



IE-352

Manufacturing Processes – 2

Summer-2013

Dr Ashraf Afifi

**Industrial Engineering Department
King Saud University**

Course Specifications

Intended Learning Outcomes:

At the end of this course, students are expected to acquire knowledge regarding the following:

1. Work piece design analysis for manufacturing (tolerancing, dimensioning, material requirement) [a,b, e].
2. Machining process operations (traditional and non-traditional) [a, e].
3. Metal cutting analysis (force, power, machining time calculations in different machining processes. [a, b, e].
4. Process design and planning (cutting and material conditions selection) [c, e].
5. Economics of metal cutting operations [a, c, e].

Course Specifications

Learning Resources:

Textbook: Manufacturing Engineering and Technology. Serope Kalpakjian, Steven R. Schmid. Fourth Edition. Prentice Hall: New Jersey, 2001. ISBN: 0-13-017440-8

Reference: Fundamentals of Modern Manufacturing. Mikell P. Groover. First Edition. Prentice Hall: New Jersey, 1996. ISBN: 0-13-376583-0.

Websites (sample):

<http://www.stefanelli.eng.br/en/index.html>

http://www.engineersedge.com/tolerance__calc_menu.shtml

Assessment Methods:

Final exam 40%, Midterms 20%, Quizzes 10%, Lab work 10%, homework 5%, Project 10% and Attendance 5%.

Course Outline

- 1. Introduction and Overview of Manufacturing**
- 2. Machining Fundamentals – Measurement**
- 3. Coordinate Dimensioning and Tolerancing**
- 4. Geometric Tolerances**
- 5. Machining Processes and Machine Tools**
- 6. Cutting-Tool Materials and Cutting Fluids**

The background features a light blue gradient with several semi-transparent gears of various sizes and colors (white, light blue, grey) scattered across it. On the far left, there is a vertical strip with a colorful, abstract, and textured pattern in shades of red, orange, yellow, and purple.

Lecture (1)

Introduction and Overview of Manufacturing



Outline

1. What is Manufacturing?
2. Materials in Manufacturing
3. Manufacturing Processes
4. Production Systems

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1- What is manufacturing?

“act of making something (a product) from raw materials”



Manufacturing is Important

- Technologically
- Economically
- Historically

Manufacturing - Technologically Important

What is technology?

Technology - the application of science to provide society and its members with those things that are needed or desired.

Technology provides the products that help our society and its members live better.

What do these products have in common?

They are all manufactured.

Manufacturing is the essential factor that makes technology possible.





Manufacturing - Economically Important

Manufacturing is one way by which nations create material wealth

U.S. economy:

<u>Sector</u>	<u>% of GNP*</u>
Manufacturing	20%
Agriculture, minerals, etc.	5%
Construction & utilities	5%
Service sector – retail, transportation, banking, communication, education, and government	70%

* GNP= Gross Net Product



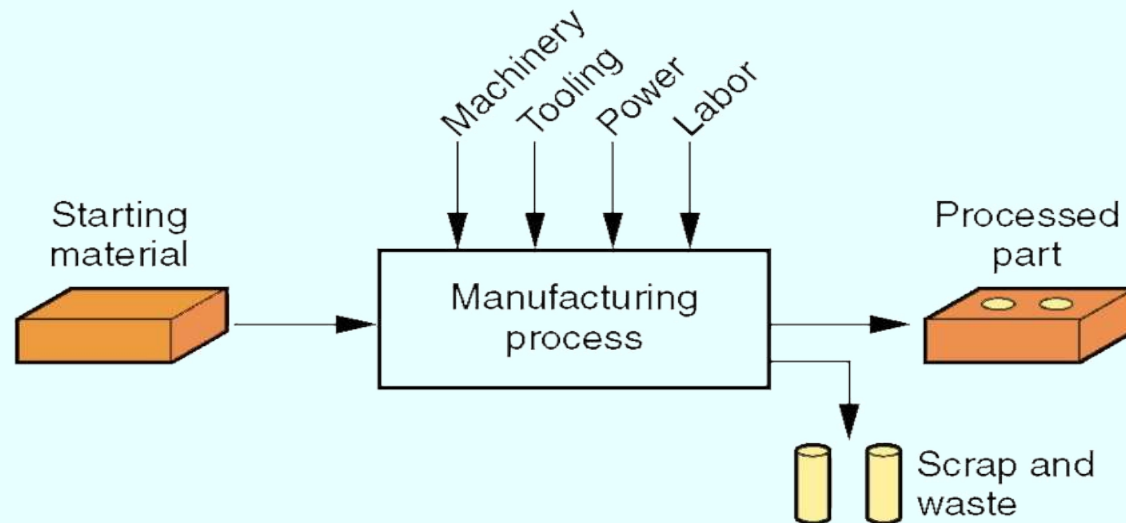
What is Manufacturing?

- The word *manufacture* is derived from two Latin words *manus* (hand) and *factus* (make); the combination means “made by hand”
- Most modern manufacturing operations are accomplished by mechanized and automated equipment that is supervised by human workers

Manufacturing - Technologically

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

- Manufacturing also includes assembly.
- Almost always carried out as a sequence of operations.



(a)

Figure 1.1 (a)
Manufacturing
as a technical
process

Manufacturing - Economically

Manufacturing *adds value* to the material by changing its shape or properties, or by combining it with other materials (this is done by means of one or more processing and/or assembly operations).

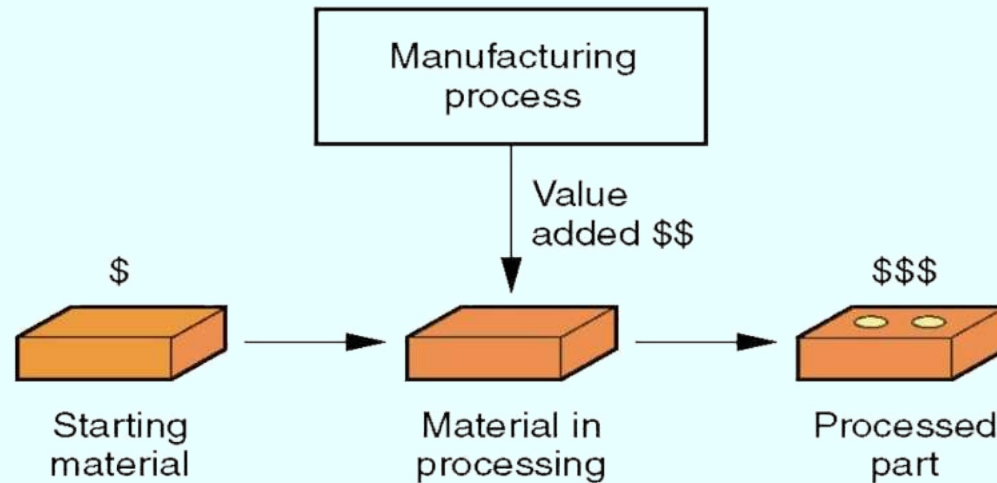


Figure 1.1 (b)
Manufacturing
as an economic
process

(b)



Manufacturing Industries

Industry consists of enterprises and organizations that produce or supply goods and services

Industries can be classified as:

Primary industries - those that cultivate and exploit natural resources, e.g., **farming, mining**.

Secondary industries - take the outputs of primary industries and convert them into consumer and capital goods - **manufacturing** is the principal activity, other examples: **construction**, and **electric power generation**.

Tertiary industries - service sector, eg banking.

Manufacturing Industries - continued

- Manufacturing includes several industries whose products are not covered in this course; e.g., apparel, beverages, chemicals, and food processing.

- For our purposes, **manufacturing** means **production of hardware**.



- Nuts and bolts, forgings, cars, airplanes, digital computers, plastic parts, and ceramic products





Production Quantity Q

- The **quantity of products Q** made by a factory has an important influence on the way its people, facilities, and procedures are organized.
- Annual production quantities can be classified into three ranges:

<u>Production range</u>	<u>Annual Quantity Q</u>
Low production	1 to 100 units
Medium production	100 to 10,000 units
High production	10,000 to millions

Product Variety P

- **Product variety P** refers to **different product types** or **models** produced in the plant.
- Different products have different features
 - They are intended for different markets
 - Some have more parts than others
- When the number of **product types** made in the factory is high, this indicates high product variety



P versus Q in Factory Operations

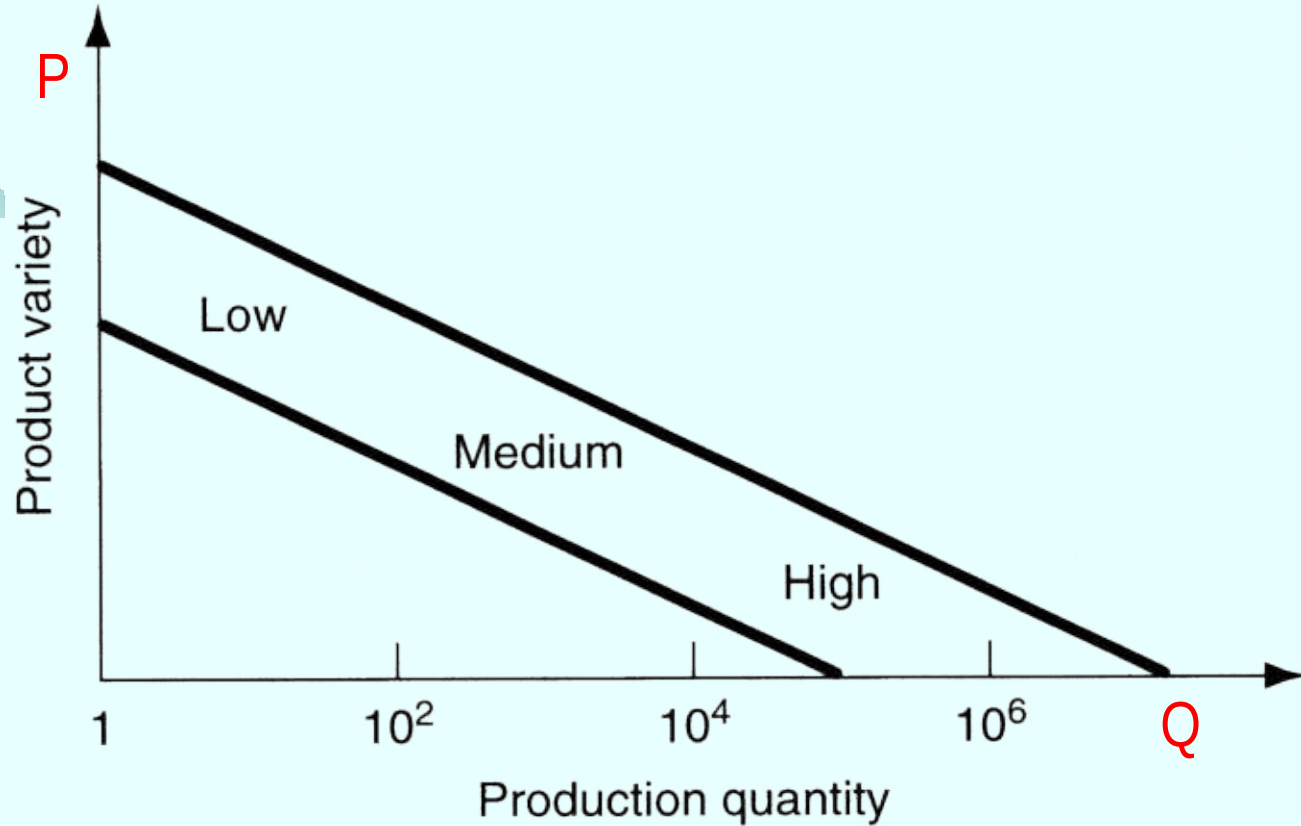


Figure 1.2 P-Q Relationship

More About Product Variety

- Although P is a quantitative parameter, it is much less exact than Q because details on how much the designs differ is not captured simply by the number of different designs.
- *Soft product variety* - small differences between products, e.g., between car models made on the same production line, with many common parts among models.
- *Hard product variety* - products differ substantially, e.g., between a small car and a large truck, with few common parts (if any).





Manufacturing Capability

- A manufacturing plant consists of *processes* and *systems* (and people, of course) designed to transform a certain limited range of *materials* into *products* of increased value.
- The three building blocks - *materials*, *processes*, and *systems* - are the subject of modern manufacturing.
- A company engaged in manufacturing cannot do everything. It must do only certain things, and it must do these things well.



Manufacturing capability - continued

- Manufacturing capability refers to the technical and physical limitations of a manufacturing firm.
- Several dimensions of this capability can be identified:
 1. Technological processing capability,
 2. Physical product limitations,
 3. Production capacity.

1. Technological Processing Capability

- The available set of manufacturing processes in the plant (or company).
 - Technological processing capability is closely related to material type.
 - Certain manufacturing processes are suited to certain materials. By specializing in certain processes, the plant is also specializing in certain materials types.
 - Technological processing capability includes not only the physical processes, but also the expertise of the plant personnel.
 - Companies must concentrate on the design and manufacture of products that are compatible with their technological processing capability.





2. Physical Product Limitations

- Given a plant with a certain set of processes, there are **size and weight limitations** on the parts or products that can be made in the plant.
- Product size and weight affect:
 - **Production equipment**
 - **Material handling equipment**



3. Production Capacity (or plant capacity)

- Defined as the **maximum quantity** that a plant can produce in a given time period (e.g., month or year) **under assumed operating conditions**.
- **Operating conditions** refer to number of shifts per week, hours per shift, direct labor manning levels in the plant, and so on.
- Capacity is measured in terms of **output units**, such as tons of steel or number of cars produced by the plant.

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2- Materials in Manufacturing



Materials in Manufacturing

Most engineering materials can be classified into one of three basic categories:

1. **Metals**
2. **Ceramics**
3. **Polymers**

Their **chemistries** and also their **mechanical and physical properties** are different, and

- These differences affect the manufacturing processes that can be used to produce products from them.



1. Metals

Metals used in manufacturing are usually *alloys*, which are composed of two or more elements, at least one of which is metallic.

Two basic groups:

Ferrous metals - based on iron, comprises about 75% of metal tonnage in the world:

Steel = Fe-C alloy (0.02 to 2.11% C)

Cast iron = Fe-C alloy (2% to 4% C)

Nonferrous metals - all other metallic elements and their alloys: aluminum, copper, magnesium, nickel, silver, tin, titanium, etc.

2. Ceramics

Compounds containing metallic (or semi-metallic) and nonmetallic elements.



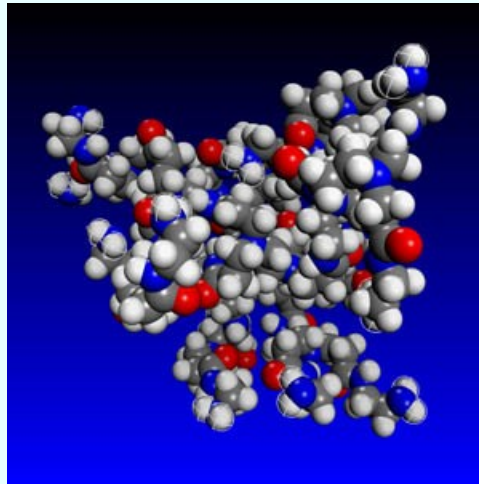
Typical nonmetallic elements are oxygen, nitrogen, and carbon.

■ For processing, ceramics can be divided into:

1. **Crystalline ceramics** – includes:
 - Traditional ceramics, such as clay.
 - Modern ceramics, such as alumina (Al_2O_3).
2. **Glasses** – mostly based on silica (SiO_2).

3. Polymers

Compound formed of repeating structural units called *mers*, whose atoms share electrons to form very large molecules.

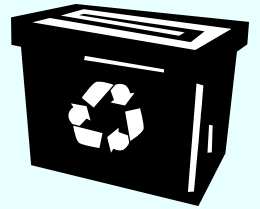


Usually consist of carbon plus one or more other elements such as hydrogen, nitrogen, oxygen, and chlorine.

3- Polymers

Three categories:

1. **Thermoplastic polymers** - can be subjected to multiple heating and cooling cycles without altering molecular structure.
2. **Thermosetting polymers** - molecules chemically transform (cure) into a rigid structure – cannot be reheated.
3. **Elastomers** - shows significant elastic behavior.



In addition - Composites

Nonhomogeneous mixtures of the other three basic types rather than a unique category.

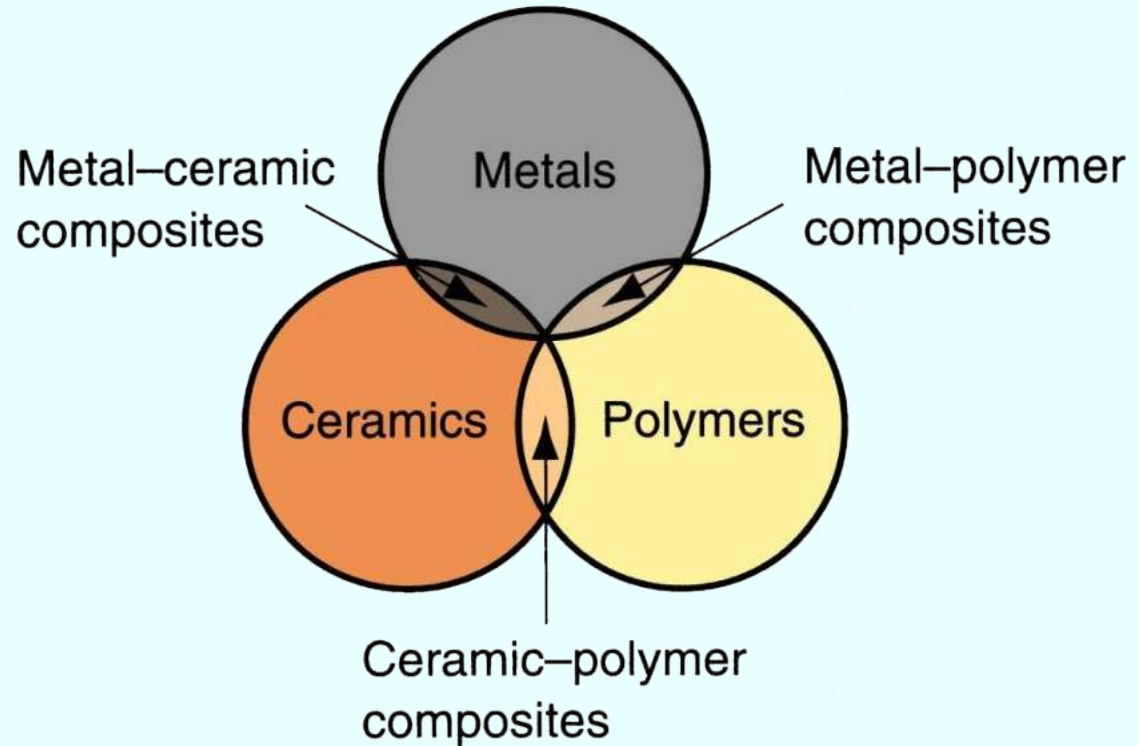


Figure 1.3 Venn diagram of three basic material types plus composites



3- Manufacturing Processes

“A manufacturing process is a designed procedure that results in physical and/or chemical changes to a starting work material with the intention of increasing the value of that material”.

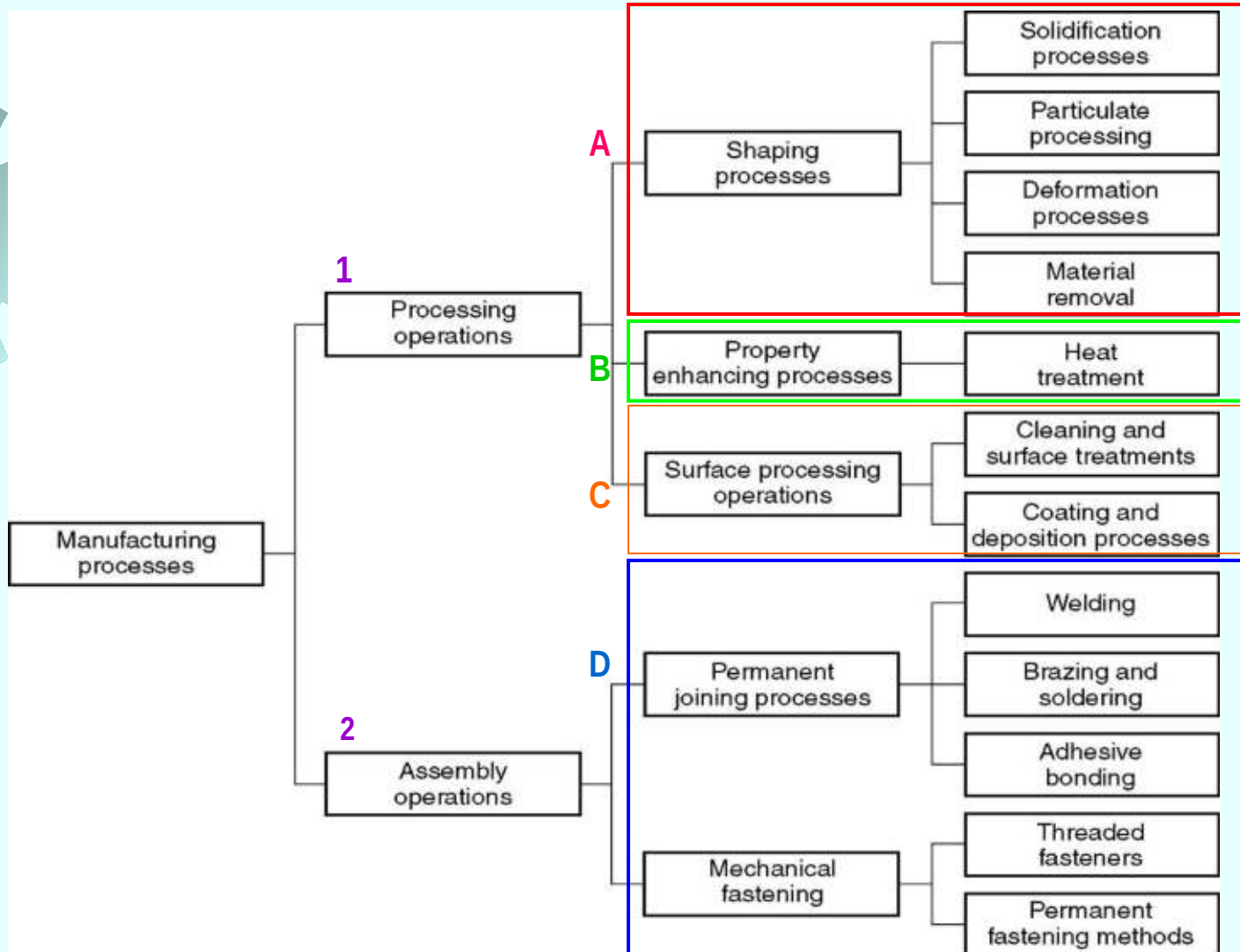
Manufacturing Processes

Two basic types:

1. **Processing operations** - transform a work material from one state of completion to a more advanced state.
 - Operations that change the geometry, properties, or appearance of the starting material.
2. **Assembly operations** - join two or more components to create a new entity.



Figure 1.4 Classification of manufacturing processes

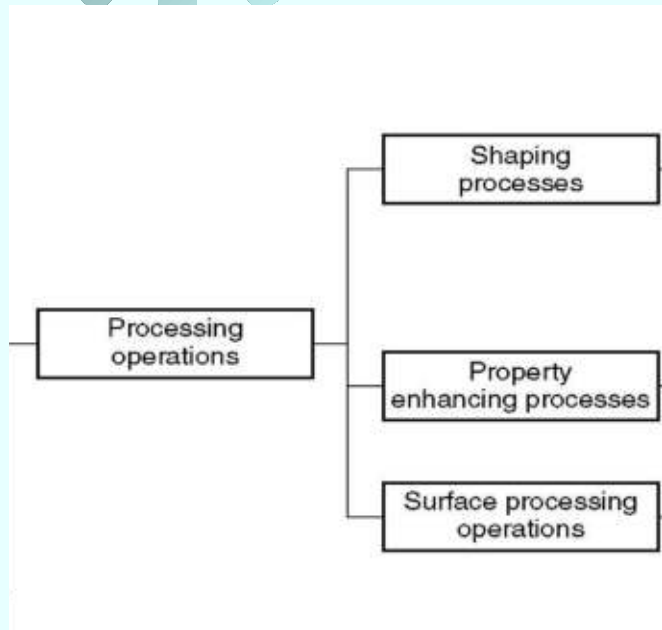


Processing Operations

Alters a material's shape, physical properties, or appearance in order to add value.

- Three categories of processing operations:

1. **Shaping operations** - alter the geometry of the starting work material.
2. **Property-enhancing operations** - improve physical properties without changing shape.
3. **Surface processing operations** - to clean, treat, coat, or deposit material on exterior surface of the work.





A

Shaping Processes – Four Categories

1. **Solidification processes** - starting material is a heated **liquid or semi-fluid**.
2. **Particulate processing** - starting material consists of **powders**.
3. **Deformation processes** - starting material is a **ductile solid** (commonly metal).
4. **Material removal processes** - starting material is a **ductile or brittle solid**.

A

1- Solidification Processes

Starting material is heated sufficiently to transform it into a liquid or highly plastic state

- Examples: metal casting, plastic molding.

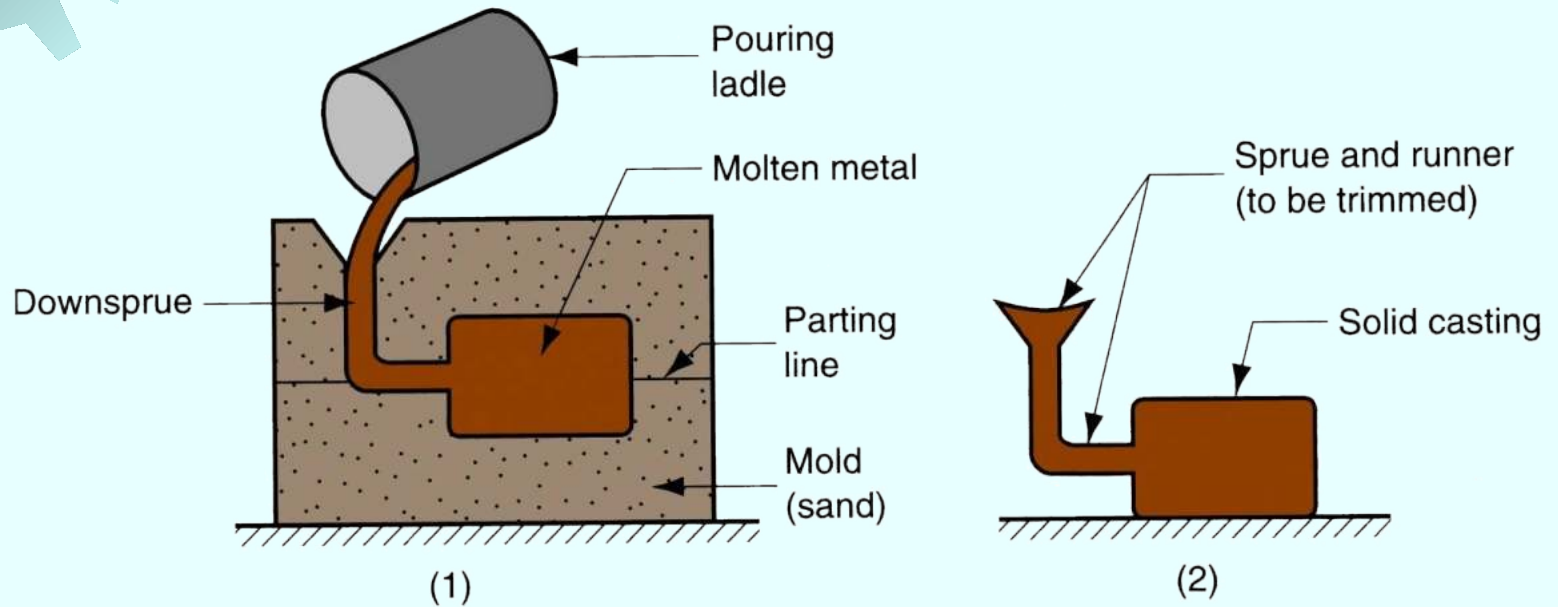


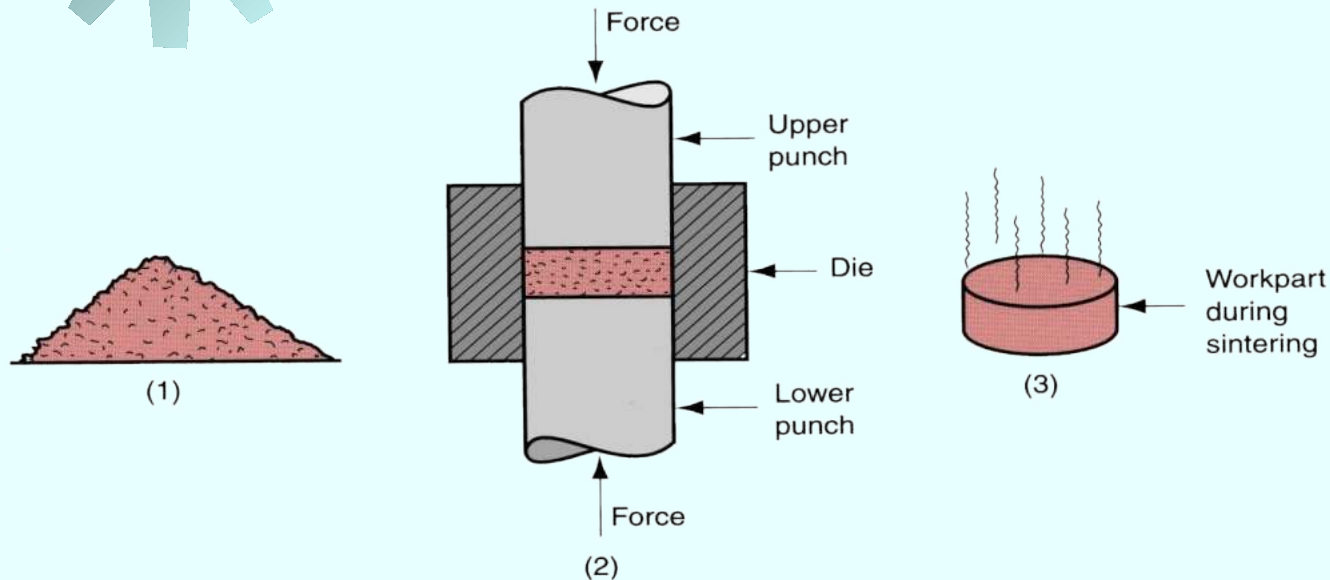
Figure 1.5 Casting and molding processes

A

2- Particulate Processing

Starting materials are powders of metals or ceramics.

- Usually involves pressing and sintering, in which powders are first compressed and then heated to bond the individual particles



Sintering is a method for making objects from powder, by heating the material (below its melting point) until its particles adhere to each other.

Figure 1.6 Particulate processing: (1) the starting material is powder; the usual process consists of (2) pressing and (3) sintering

A

3- Deformation Processes

Starting workpart is shaped by application of forces that exceed the yield strength of the material.

- Examples:
 - (a) forging,
 - (b) extrusion

Material yield strength refers to the point on the stress-strain curve beyond which the material experiences deformations that will not be completely reversed upon removal of the loading.

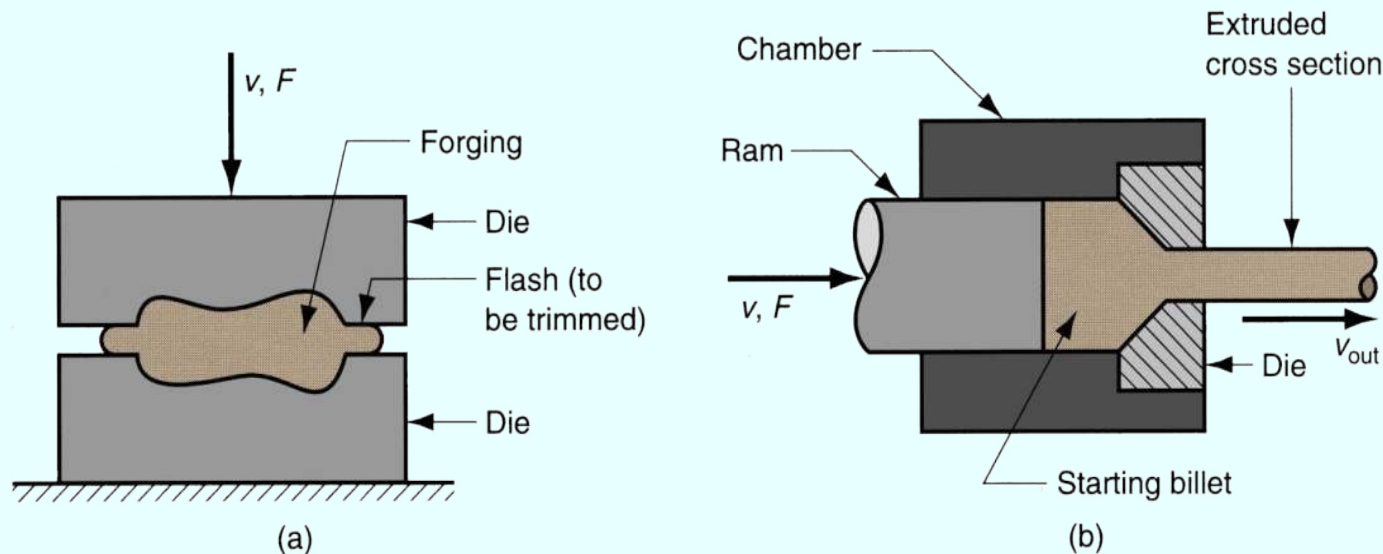


Figure 1.7 Some common deformation processes: (a) forging and (b) extrusion

A

4- Material Removal Processes

Excess material removed from the starting piece so what remains is the desired geometry

- Examples: machining such as turning, drilling, and milling; and grinding processes.

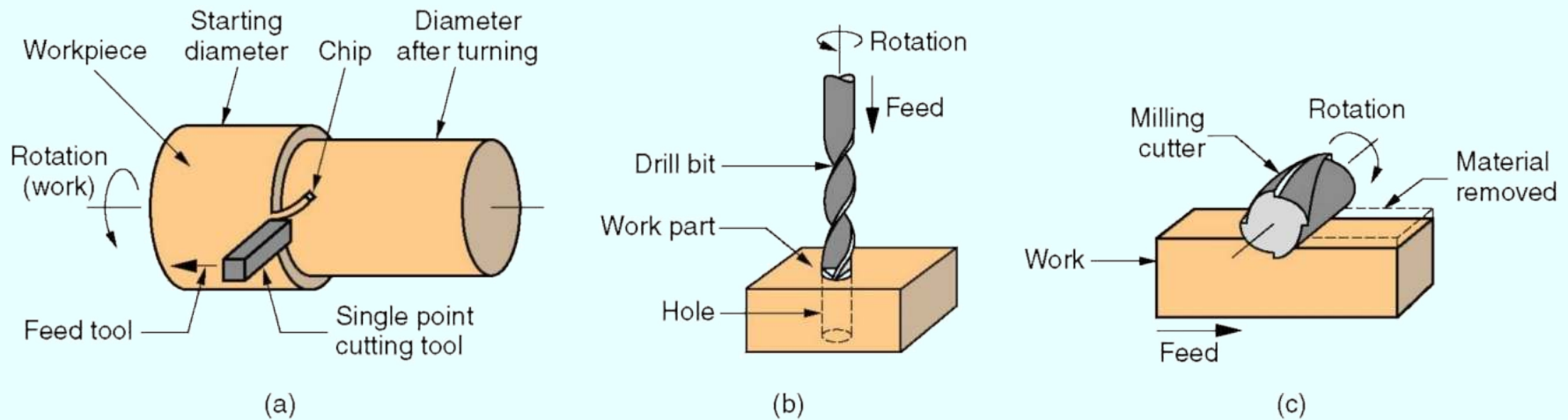


Figure 1.8 Common machining operations: (a) turning, (b) drilling, and (c) milling



B

Property-Enhancing Processes

Performed to improve mechanical or physical properties of the work material.

- Part shape is not altered.

- Examples:

- Heat treatment of metals and glasses.

Heat treating of steel is the process of heating and cooling of steel to change the steel's physical and mechanical properties without changing the original shape and size.

- Sintering of powdered metals and ceramics.

C

Surface Processing Operations

- **Cleaning** - chemical and mechanical processes to remove dirt, oil, and other contaminants from the surface.
- **Surface treatments** - mechanical working such as sand blasting, and physical processes like diffusion.

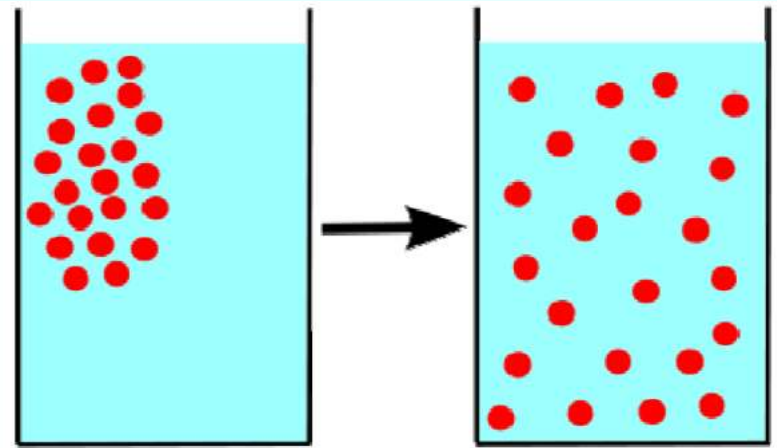
Sand blasting is an abrasive process to smooth or form surfaces whereby sand is blasted under high pressure.



C

Surface Processing Operations

Diffusion is a physical process in which molecules or ions move from a region where they are more highly concentrated to a region where they are less highly concentrated.



- **Coating and thin film deposition** - coating exterior surface of the workpart.

D

Assembly Operations

Two or more separate parts are joined to form a new entity.

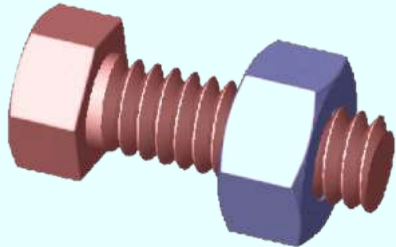
■ Types of assembly operations:

1. **Joining processes** – create a permanent joint.

- Welding, brazing, soldering, and adhesive bonding.

2. **Mechanical assembly** – fastening by mechanical methods.

- Threaded fasteners (screws, bolts and nuts); press fitting.



Press fit is a fastening between two parts which is achieved by friction after the parts are pushed together, rather than by any other means of fastening.



4- Production Systems



Production Systems

People, equipment, and procedures used for the combination of materials and processes that constitute a firm's manufacturing operations.

- A manufacturing firm must have systems and procedures to efficiently accomplish its type of production.

Two categories of production systems:

1. Production facilities
2. Manufacturing support systems

Both categories include people (people make the systems work).

Production systems

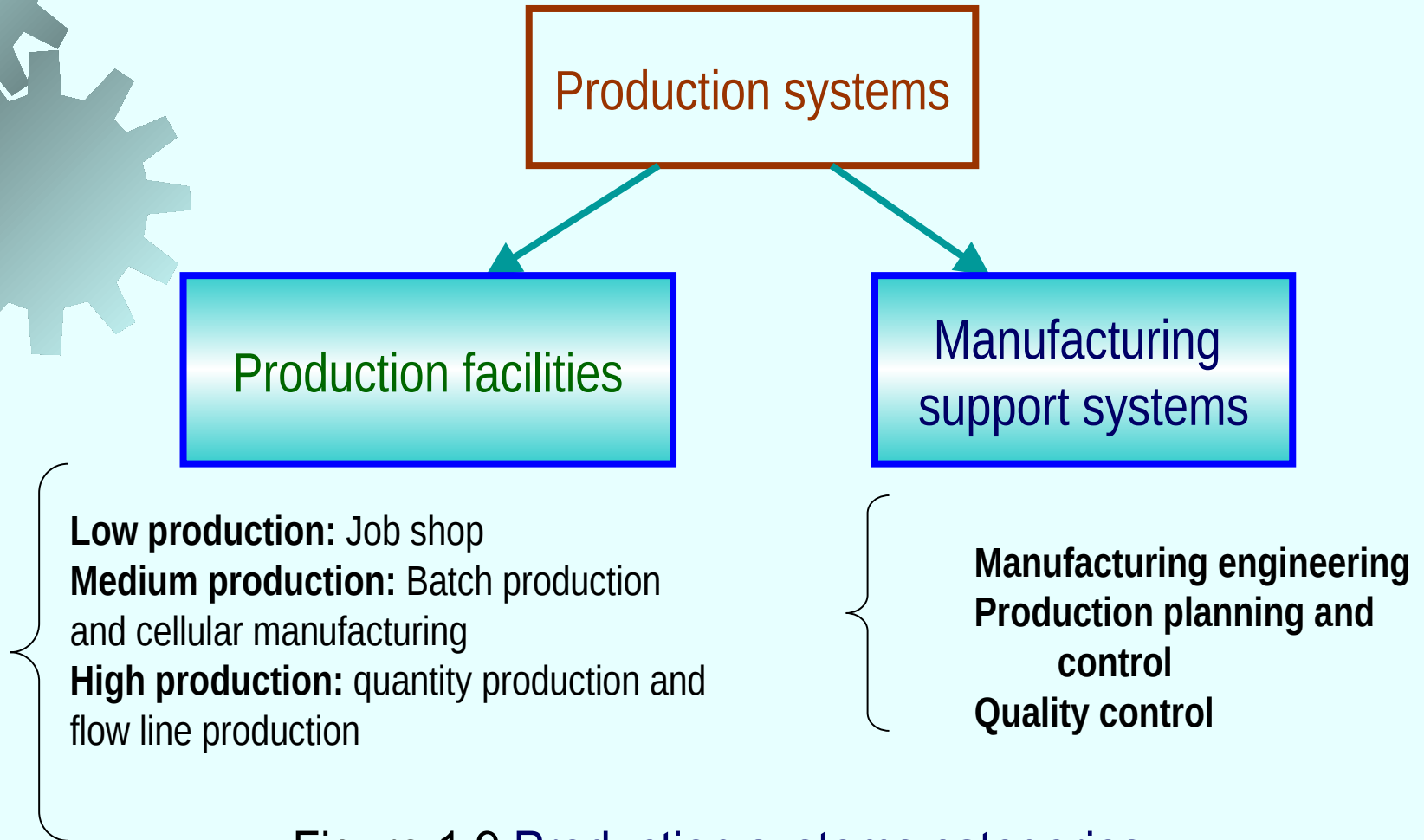


Figure 1.9 Production systems categories.



1- Production Facilities

The factory, production equipment, and material handling systems.

- Production facilities include the way the equipment is arranged in the factory - the *plant layout*.

Equipment usually organized into logical groupings, called *manufacturing systems*.

Examples:

- Automated production line.
- Machine cell consisting of an industrial robot and two machine tools.



Facilities versus Product Quantities

A company designs its manufacturing systems and organizes its factories to serve the particular mission of each plant.

- Certain types of production facilities are recognized as the most appropriate for a given type of manufacturing:
 1. Low production – 1 to 100
 2. Medium production – 100 to 10,000
 3. High production – 10,000 to >1,000,000

- Different facilities are required for each of the three quantity ranges

Low Production

Job shop is the term used for this type of production facility.

- A job shop makes low quantities of specialized and customized products.
 - Products are typically complex, e.g., space capsules, prototype aircraft, special machinery.



- Equipment in a job shop is general purpose.
- Labor force is highly skilled.
- Designed for maximum flexibility.

Medium Production

Two different types of facility, depending on product variety:

Batch production

- Suited to hard product variety.
- Setups required between batches.



Cellular manufacturing

- Suited to soft product variety.
- Worker cells organized to process parts without setups between different part styles.





High Production

- Often referred to as *mass production*
 - High demand for product.
 - Manufacturing system dedicated to the production of that product.

- Two categories of mass production:
 1. **Quantity production**

 2. **Flow line production**



Quantity Production

Mass production of single parts on single machine or small numbers of machines.

- Typically involves standard machines equipped with special tooling.
- Equipment is dedicated full-time to the production of one part or product type.
- Typical layouts used in quantity production are process layout and cellular layout.



Flow Line Production

Multiple machines or workstations arranged in sequence, e.g., production lines.

- Product is complex
 - Requires multiple processing and/or assembly operations.
- Work units are physically moved through the sequence to complete the product.
- Workstations and equipment are designed specifically for the product to maximize efficiency.

2- Manufacturing Support Systems

A company must organize itself

- to design the processes and equipment,
- plan and control production, and
- satisfy product quality requirements

Accomplished by manufacturing support systems - people and procedures by which a company manages its production operations.

Typical departments:

1. Manufacturing engineering
2. Production planning and control
3. Quality control