Ch 2: Manufacturing Operations

Learning Objectives:

By the end of the lecture the student should be able to:

- Explain the difference between technological and economical definition of manufacturing.
- Properly classify manufacturing industry with respect to size, processes used, product produced.
- Outline and explain four main manufacturing operations for desecrate product production.
- Explain processing operations.
- Explain the relationship between product quantity and product variety.
- Explain the relationships between plant layout and type of production facility.
- Explain the relationships between product quantity/variety and type of production facility.

NOTE: Materials used to create this presentation were supplied from:

Lecture notes designed by 2008 Pearson Education Inc. Third Edition by Professor Mikell P. Groover

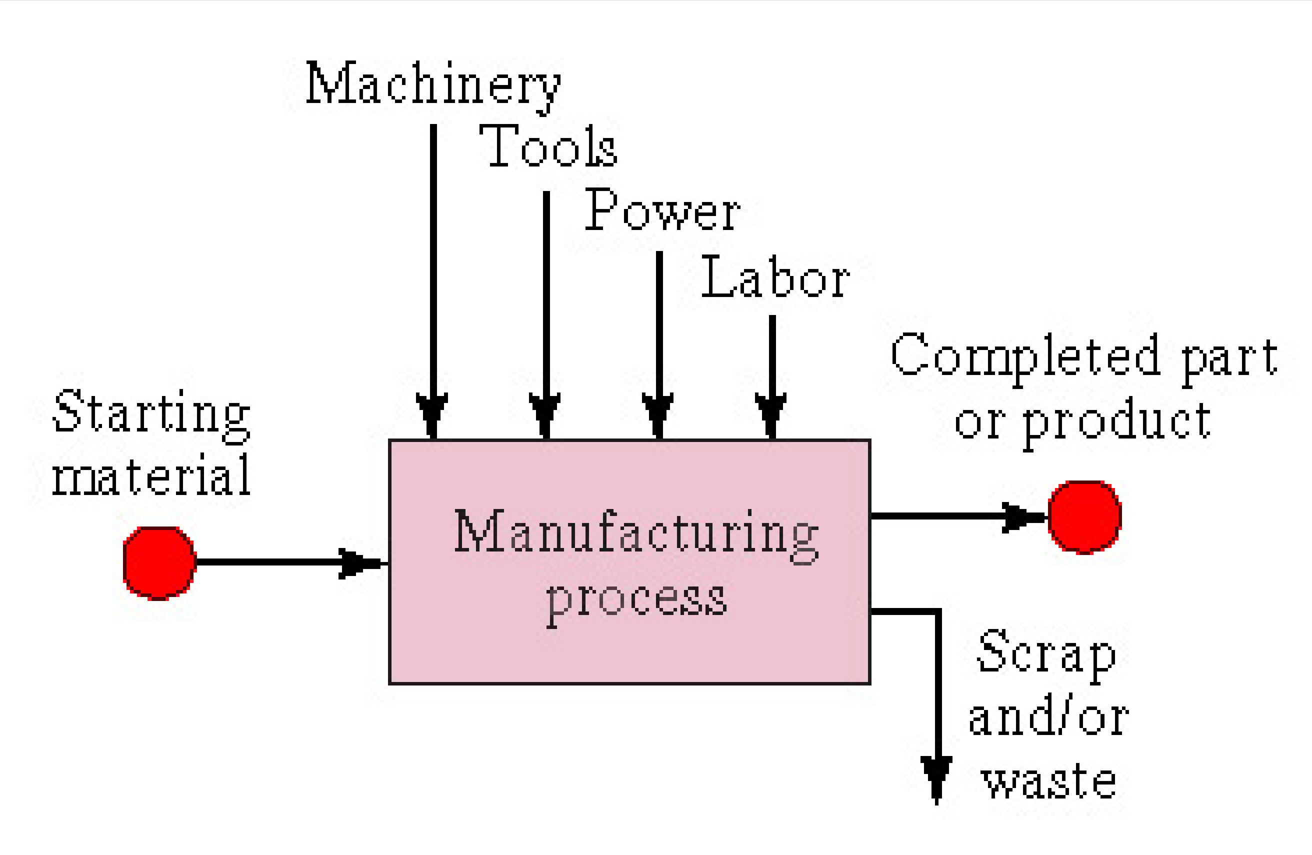
Lecture notes designed by Professor Darek Ceglarek, University of Wisconsin – Madison.

Manufacturing Operations - Technological Definition

Application of physical and chemical processes to alter the geometry, properties, and/or appearance of a given starting material to make parts or products

- Manufacturing also includes the joining of multiple parts to make assembled products
- Accomplished by a combination of machinery, tools, power, and manual labor.
- Almost always carried out as a sequence of operations

Manufacturing Technological Definition

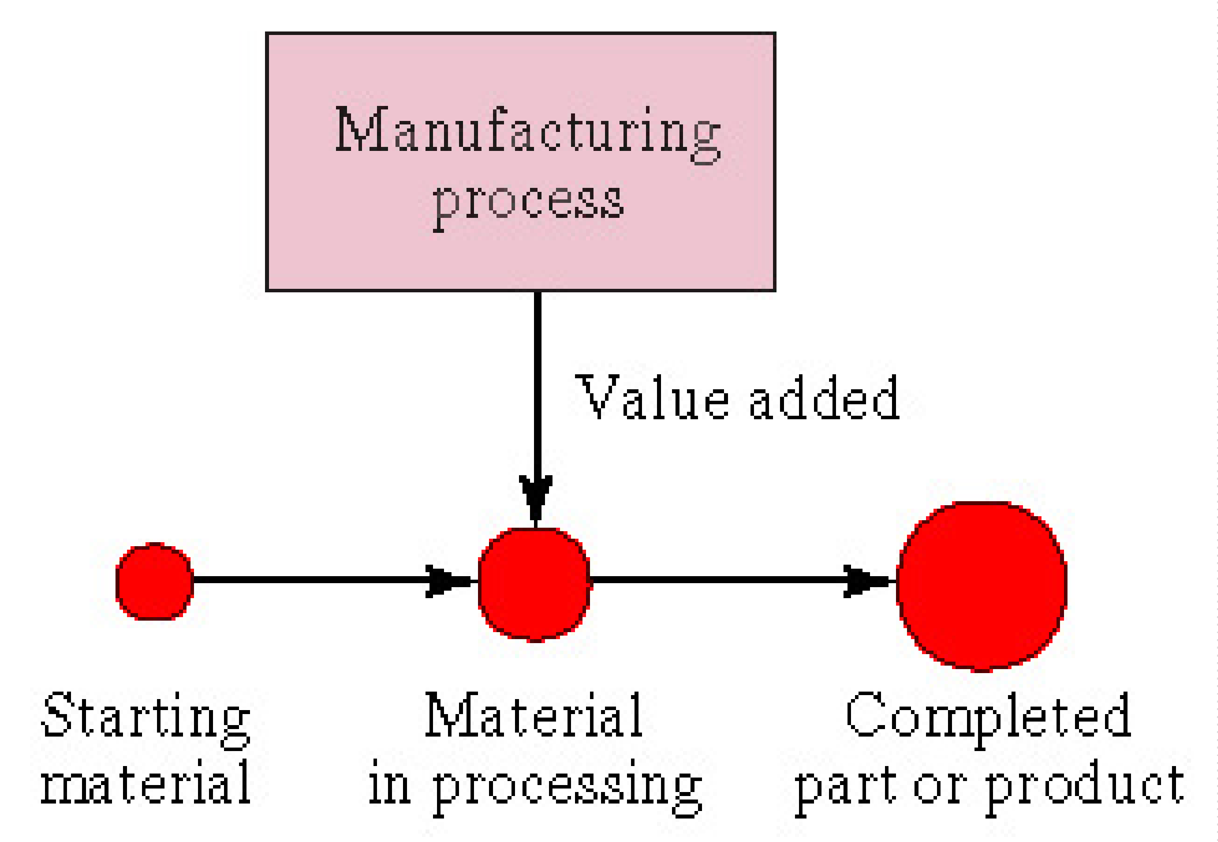


Manufacturing - Economic Definition

Transformation of materials into items of greater value by means of one or more processing and/or assembly operations

- Manufacturing *adds value* to the material
- Examples:
  - Converting iron ore to steel adds value
  - Transforming sand into glass adds value
  - Refining petroleum into plastic adds value

Manufacturing - Economic Definition



Classification of Industries

1. Primary industries – cultivate and exploit natural resources
   - Examples: agriculture, mining
2. Secondary industries – convert output of primary industries into products
   - Examples: manufacturing, power generation, construction
3. Tertiary industries – service sector
   - Examples: banking, education, government, legal services, retail trade, transportation

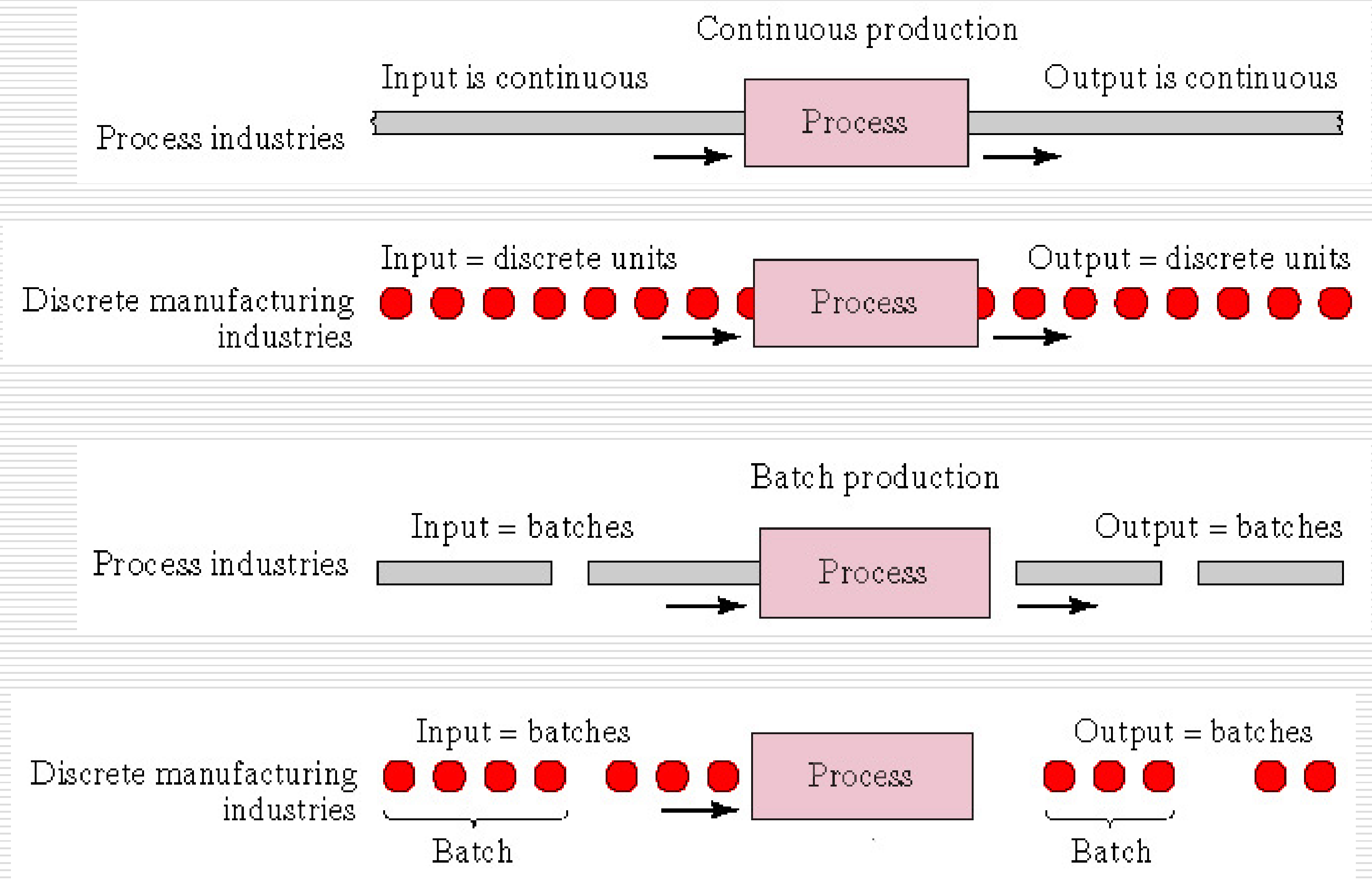
International Standard Industrial Classification (ISIC)

	ISIC Code
Food, beverages, tobacco	31
Textiles, apparel, leather and fur products	32
Wood and wood products, cork	33
Paper, printing, publishing, bookbinding	34
Chemicals, coal, petroleum, & their products	35
Ceramics, glass, mineral products	36
Basic metals, e.g., steel, aluminum	37
Fabricated products, e.g., cars, machines, etc.	38
Other products, e.g., jewelry, toys	39

More Industry Classifications

- Process industries, e.g., chemicals, petroleum, basic metals, foods and beverages, power generation
  - Continuous production
  - Batch production
- Discrete product (and part) industries, e.g., cars, aircraft, appliances, machinery, and their component parts
  - Continuous production
  - Batch production

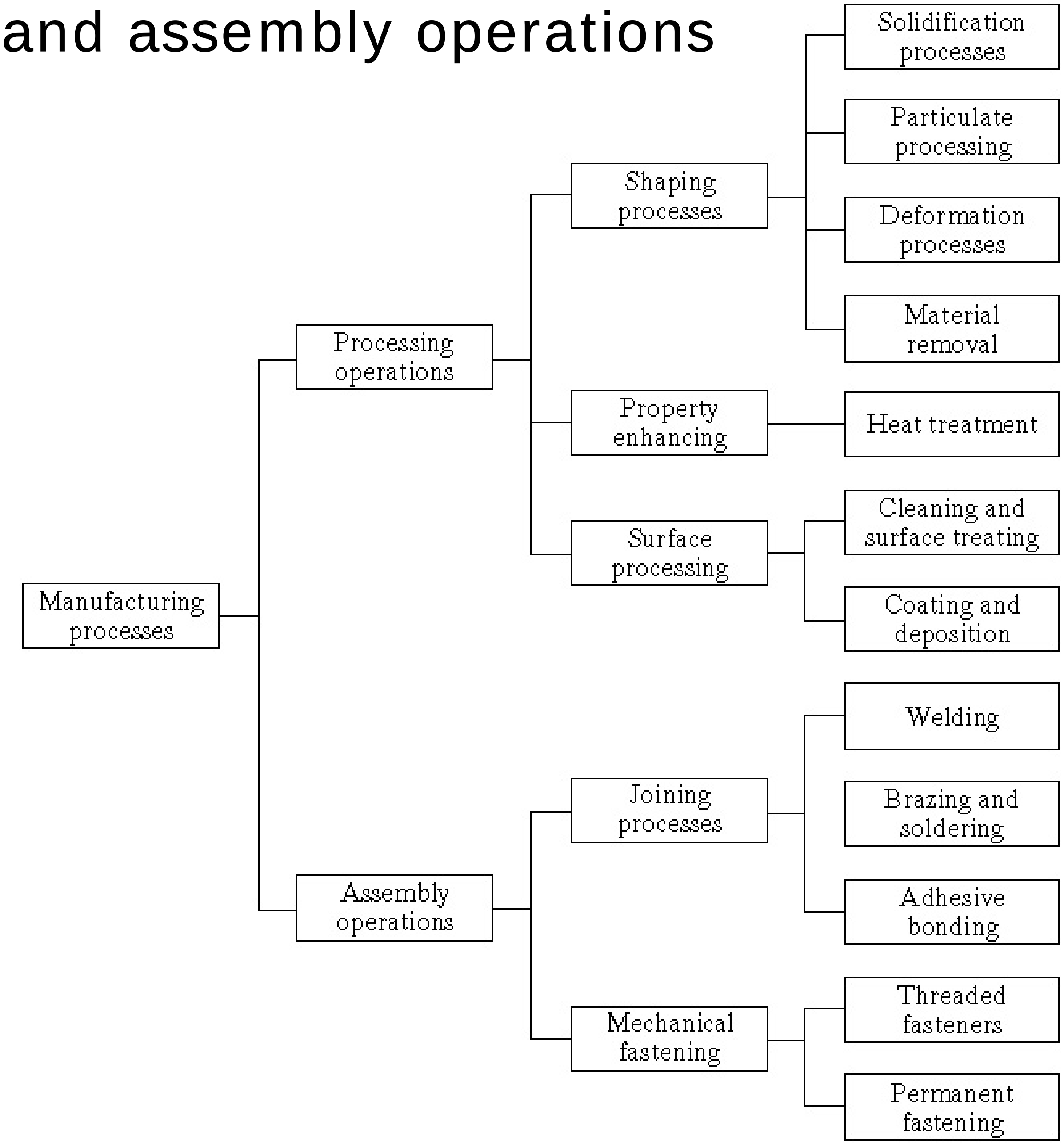
Process Industries and Discrete Manufacturing Industries



Manufacturing Operations

- There are certain basic activities that must be carried out in a factory to convert raw materials into finished products
- For discrete products:
  1. Processing and assembly operations
  2. Material handling
  3. Inspection and testing
  4. Coordination and control

1. Processing and assembly operations



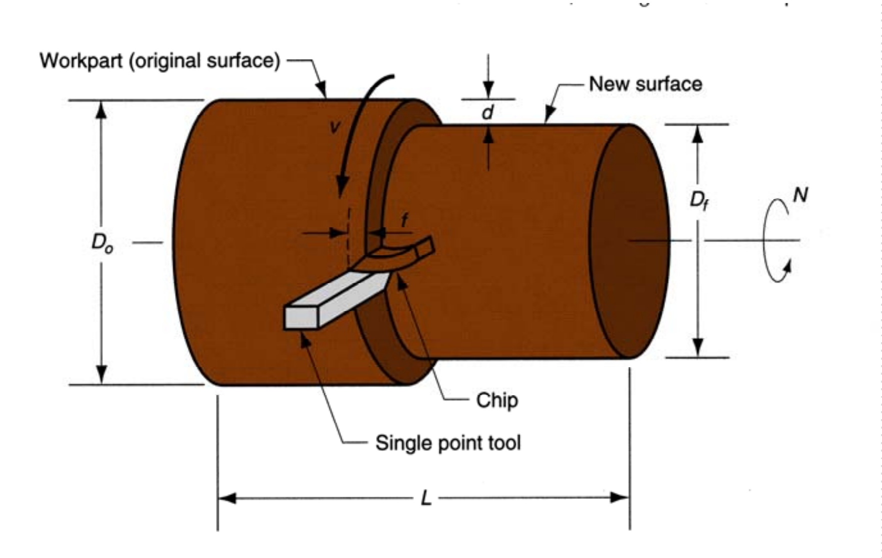
Processing Operations

- Shaping operations
  1. Solidification processes
  2. Particulate processing
  3. Deformation processes
  4. Material removal processes
- Property-enhancing operations (heat treatments)
- Surface processing operations
  - Cleaning and surface treatments
  - Coating and thin-film deposition

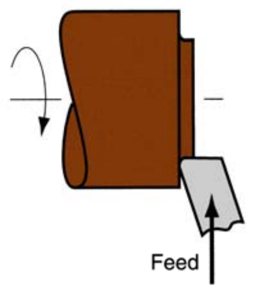
Material Removal Processes - Turning

A single point cutting tool removes material from a rotating workpiece to generate a cylindrical shape

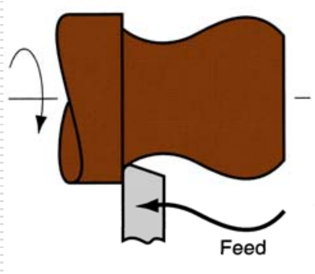
- Performed on a machine tool called a *lathe*
- Variations of turning that are performed on a lathe:
  - Facing
  - Contour turning
  - Chamfering
  - Cutoff
  - Threading



Turning Operations - Examples



(a)



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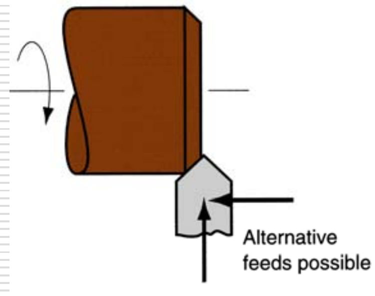

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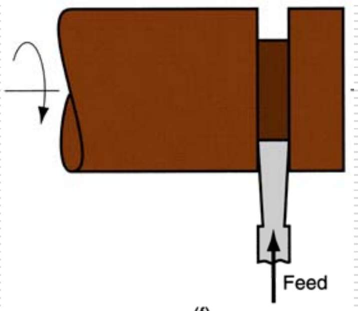

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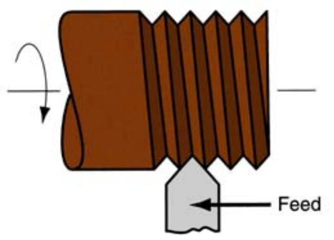


(g)

a) Facing
c) Contour turning
e) Chamfering
f) Cutoff
g) Threading

Cutting Tools and Inserts - Turning

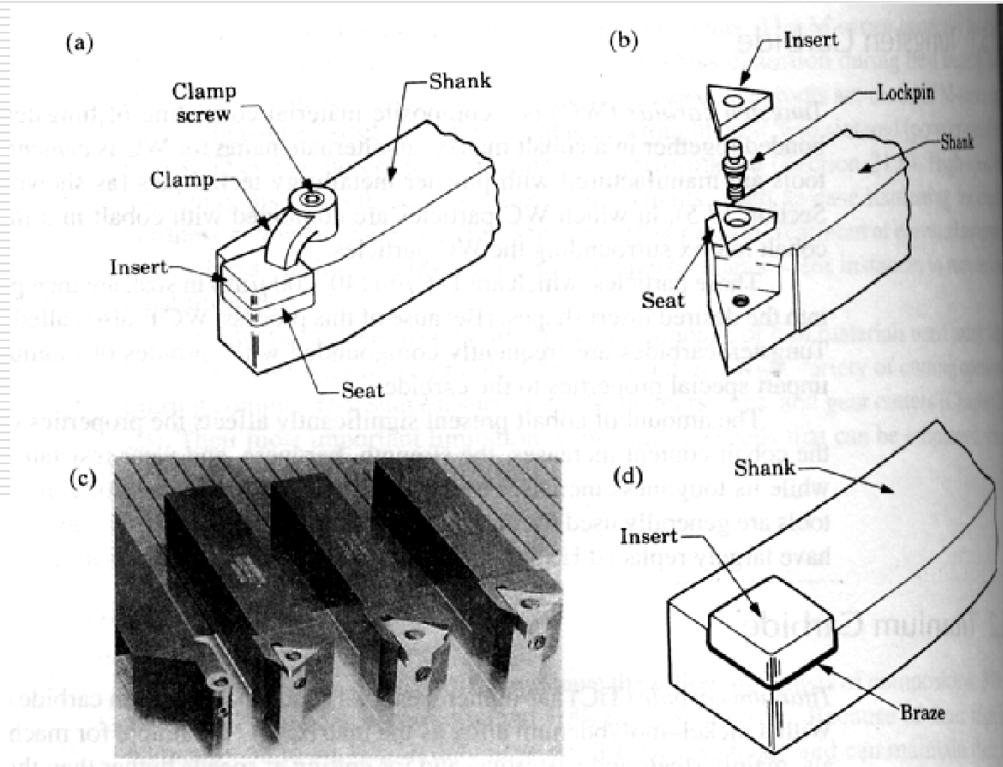
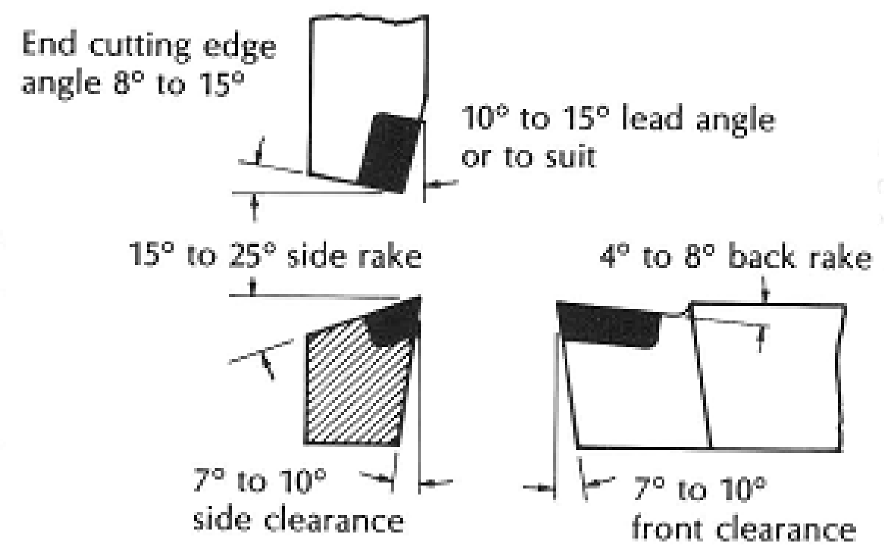


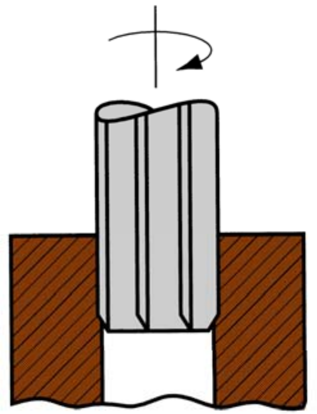
FIGURE 21.3 Methods of attaching inserts to toolholders: (a) Clamping, and (b) Wing lockpins. (c) Examples of inserts attached to toolholders with threade lockpins, which are secured with side screws. *Source*: Courtesy of Valenite. (d) Insert brazed on a tool shank (see Section 30.2).



Turning vs. Boring

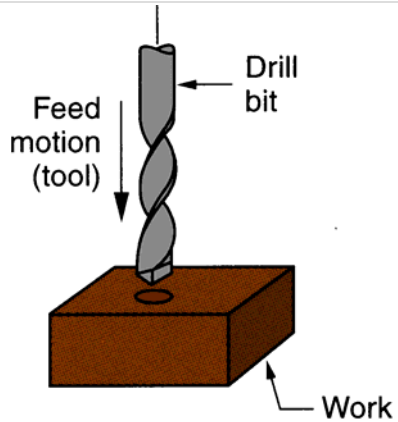
- Difference between boring and turning:
  - *Boring* is performed on the inside diameter of an existing hole
  - *Turning* is performed on the outside diameter of an existing cylinder
- In effect, boring is an internal turning operation

Reaming, Drilling, Tapping



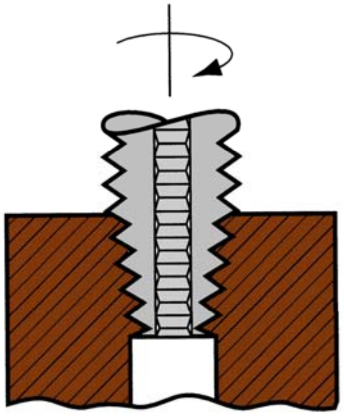
(a)

Reaming



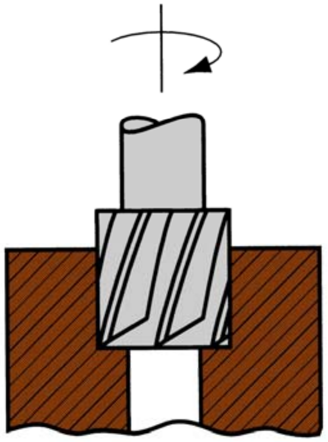
(b)

Drilling



(b)

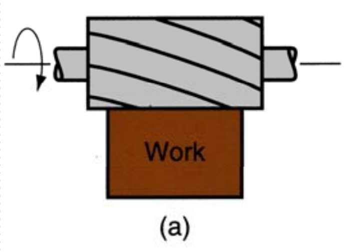
Tapping



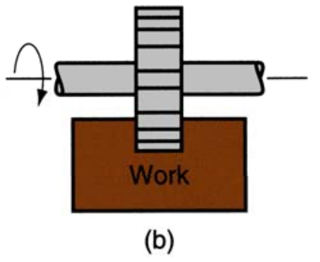
(c)

Counterboring

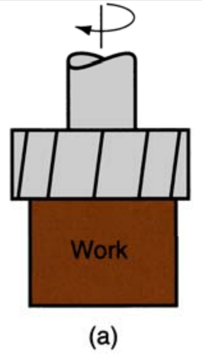
Milling



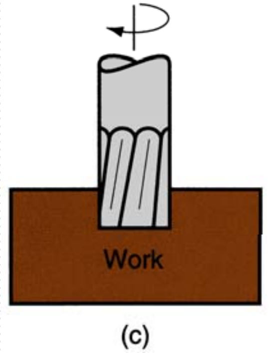
Slab Milling



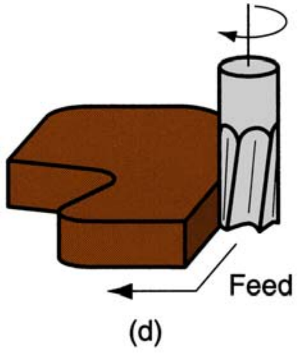
Slotting



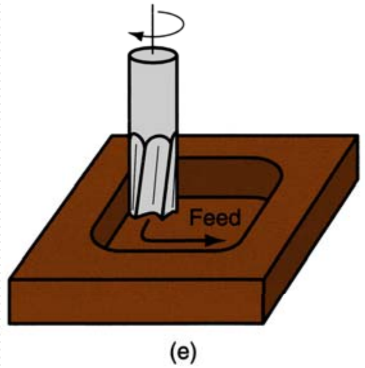
Face Milling



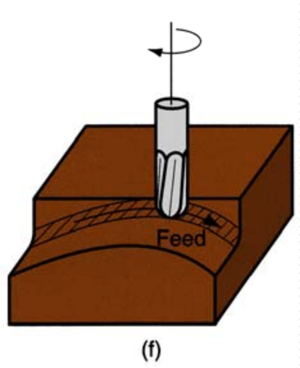
End Milling



Profile Milling

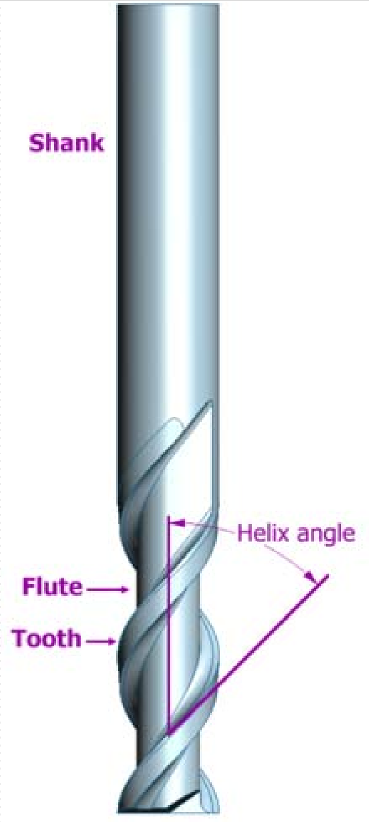


Pocket Milling

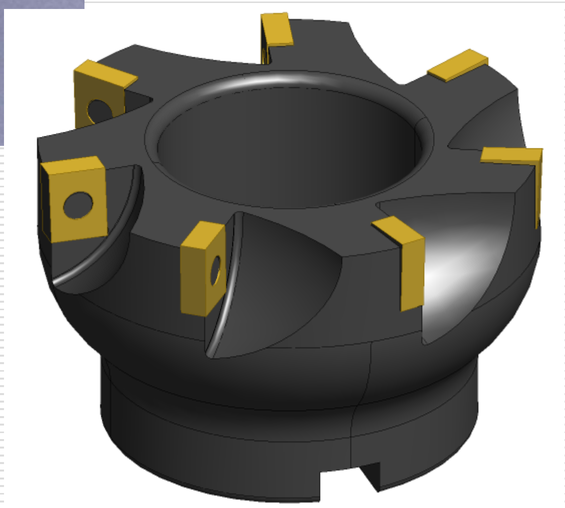


Surface Contouring

Tools - End and Face Mills



From top: slot , roughing and ball nose end mills



End Mill cutter with two flutes

Face Mill

Source: http://en.wikipedia.org/wiki/Milling_cutter

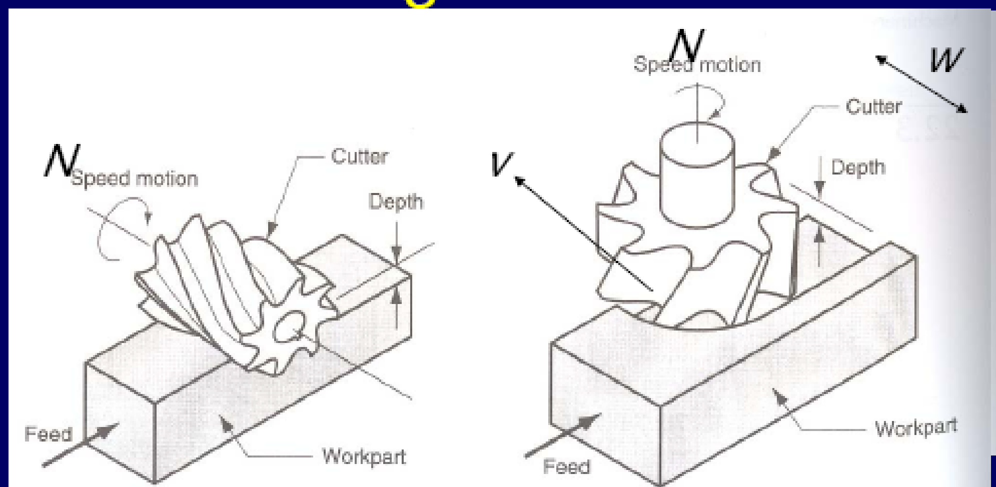
Material Removal Rate (MRR) and Chip Formation

Achieving the correct size of chip is of critical importance. The size of this chip depends on several variables.

- **Surface cutting speed (V):** This is the speed at which each tooth cuts through the material as the tool spins.
- **Spindle speed (N):** This is the rotation speed of the tool, and is measured in revolutions per minute (RPM).
- **Feed per tooth (f):** This is the distance the material is fed into the cutter as each tooth rotates.
- **Feed rate (fr):** This is the speed at which the material is fed into the cutter.
- **Diameter of the tool (D)**
- **Depth of cut (d)**
- **Width of cut (w)**

MRR Calculations

Milling Calculations

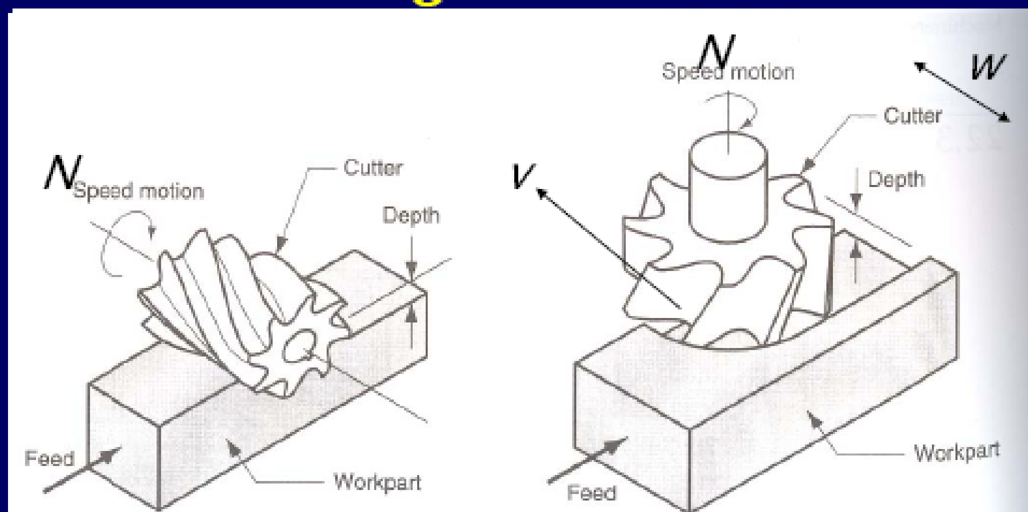


- f = feed (chip load): inch/tooth (mm/tooth)
- f_r = feed rate = inch/min = $N * nt * f$ (SET ON THE MACHINE)
- n_t = number of cutter teeth
- V = cutting speed (feet/min) (m/min)

Source:http://www.public.iastate.edu/~nkuennen/

MRR Calculations

Milling Calculations



- *N* = rotational speed (RPM) = *v* / (pi * *D*) (SET ON THE MACHINE)
- MRR = *w* * *d* * *fr*
- *d* = depth of cut
- *w* = width of cut

Source:http://www.public.iastate.edu/~nkuennen/

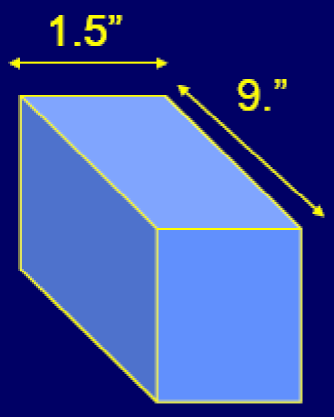
Example

- We want to face mill the top of aluminum block (1.5 by 9 inches) at the cutting depth of 0.1 inch. We will use a 0.2 inch wide face mill with 5 cutting inserts.

  The manufacturer recommends the cutting speed (V) = 350 feet/min and feed per tooth (f) = 0.01 (inch per tooth).

- N = v / (pi * D) = 350*12/ (pi*2) = 668 RPM
- Feed rate = $f * n_t *$ N = 0.010 * 5 * 668 = 33inches/min

What is MRR?



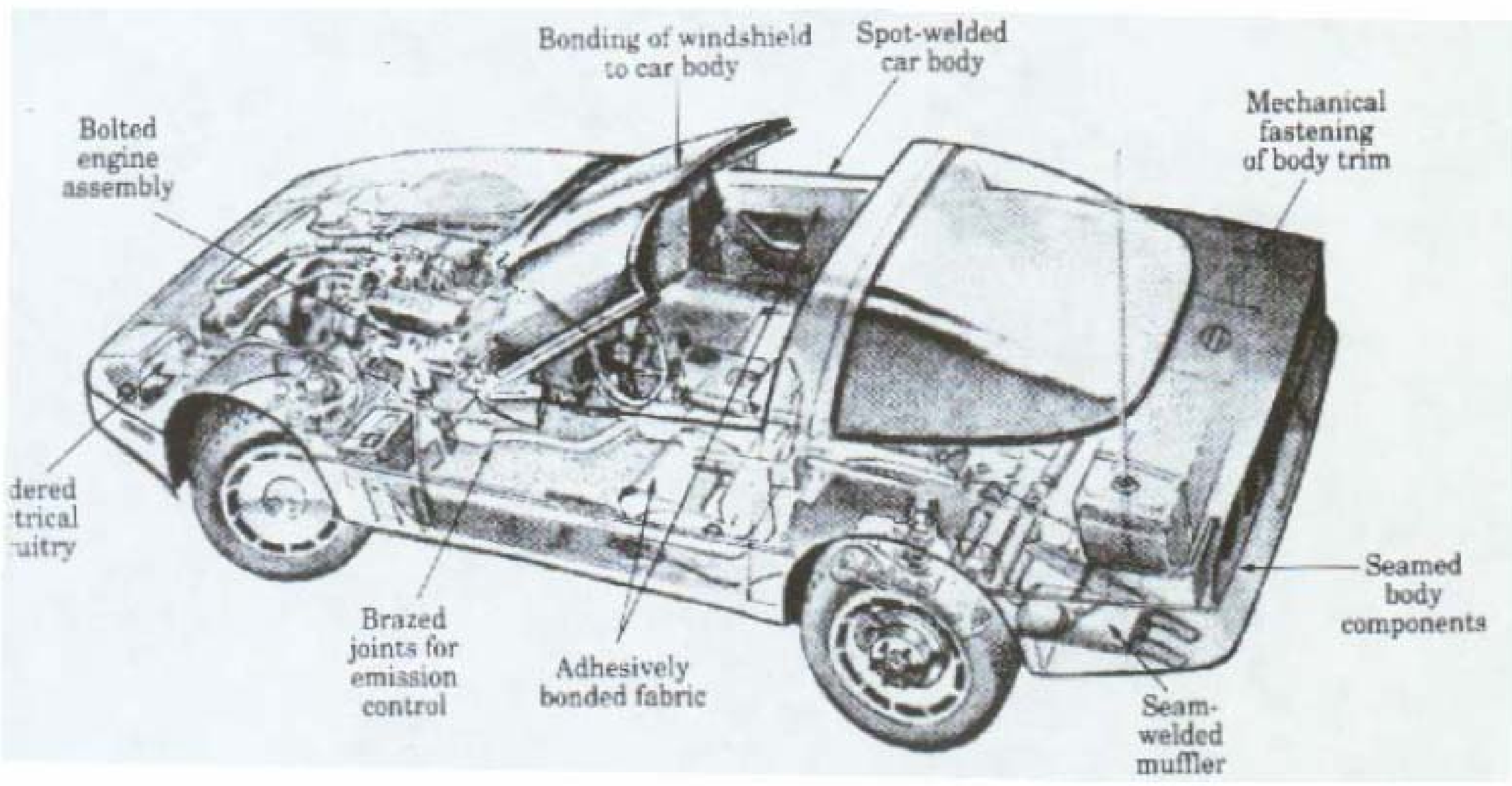
- Material removal rate MRR = feedrate * width of cut * depth of cut = 33 * 1.5 * 0.1 = 4.95in^3/min

Source:http://www.public.iastate.edu/~nkuennen/

Assembly Operations

- Joining processes
  - Welding
  - Brazing and soldering (joining two materials using the third; soldering uses lower melting temperature filler metal)
  - Adhesive bonding
- Mechanical assembly
  - Threaded fasteners (e.g., bolts and nuts, screws)
  - Rivets
  - Interference fits (e.g., press fitting, shrink fits)
  - Other

Joining Technology in Automobile

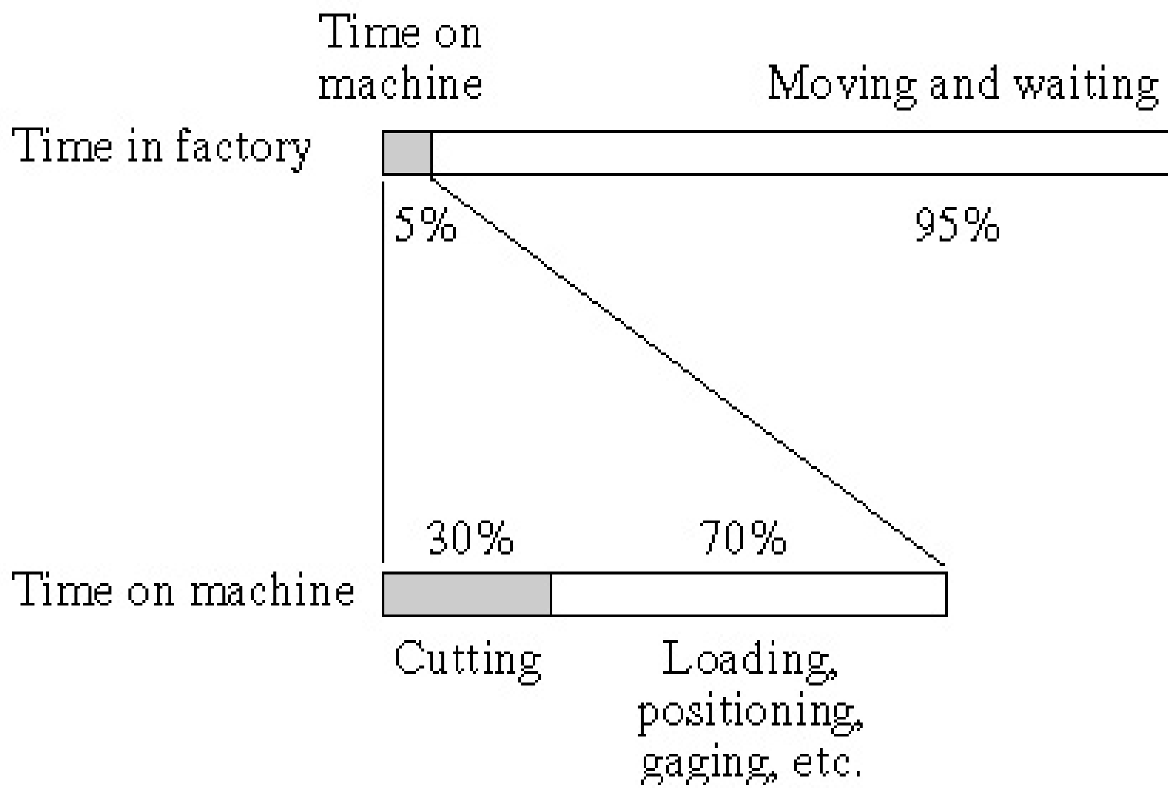


Source: Serope Kalpakjian (1993)

Material Handling

- Material transport
  - Vehicles, e.g., forklift trucks, AGVs, monorails
  - Conveyors
  - Hoists and cranes
- Storage systems
- Unitizing equipment
- Automatic identification and data capture
  - Bar codes
  - RFID
  - Other AIDC

Time Spent in Material Handling

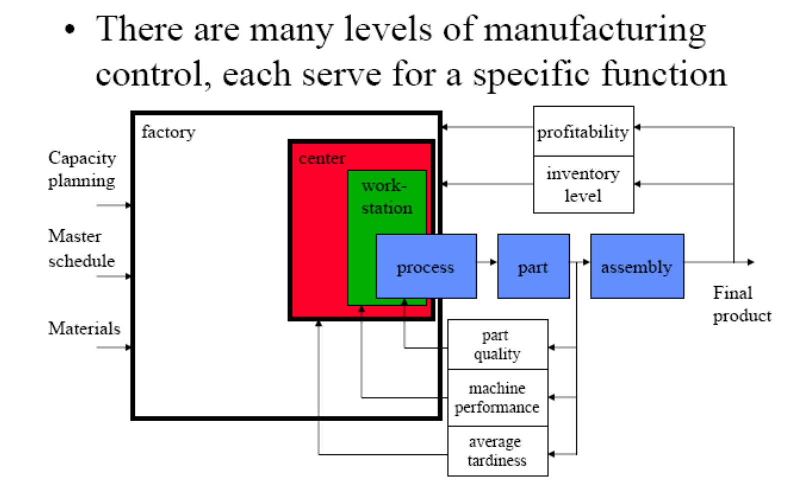


Inspection and Testing

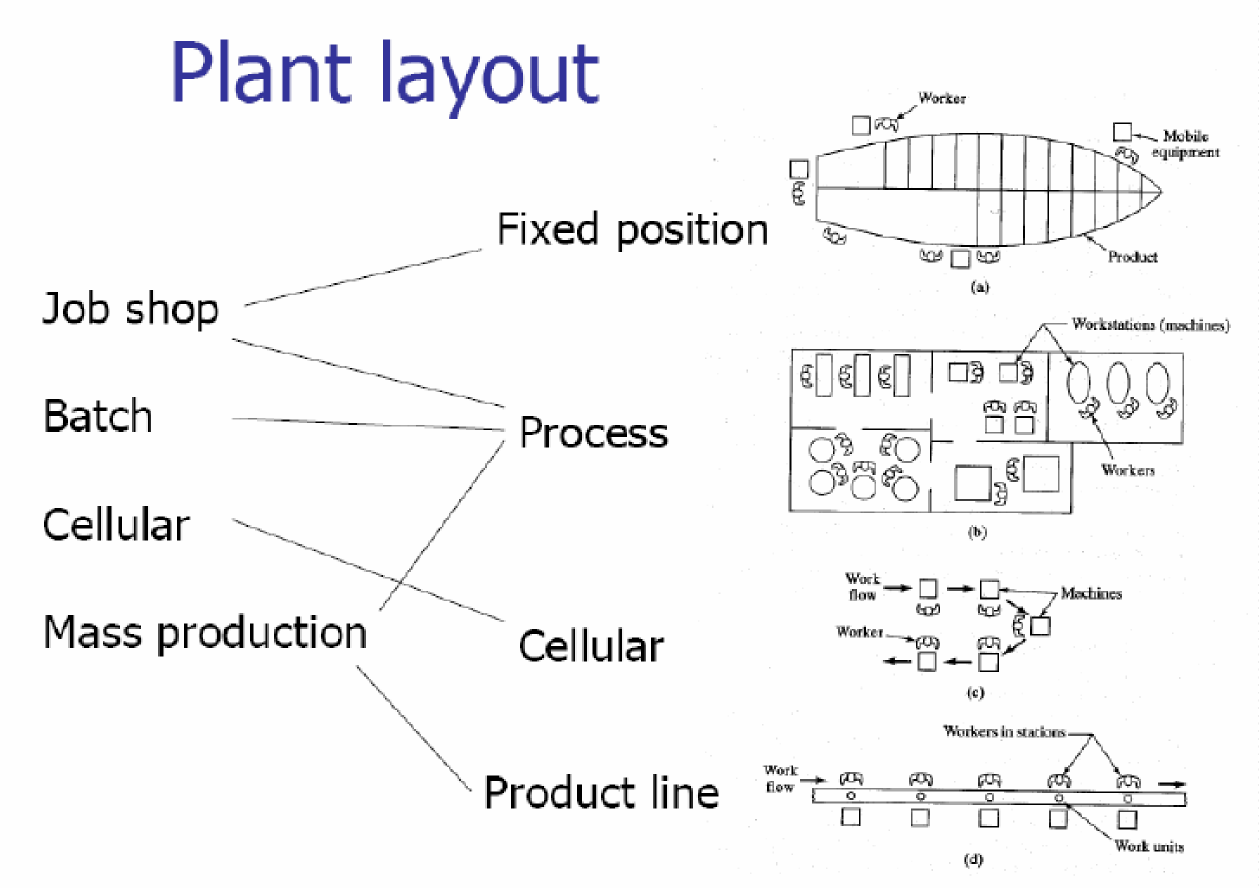
- Inspection – examination of the product and its components to determine whether they conform to design specifications
- Testing – observing the product (or part, material, subassembly) during actual operation or under conditions that might occur during operation

Coordination and Control

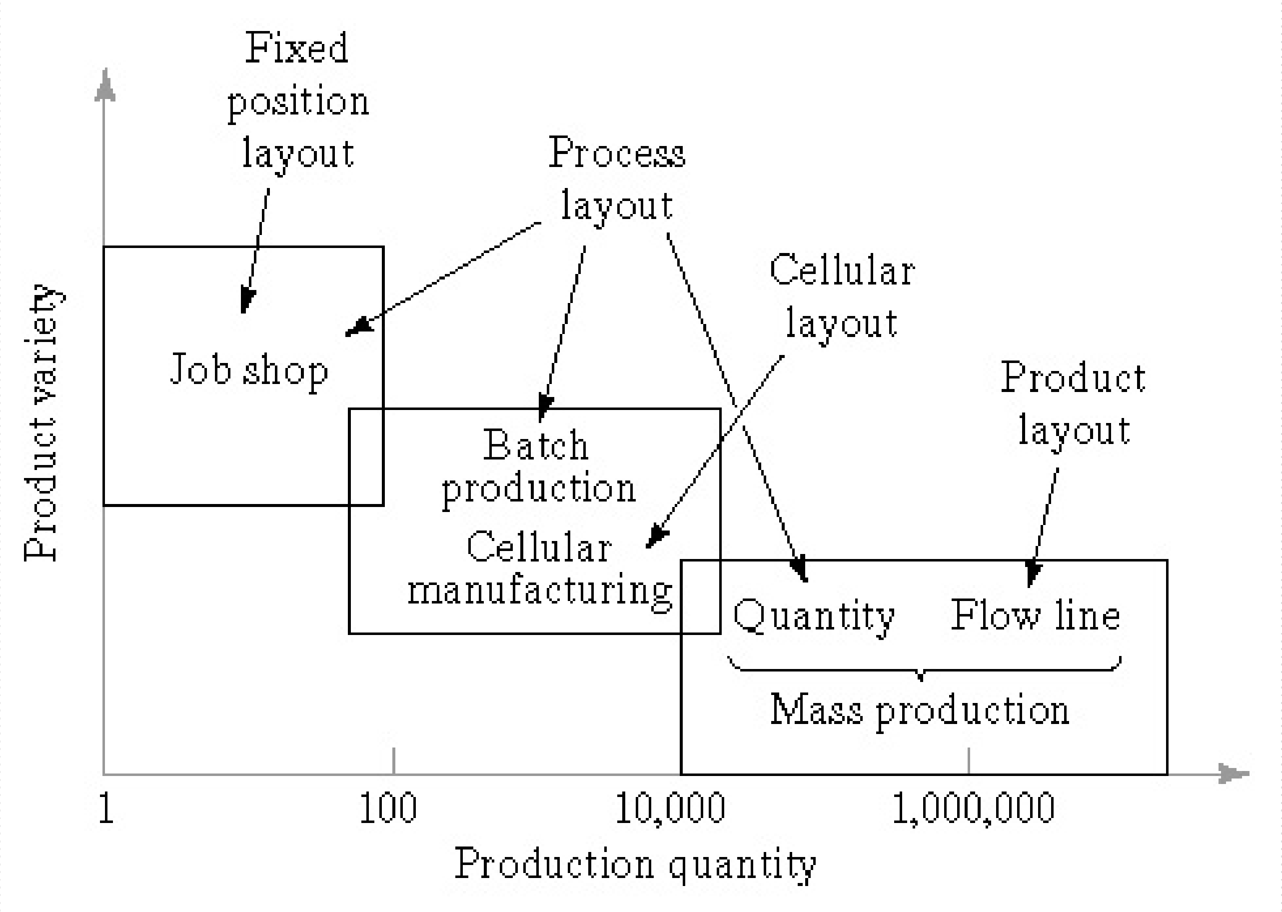
- Regulation of the individual processing and assembly operations
  - Process control
- Management of plant level activities
  - Production planning and control



Plant Layout



Relationships between Plant Layout and Type of Production Facility



Limitations and Capabilities of a Manufacturing Plant

Manufacturing capability - the technical and physical limitations of a manufacturing firm and each of its plants

- Three dimensions of manufacturing capability:

1. Technological processing capability - the available set of manufacturing processes
2. Physical size and weight of product
3. Production capacity (plant capacity) - production quantity that can be made in a given time

Product-Process Matrix

These process structures differ in several respects such as:

- Flow - ranging from a large number of possible sequences of activities to only one possible sequence.
- Flexibility - A process is flexible to the extent that the process performance and cost is independent of changes in the output. Changes may be changes in production volume or changes in the product mix.
- Number of products - ranging from the capability of producing a multitude of different products to producing only one specific product.
- Capital investment - ranging from using lower cost general purpose equipment to expensive specialized equipment.
- Variable cost - ranging from a high unit cost to a low unit cost.
- Labor content and skill - ranging from high labor content with high skill to low content and low skill.
- Volume - ranging from a quantity of one to large scale mass production.

Comparison of Process Structures and Characteristics

	Project	Job Shop	Batch Process	Assembly Line	Continuous Flow
Flow	None → Continuous				
Flexibility	High → Low				
No. of Products	High → Low				
Capital Investment	Low → High				
Variable Cost	High → Low				
Labor Content	High → Low				
Labor Skill	High → Low				
Volume	Low → High				

Job Shop

- Flow - jumbled flow
- Flexibility - high
- Products - many
- Capital investment - low
- Variable cost - high
- Labor content and skill - high
- Volume - low

pass. In a job shop, it is not necessary for all activities to be performed on all products, and their sequence may be different for different products.

To illustrate the concept of a job shop, consider the case of a machine shop. In a machine shop, a variety of equipment such as drill presses, lathes, and milling machines is arranged in stations. Work is passed only to those machines required by it, and in the sequence required by it. This is a very flexible arrangement that can be

A *job shop* is a flexible operation that has several activities through which work can

A job shop uses general purpose equipment and relies on the knowledge of workers to produce a wide variety of products. Volume is adjusted by adding or removing labor as needed. Job shops are low in efficiency but high in flexibility. Rather than selling specific products, a job shop often sells its capabilities.

Batch Process

- Flow - disconnected, with some dominant flows
- Flexibility - moderate
- Products - several
- Capital investment - moderate
- Variable cost - moderate
- Labor content and skill - moderate
- Volume - moderate

A *batch process* is similar to a job shop, except that the sequence of activities tends to be in a line and is less flexible. In a batch process, dominant flows can be identified. The activities, while in-line, are disconnected from one another. Products are produced in batches, for example, to fill specific customer orders.

A batch process executes different production runs for different products. The disadvantage is the setup time required to change from one product to the other, but the advantage is that some flexibility in product mix can be achieved.

Assembly Line Process

- Flow - connected line
- Flexibility - low
- Products - a few
- Capital investment - high
- Variable cost - low
- Labor content and skill - low
- Volume - high

Like a batch process, an *assembly line* processes work in fixed sequence. However, the assembly line connects the activities and paces them, for example, with a conveyor belt. A good example of an assembly line is an automobile plant.

Continuous Flow Process

- Flow - continuous
- Flexibility - very low
- Products - one
- Capital investment - very high
- Variable cost - very low
- Labor content and skill - very low, but with skilled overseers
- Volume - very high

Like the assembly line, a *continuous flow* process has a fixed pace and fixed sequence of activities. Rather than being processed in discrete steps, the product is processed in a continuous flow; its quantity tends to be measured in weight or volume. The direct labor content and associated skill is low, but the skill level required to oversee the sophisticated equipment in the process may be high. Petroleum refineries and sugar processing facilities use a continuous flow process.