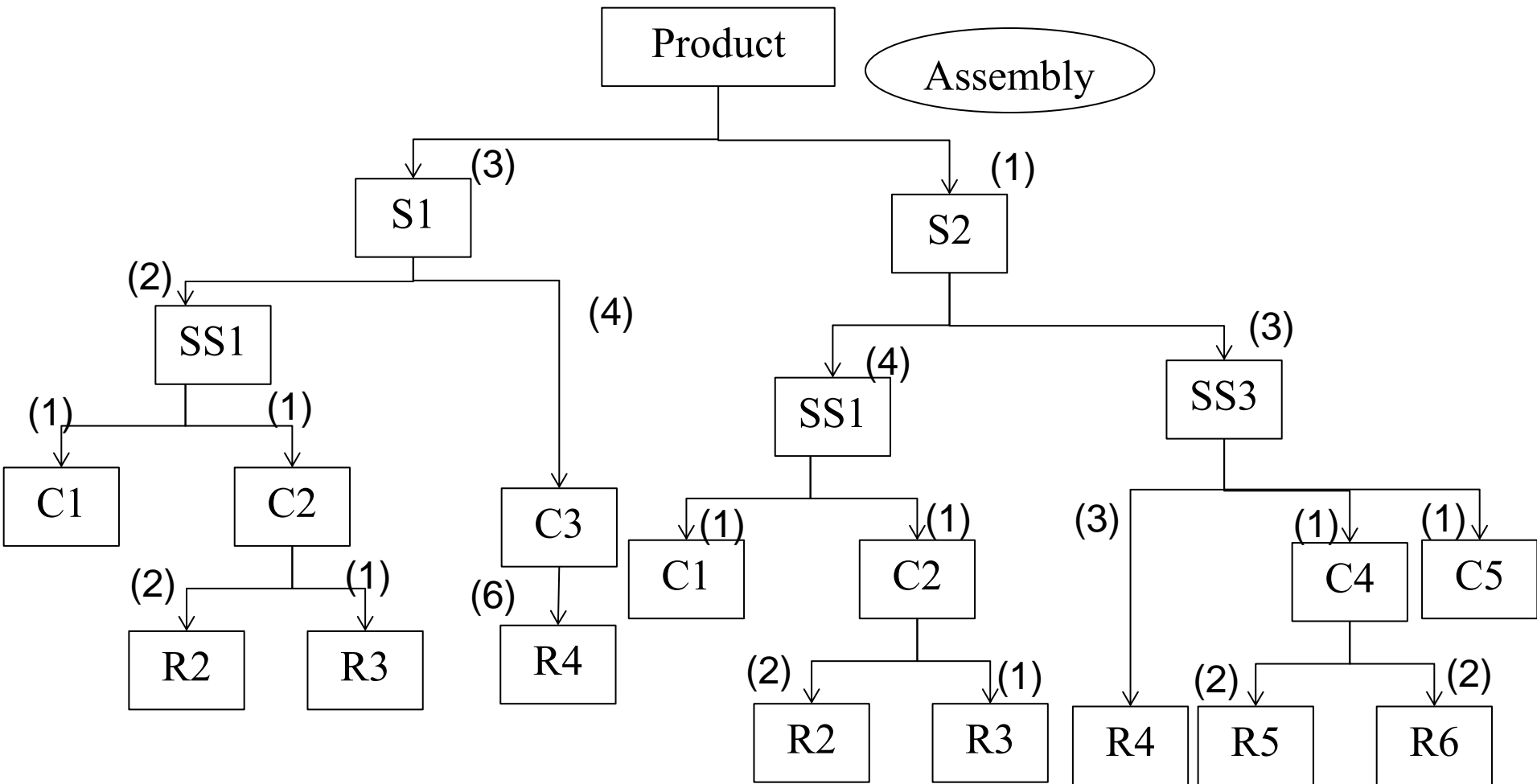
- Concurrent (simultaneous) Engineering:
 - All elements of a product's life-cycle, from functionality, producibility, assembly, testability, maintenance issues, environmental impact and finally disposal and recycling, should be taken into careful consideration in the early design phases
 - Functions of design engineering and manufacturing engineering (and other functions) are integrated to reduce the elapsed time required to bring a new product to the market
 - The integration of key functions at the outset of a process in order to emphasize the simultaneous development of a product and its associated processes
 - Has been applied most notably in the aerospace industry

Process Engineering

- Design of the actual process to be used in the manufacture of the product
- Defining product structure and specifications
- Component manufacturability available processes
- Evaluating the cost of each alternative process
- Operations sequence
- Documentation

Product structure and specifications

- Bill of material



BOM

BILL OF MATERIAL			
<i>Product Description:</i> Bookcase, metal, 3 shelves. <i>Stock Number:</i> 1			
Component		Quantity (Amount) Required	Source
Stock No.	Description		
3	Shelf	3	Manufacturing
4	Leg	4	Manufacturing
5	Inserts	8	Purchasing
6	Screws	12	Purchasing

BILL OF MATERIAL			
<i>Product Description:</i> Shelf <i>Stock Number:</i> 3			
Component		Quantity (Amount) Required	Source
Stock No.	Description		
8	Sheet metal	3 square feet	Purchasing

BILL OF MATERIAL			
<i>Product Description:</i> Leg <i>Stock Number:</i> 4			
Component		Quantity (Amount) Required	Source
Stock No.	Description		
8	Sheet metal	2 square feet	Purchasing

Process Engineering

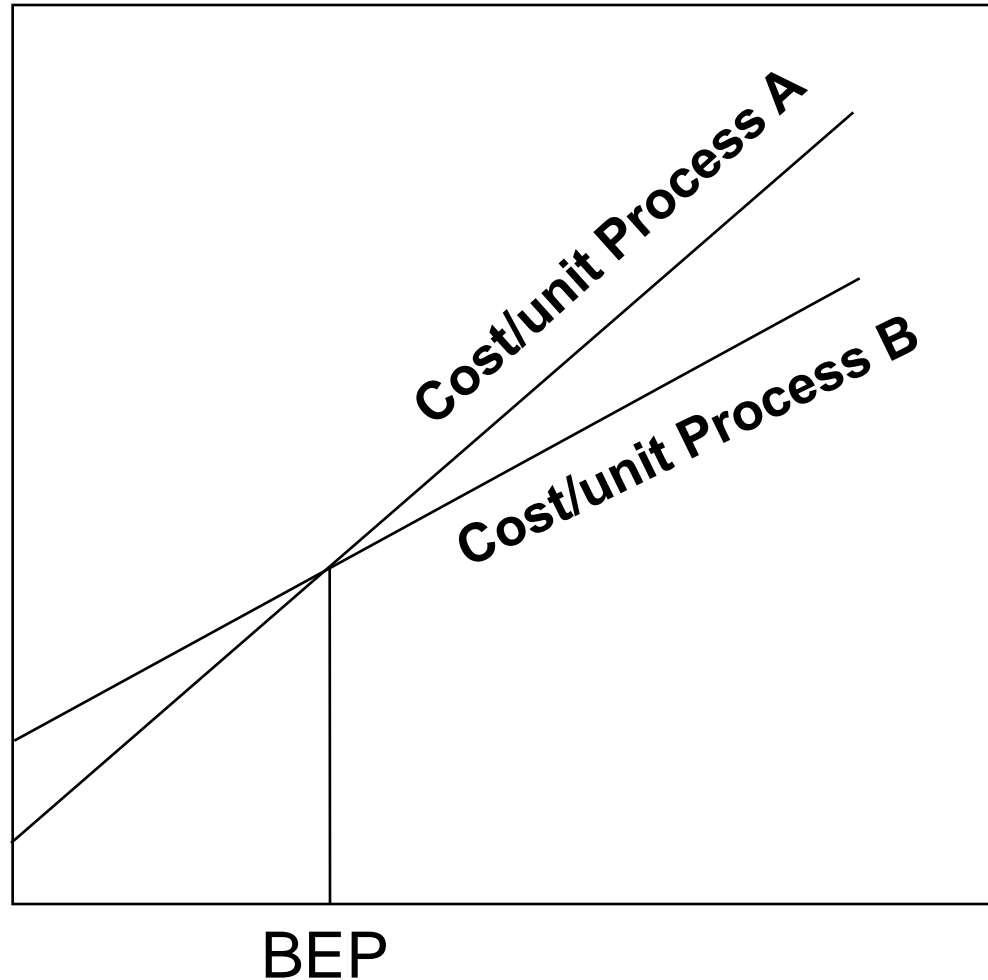
- Component manufacturability
 - Relative ease or difficulty of producing the component within tolerance
 - Tighter tolerances more expensive
 - Standardized features (e.g., size of a hole vs. commonly available drill size)
 - Commonly available material vs particular characteristics
- Available processes
 - List of candidate processes for each item
 - Compatibility of material
 - The ability to produce the desired tolerance
 - Part (re)design required to make it easy to produce

Evaluating the cost of each process

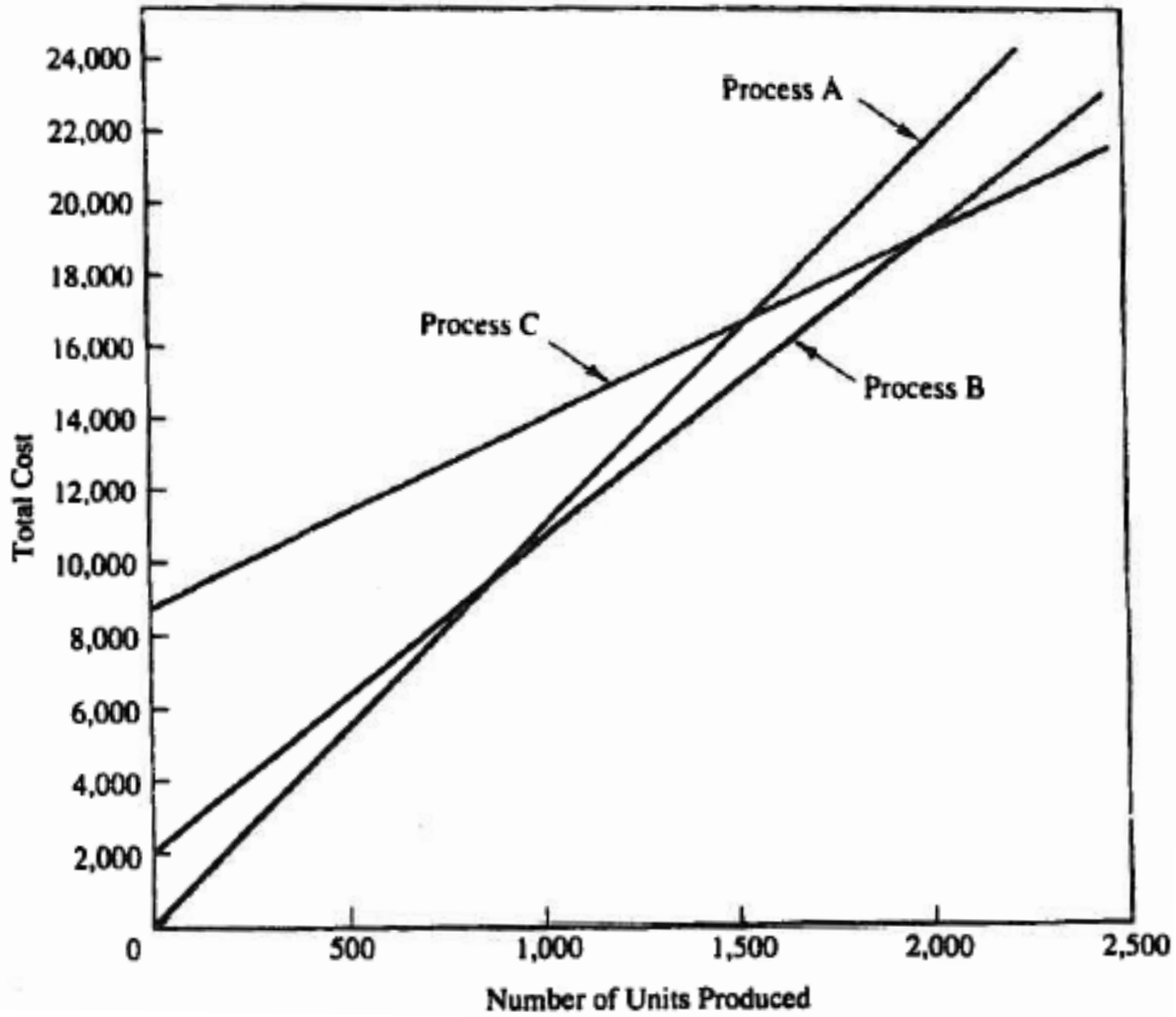
- Purchase of a machine
- Installation
- Jigs/Fixture
- Space occupied

Variable cost:
material,
labor, tools

Fixed Cost



BEP



Example

Process	Total Annual Fixed Costs	Variable cost per unit
A	\$110,000	\$2
B	\$80,000	\$4
C	\$75,000	\$5

- If projected annual demand is 10,000 units per year, which process should be selected?
- At what volume would each of these processes be preferred?

Solution

- a)
 - $TC(A) = \$130,000$
 - $TC(B) = \$120,000$
 - $TC(C) = \$125,000$
- b)
 - $BEP(BC) = 5,000$ units
 - $BEP(CA) = 15,000$ units

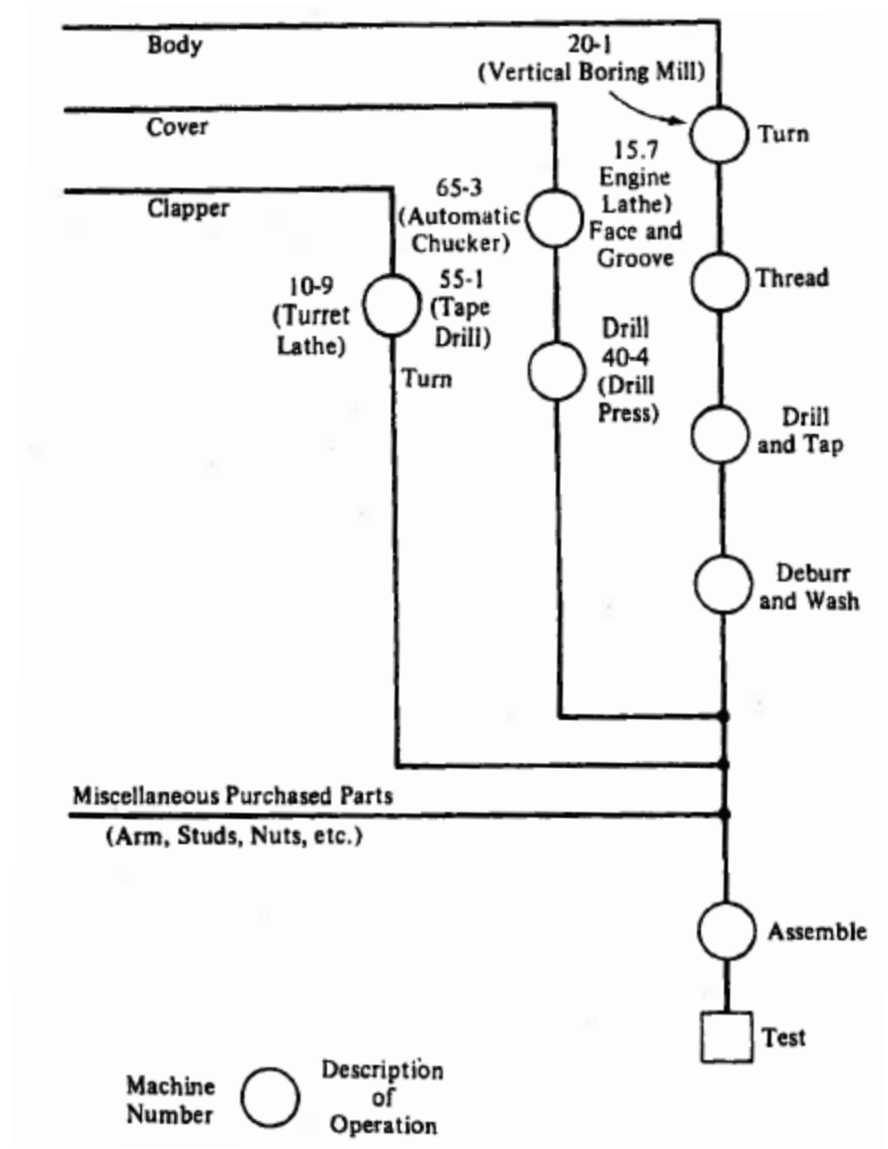
 - Between 0-5,000, choose C
 - Between 5,000-15,000, choose B
 - Above 15,000, choose A
 - At 15,000, either A or B

Determining the sequence of operations

- Minimization of material handling
 - Part is routed along the shortest path without backtracking
- No succeeding operation adversely affects previous operations
 - Leaving burrs, debris, scratches, etc.
- Performing as many operations on each machine as possible
 - Close tolerance is achieved and quality assured

Determining the sequence of operations

- Operations process chart



Industrial Processes

- Refining and Alloying
- Casting
- Metal Forming
- Metal Cutting
- Welding
- Assembly
- Finishing

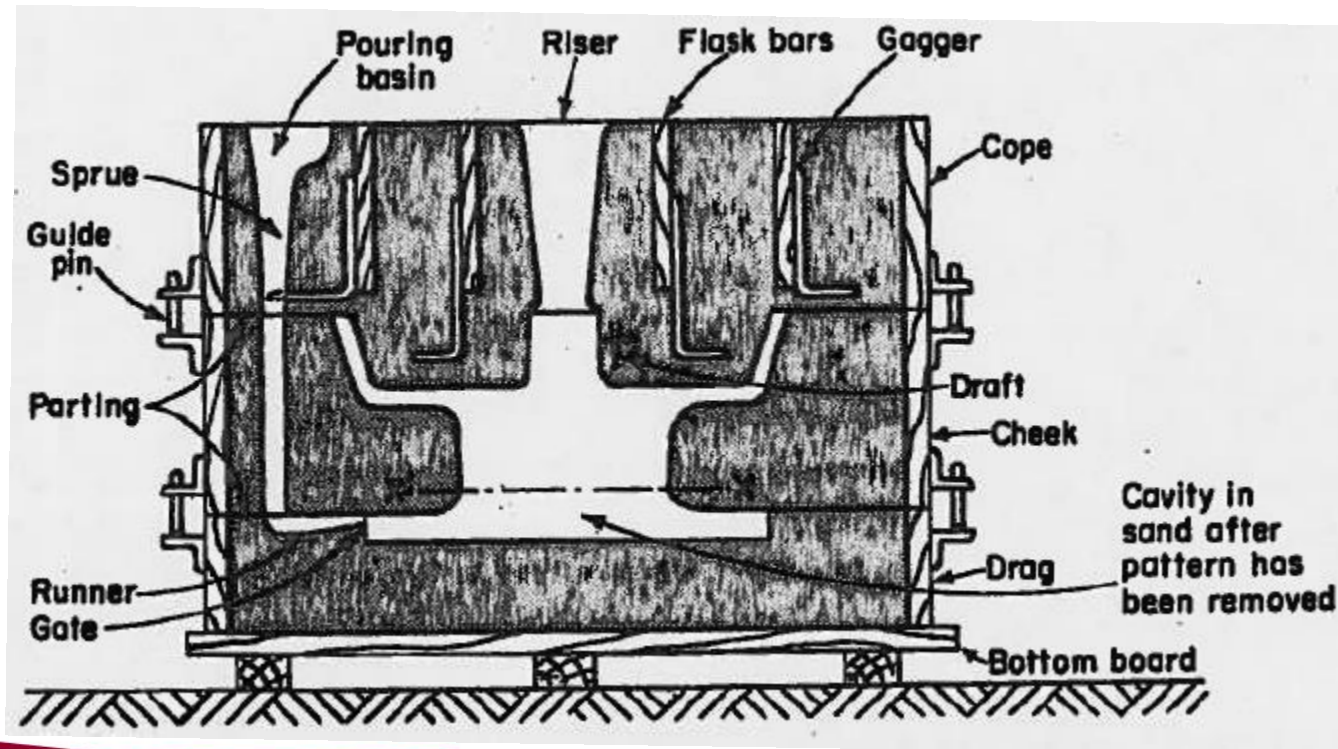
3D printing (Additive manufacturing)

Refining and Alloying

- Refining
 - Metal ore → improve its usefulness
 - Iron ore → steel
 - Blast furnace → Steel mill (open hearth, basic oxygen, electric furnace process)
 - Different types of steel depending on the temperature and chemical composition of the furnace
- Alloying
 - Metals from primary operations do not have the properties necessary for the specific design
 - Metallurgical transformation to improve the hardness, strength, workability, etc.
 - Heat treating
 - Combining metals (alloys)

Casting

- To obtain an approximate shape from a metal
- Forming objects by pouring liquid metal into a mold and allowing the metal to solidify
- Mold design is critical
- Sand casting → expensive for high production volume
- Permanente molds

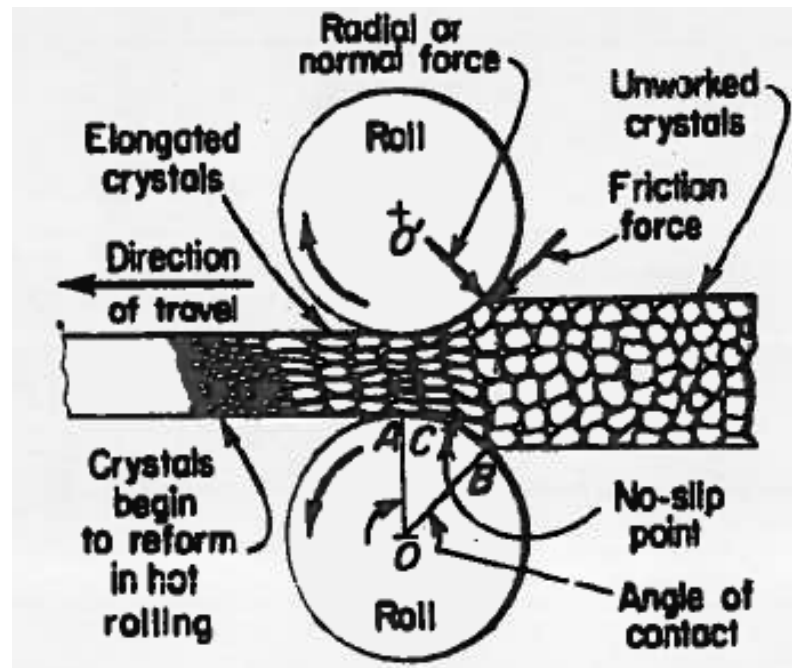


Metal forming

- The metal is worked under pressure to form a desired shape and/or to improve its physical properties (hot or cold)
- Hot working: temperature above crystallization → unusual shapes
- Cold working: hold close tolerance, good surface finish
- Rolling
- Wire drawing
- Forging
- Extrusion
- Bending
- Drawing and stretching

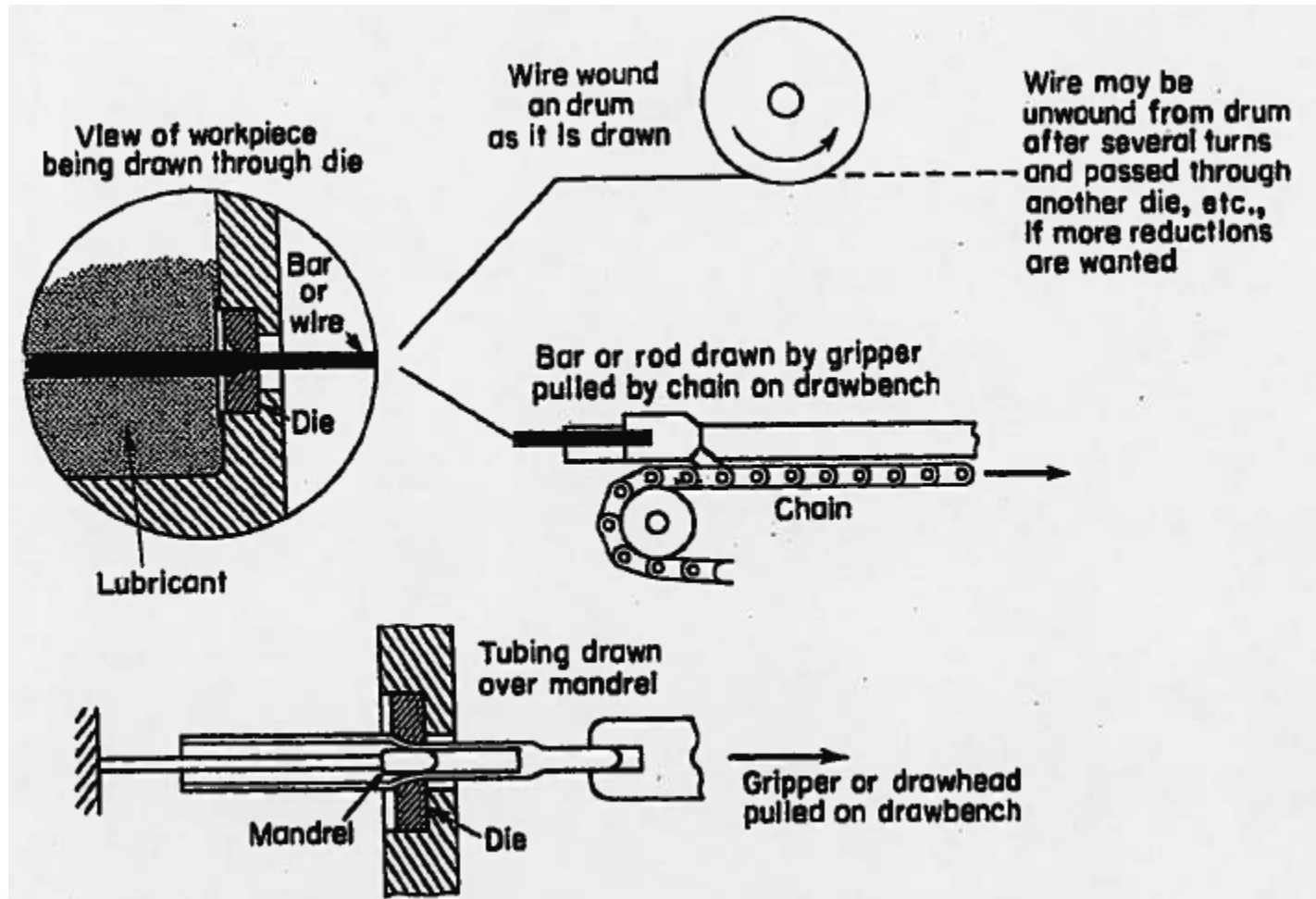
Rolling operation

Metal is elongated or widened



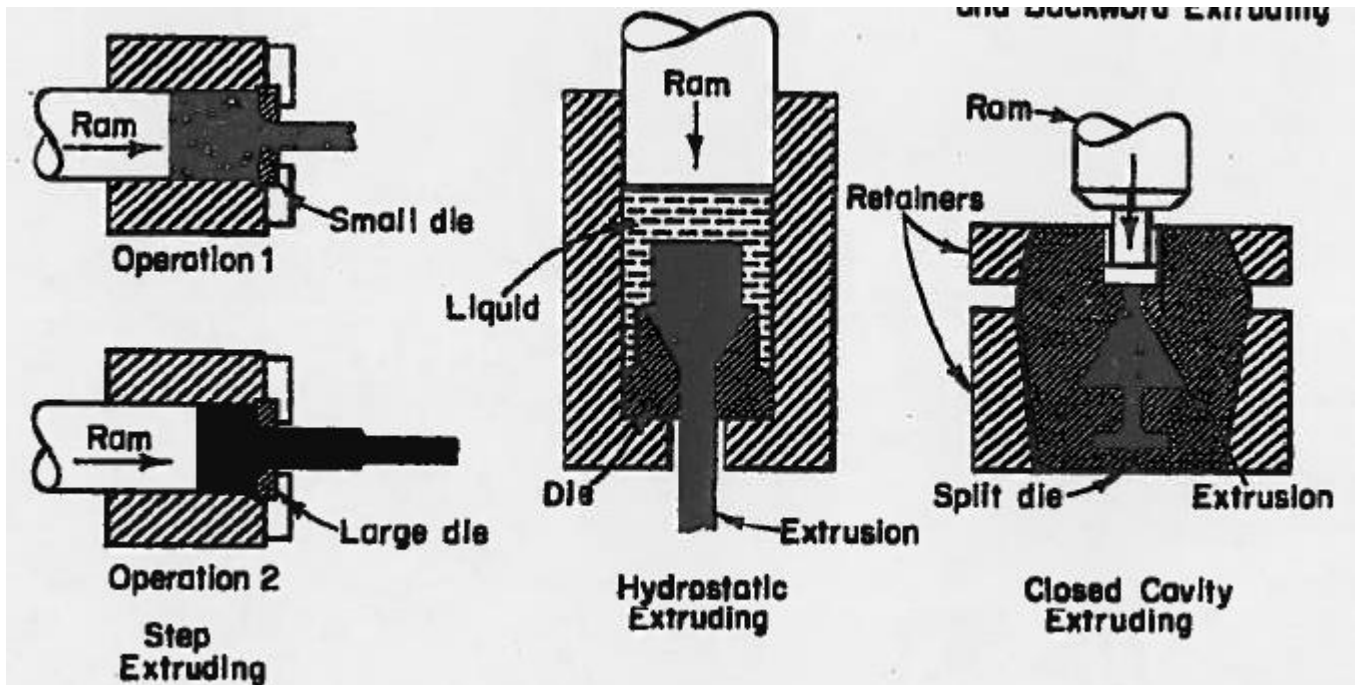
Wire drawing

Wire or rod is reduced in cross-sectional diameter by being drawn through a die



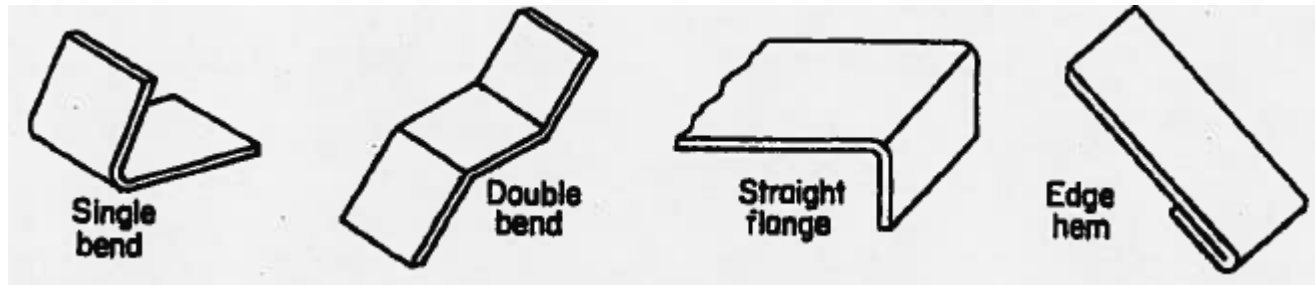
Metal forming

- Forging: a single or a series of intermittent applications of pressure (instead of continuous pressure)
 - Hammering of horseshoe
- Extrusion
 - Compressing a metal beyond its elastic limits and forcing it to flow through and to take on the shape of an opening

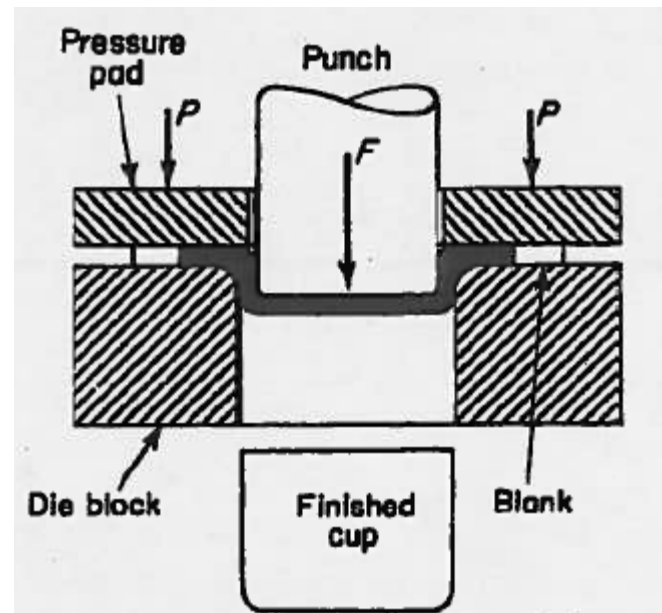


Metal forming

- Bending
 - Applying force to permanently distort the metal to the preconceived shape

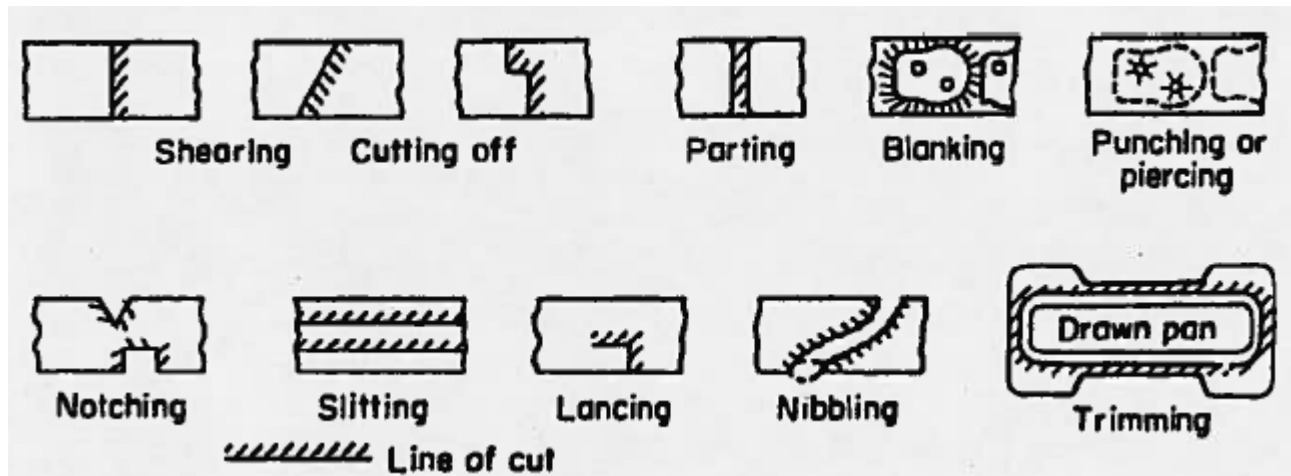


- Drawing and stretching
 - Produce seamless vessels by applying pressure and forcing the sheet metal to take on a shape



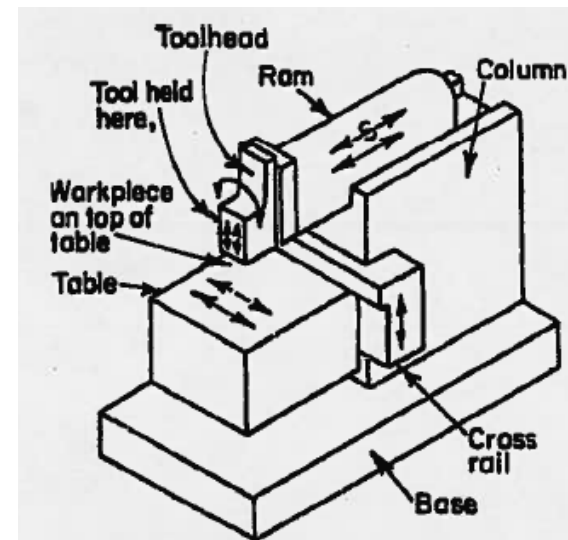
Metal cutting

- Shearing
 - Applying pressure and forcing the metal between two sharp edges
 - Blanking, parting, punching, nibbling, shearing along a straight line



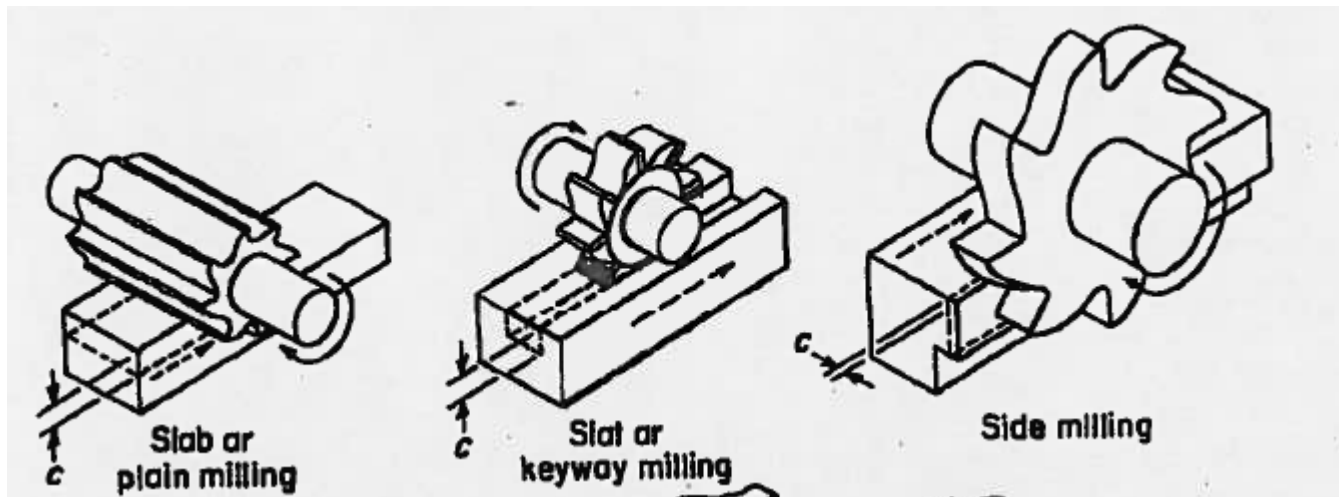
Metal cutting

- Turning
 - Rotating the workpiece and cutting metal by feeding a cutting tool
- Drilling
 - Opening, enlarging or finishing a hole
- Shaping and planing
 - Surfaces are cut by a reciprocating action
 - Shaping: the workpiece is stationary and the tool reciprocates
 - Planing: the tool is stationary



Metal cutting

- Milling
 - A revolving cutting tool with a number of teeth takes intermittent, successive cuts

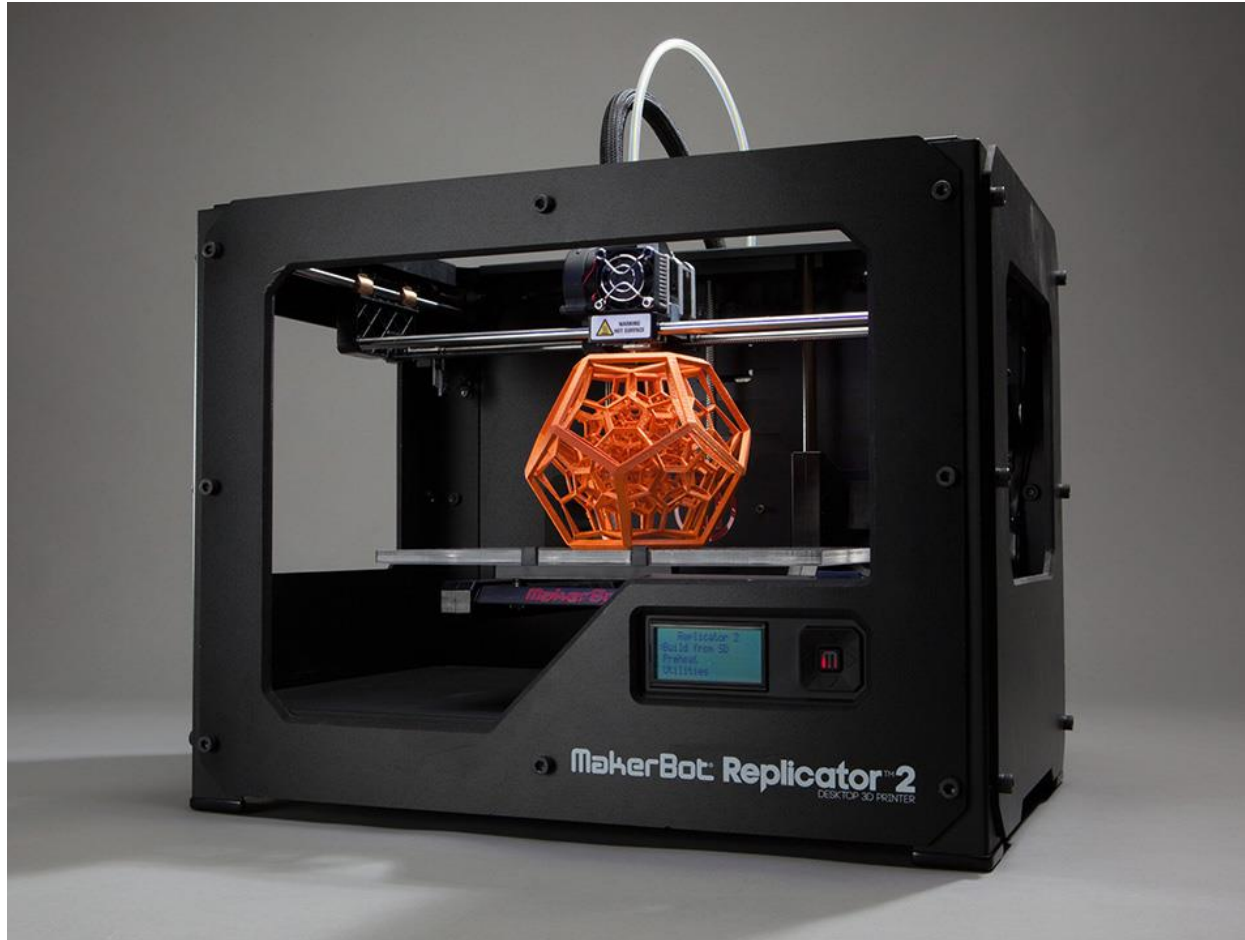


- Broaching (similar to milling- cutting tool is not revolved; it is pushed or pulled)
- Sawing-Filling
- Grinding (removal of metal in small pieces to improve surface finishes on very hard metal)

Welding

- Two pieces of the same metal are made to bond through the application of heat or pressure or both
 - Electric arc
 - Resistance welding
 - Beam welding
 - Thermit welding
 - Pressure welding
 - Gas welding
 - Brazing and soldering

3D printer



Ancillary Functions

- Tool, jig and fixture design
- Cost estimating
 - Material
 - Labor
 - Overhead (indirect costs)
- Maintenance systems design
 - Preventive maintenance for exceptionally important machines
 - Emergency maintenance (for machines that occasionally break)
- Packaging systems
 - To protect the final product during transit against damage
 - Various design options with their cost

Tool design considerations

Tool design for the most effective operation

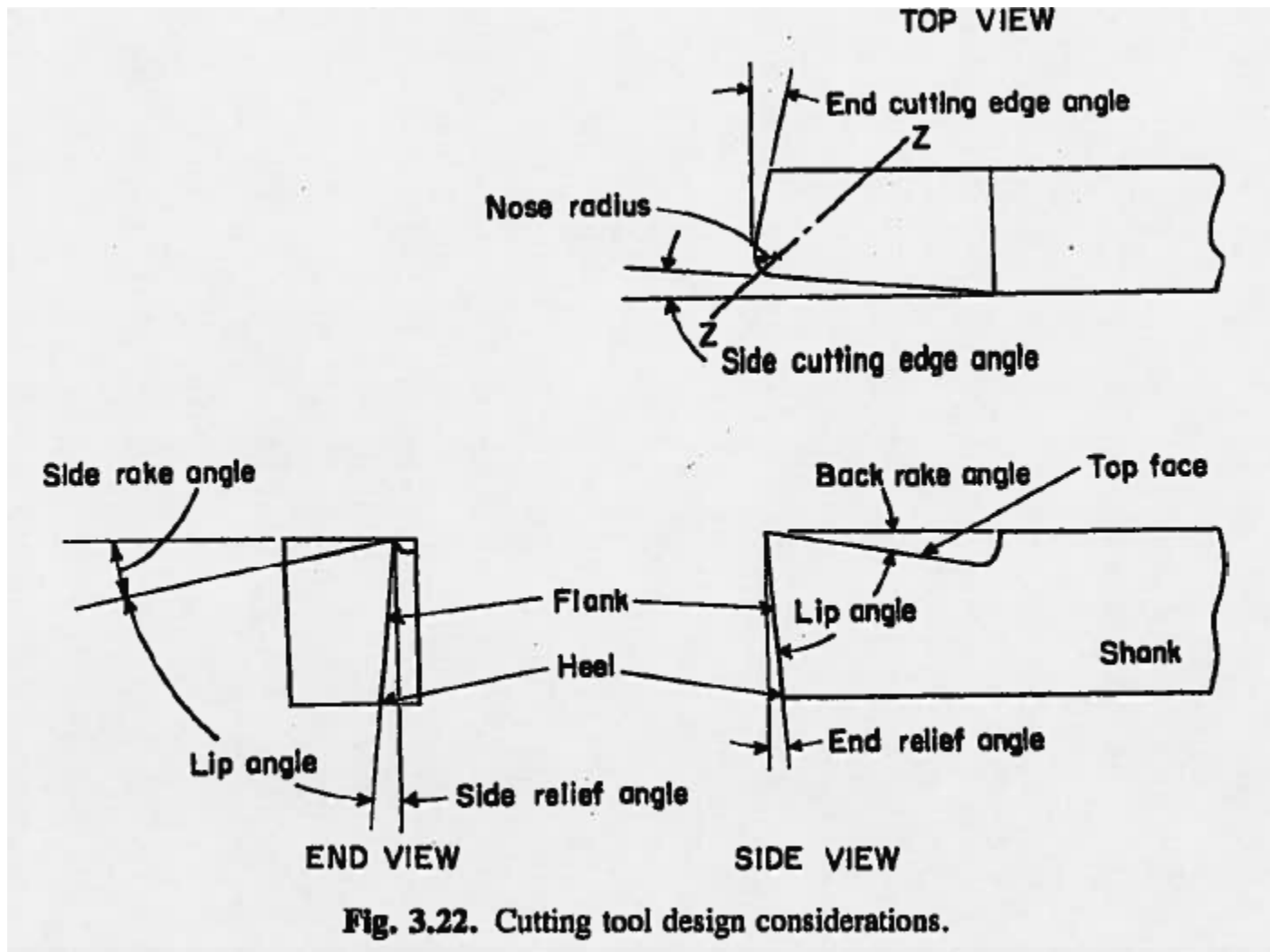


Fig. 3.22. Cutting tool design considerations.

Jig and fixture design

- Fixture: a device used to hold and locate a workpiece

- Vise



- Jig: guides the tool into the workpiece

- Drilling jig



**THANK YOU FOR YOUR
ATTENTION**