Manufacturing Processes

Lecture 1

Introduction

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Lecturer Interest Areas

- Material Processing
- Manufacturing Technologies
- Biomaterials
- Material Characterization
- Manufacturing of Permanent, Degradable Implants

Contents

- Introduction to Manufacturing Technologies
  - About Lecture
  - Rules of Conduct

Manufacturing Technologies

During courses;

- Please be awake! and be aware of what we are doing
- Please ask me questions
- I will ask you about the breaks
- We are going to take a break more than once.☺

Manufacturing Technologies

- 14 weeks lecture
- 4 hours per week
- Each 40 min lecture has 20 min break
- Homework
- Mid-Term Exam
- Final Exam

Activity	Amount	Grade Percentage
Mid-Term Exam	2	60%
Final Exam	1	40 %

Manufacturing Technologies-Lecture Content

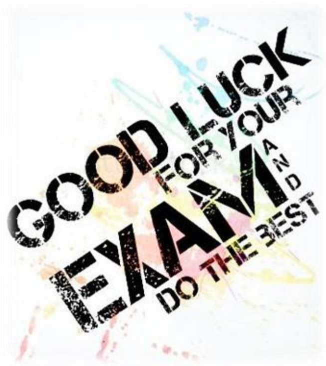
WEEKLY SUBJECTS AND RELATED PREPARATION STUDIES	
Weeks	Course Outline
1	Introduction
2	Casting
3	Casting
4	Casting/Metal Forming
5	Metal Forming
6	Metal Forming
7	Welding&Joining
8	1. Mid Term
9	Welding&Joining
10	Welding&Joining/Machining
11	Machining -2. Mid Term
12	Machining
13	Machine Calculations
14	Final

Lecture Evaluation: Final Note = [0.30x2Midterm]+[0.40×*Final*]

Manufacturing Technologies

For Examinations,

- Exams will be face to face



Lecture Outcomes

- Learner will be able to describe what the manufacturing technology is and its role in our country todays sceneries
- Learner will be able to know developments and new trends in manufacturing technologies
- Learner will be able to determine how to manufacture a product
- Learner will be able to determine the optimal manufacturing type for a product

Manufacturing Technologies

Manufacturing Techologies is Well-Documented;

- **Books:**

- ✓ Mikell P. Groover, **Fundamentals of Modern Manufacturing Materials, Processes, and Systems** Fourth Edition, John Wiley & Sons, Inc.
- ✓ Rajender Singh, Introduction to Basic Manufacturing Processes and Workshop
- ✓ Technology, New Age International (P) Ltd., Publishers, 2006, ISBN (10) : 81-224- 2316-7.
- ✓ Mustafa Yurdakul, Yusuf Tansel İç, Modern İmalatın Prensipleri, Nobel Yayın Dağıtım, 2015.
- ✓ Serope Kalpakjian, Steven Schmid, Manufacturing Engineering & Technology, 7thEdition, Pearson
- ✓ PhilipD.Rufe, Fundamentals of Manufacturing 3rd Edition,Society of ManfuacturingEngineers
- ✓ John A.S.,Introduction to Manufacturing Processes,M cGrawHill.

- **Don’t be afraid to Google it!**

Introduction

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 is accomplished by automated and computer-controlled machinery.
• Economically, manufacturing has an important means by which a nation creates material wealth.

Introduction

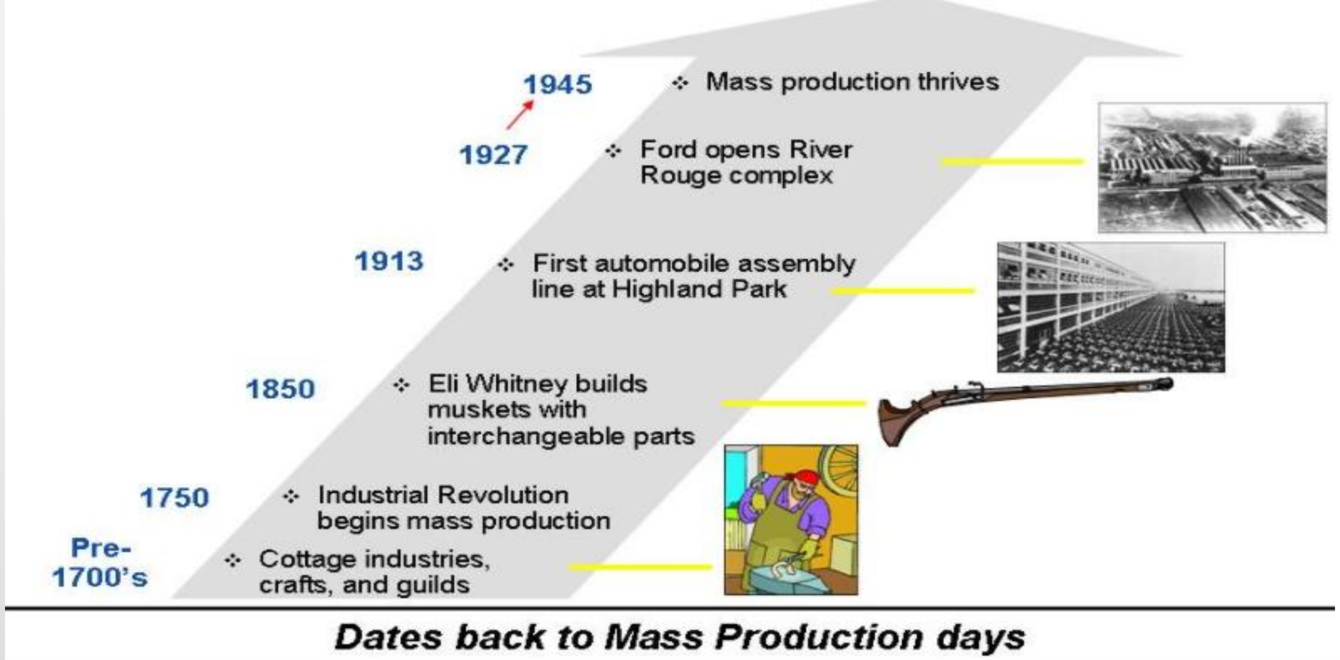
History of manufacturing

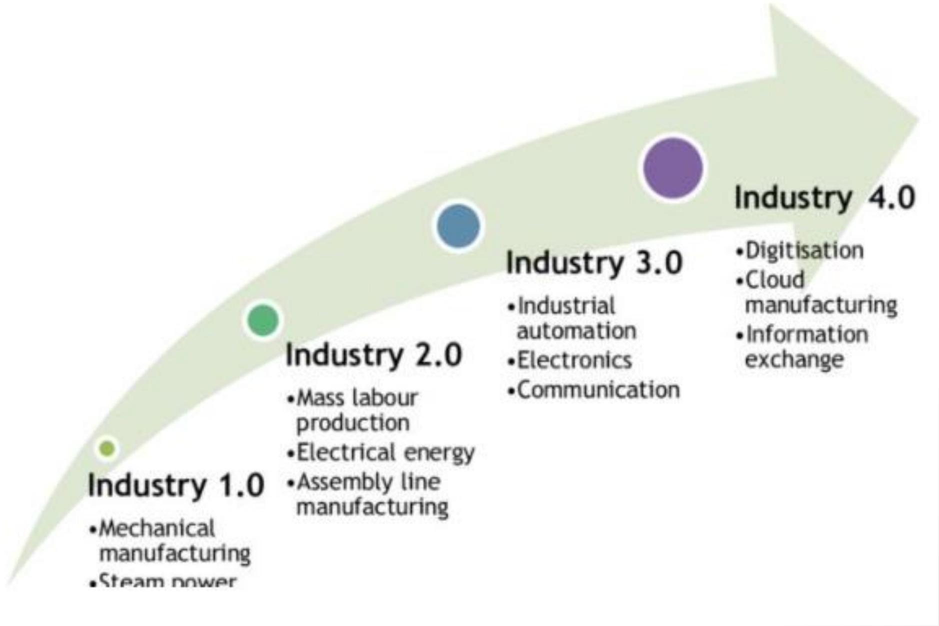
The history of manufacturing can be separated into two subjects:

(1) Human’s discovery and invention of materials and processes to make things, and

(2) Development of the systems of manufacturing. Some of the processes—casting, hammering (forging), and grinding—date back 6000 years or more.

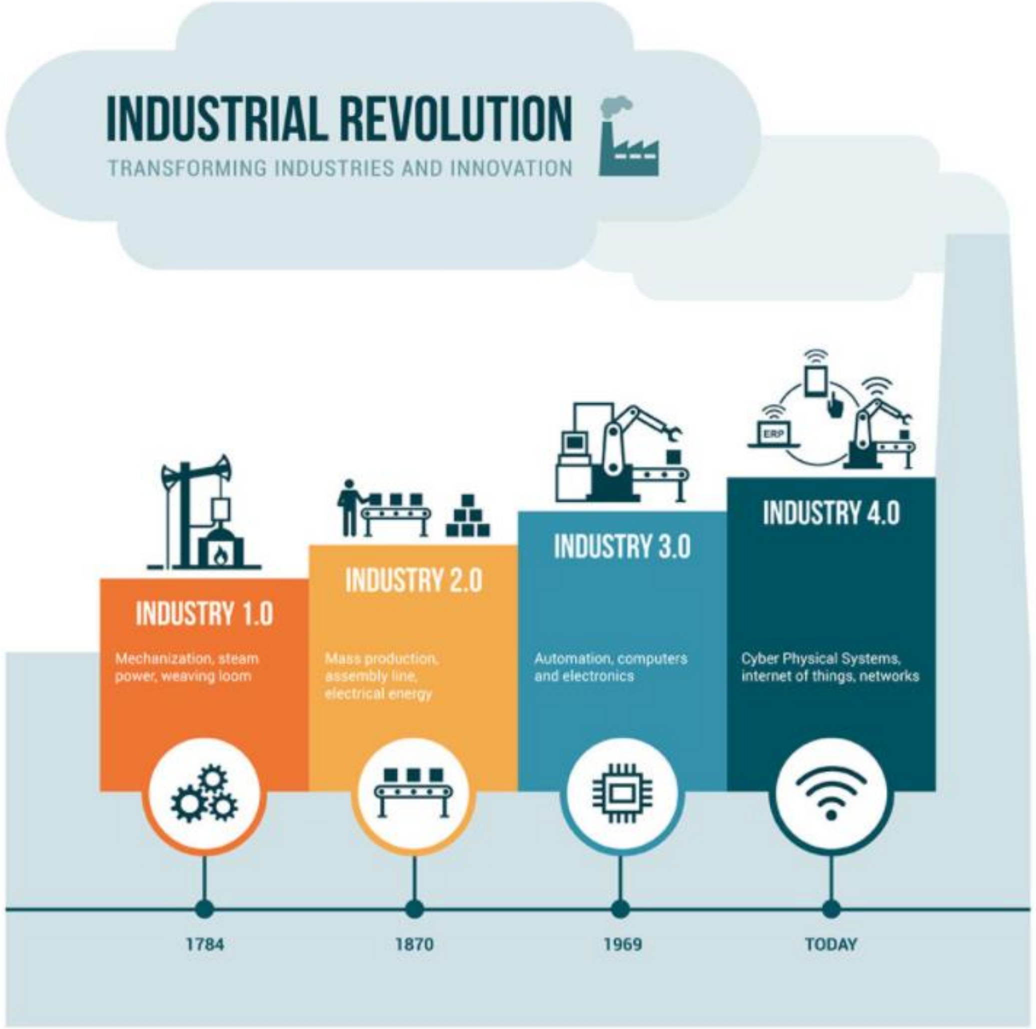
Systems of manufacturing refer to the ways of organizing people and equipment so that production can be performed more efficiently.





Introduction- Latest developements: I4.0

In 2011, the German government have brought into the world a new heading called Industry 4.0(I4.0), assumed as the fourth industrial revolution. I4.0 aim is to work with a higher level of automatization achieving a higher level of operational productivity and efficiency, connecting the physical to the virtual world. It will bring computerization and inter-connection into the traditional industry. *

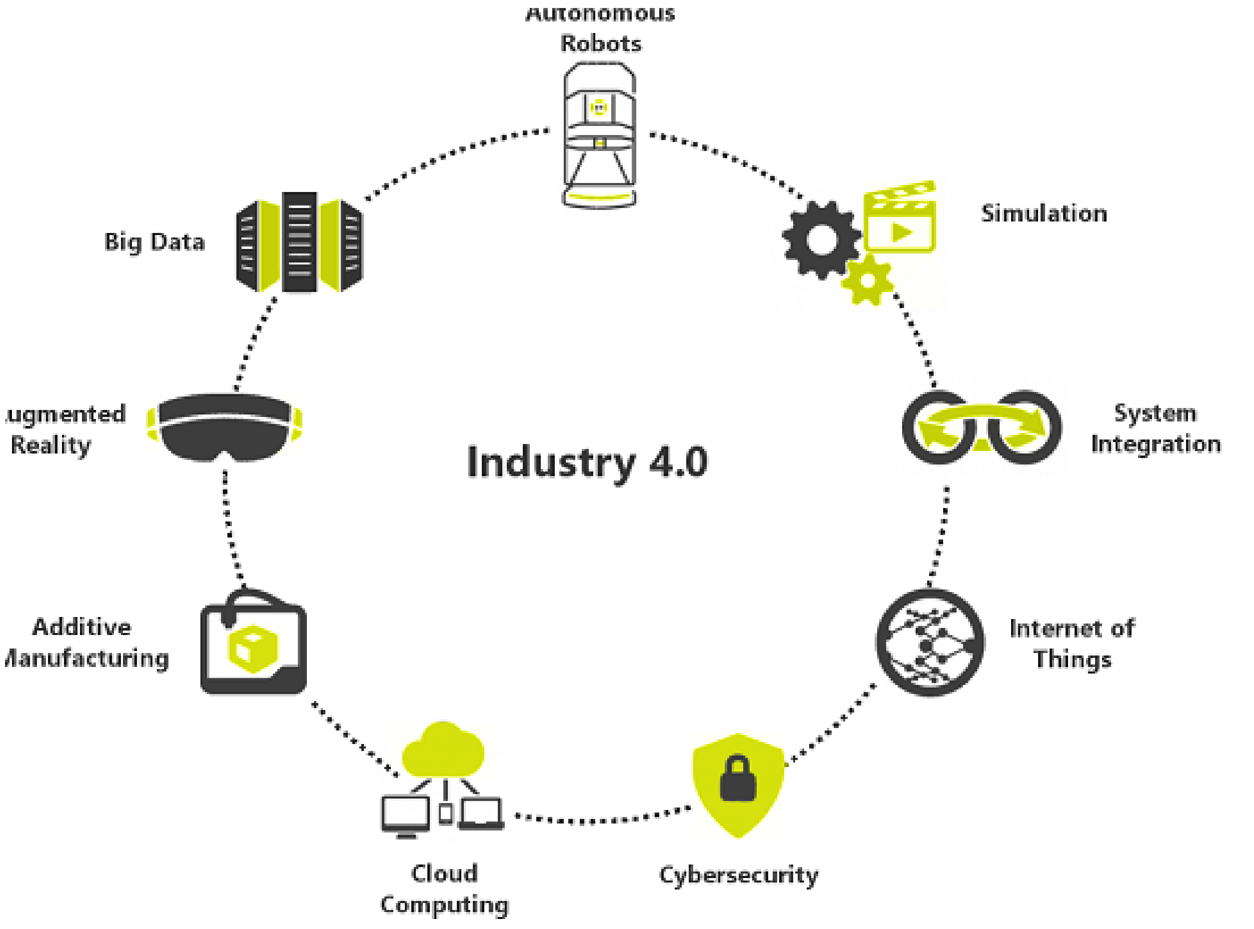


https://www.youtube.com/watch?v=VU5ns5sFN7I

V.Alcácer, V.Cruz-Machado, Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems, Engineering Science and Technology, an International Journal Volume 22, Issue 3, June 2019, Pages 899-919

Introduction- Latest developements: I4.0

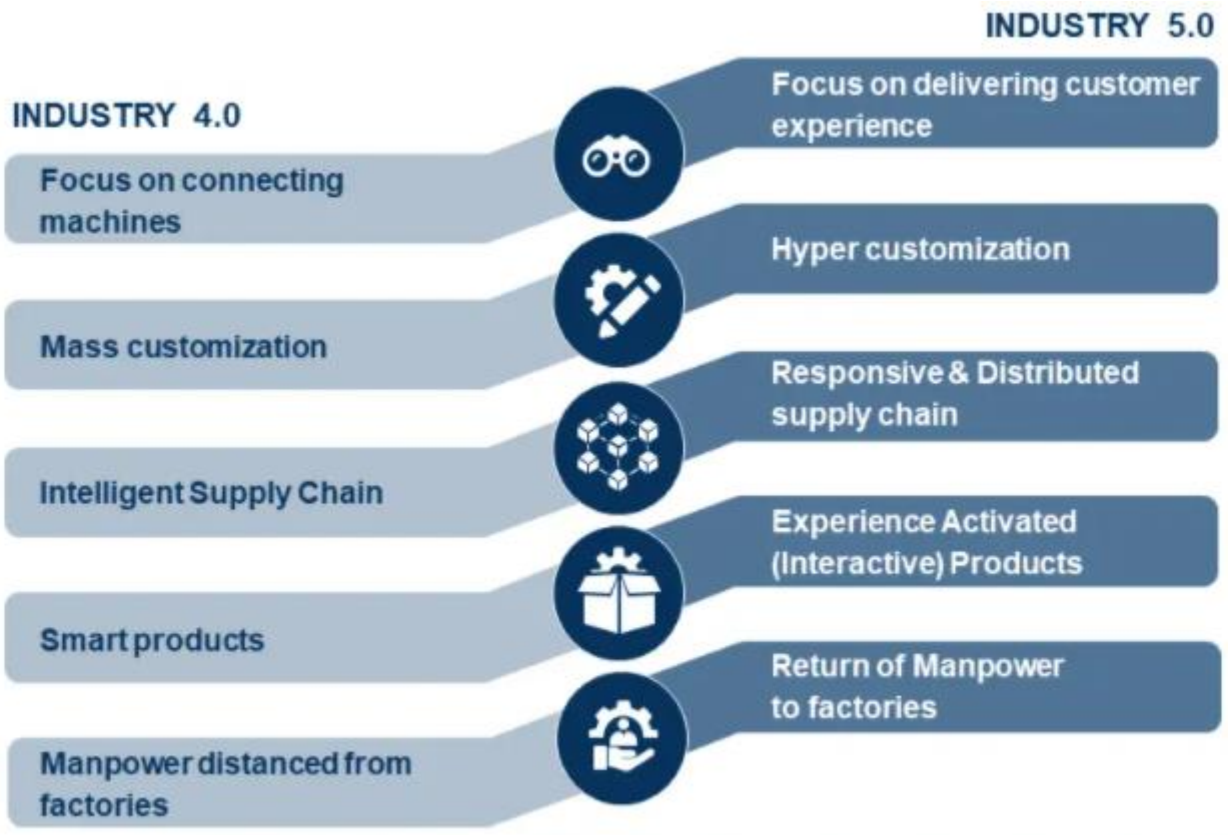
- Industry 4.0 is distinctly different from the age of the computer which preceded it. Industry 4.0 is characterized by a fusion of new technologies that is blurring the lines between the physical and digital worlds of manufacturing. The increasing prevalence of Cyber-Physical Systems (CPSs), Internet of Things (IoT) and **Cloud Computing** has been the driving force behind the technological advancements in manufacturing that have triggered a new industrial revolution. Moreover, this trend towards industrial digitalization is evolving at a velocity, scope and systems impact never before experienced in the history of manufacturing. The basic premise of Industry 4.0 is that new technologies are enabling businesses to connect people, things, machines, and systems in order to create intelligent networks along the entire value chain. By merging the virtual and physical worlds of manufacturing, billions of machines, systems and sensors will communicate with each other, share information and control each other autonomously. This will not only enable companies to make production significantly more efficient, it will give them greater flexibility when it comes to tailoring production to meet consumer demands and market requirements.*



*https://www.engusa.com/en/posts/welcome-to-the-future-industry-4-0

Introduction- Latest developements: I5.0

What about I5.0??



https://www.youtube.com/watch?v=VU5ns5sFN7I&t=2s

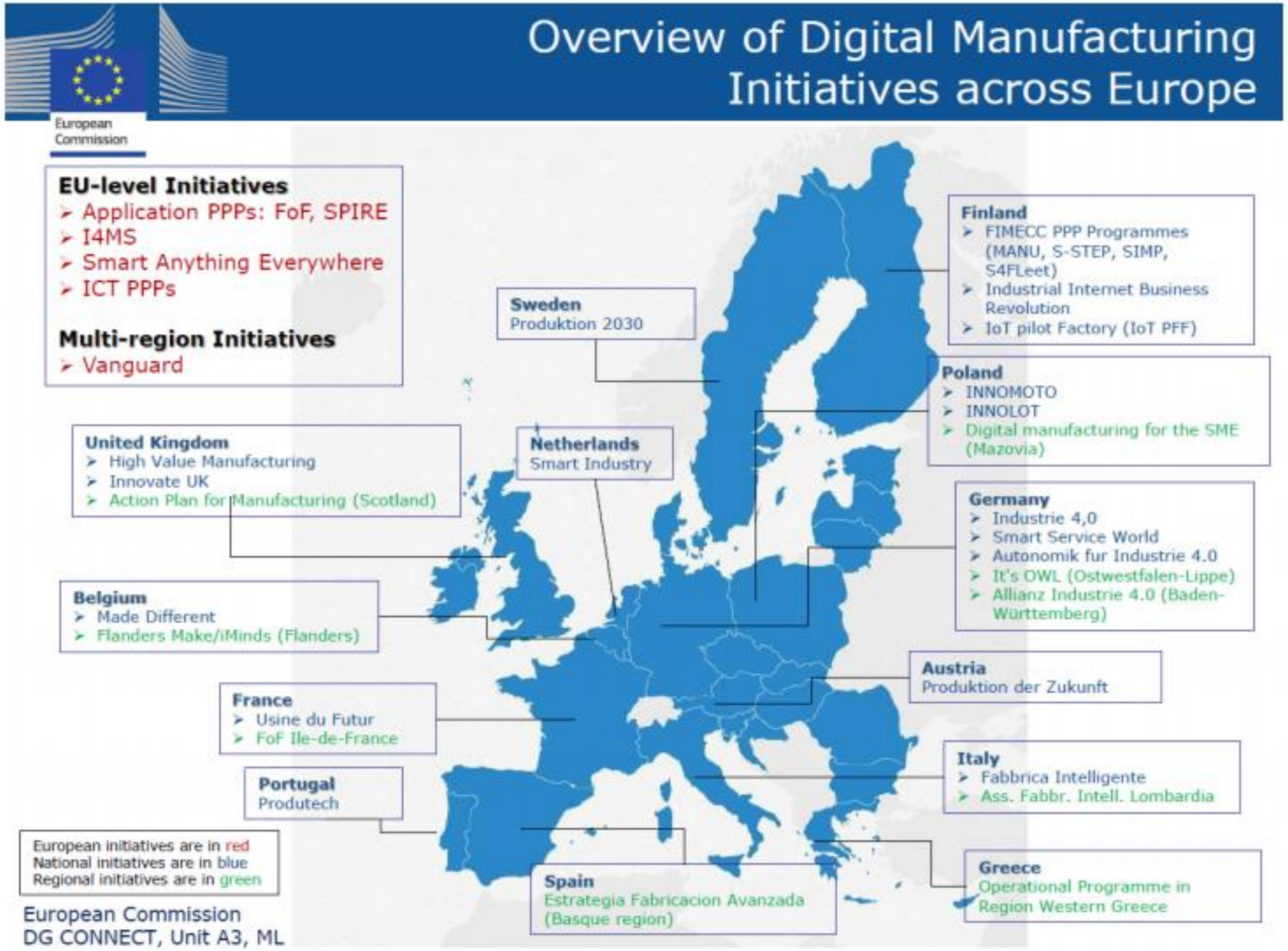
*https://ww2.frost.com/frost-perspectives/industry-5-0-bringing-empowered-humans-back-to-the-shop-floor/

Introduction- Latest developements: I5.0

The enablers of I5.0:

*https://ww2.frost.com/frost-perspectives/industry-5-0-bringing-empowered-humans-back-to-the-shop-floor/

Introduction- An overview from Europe



Introduction

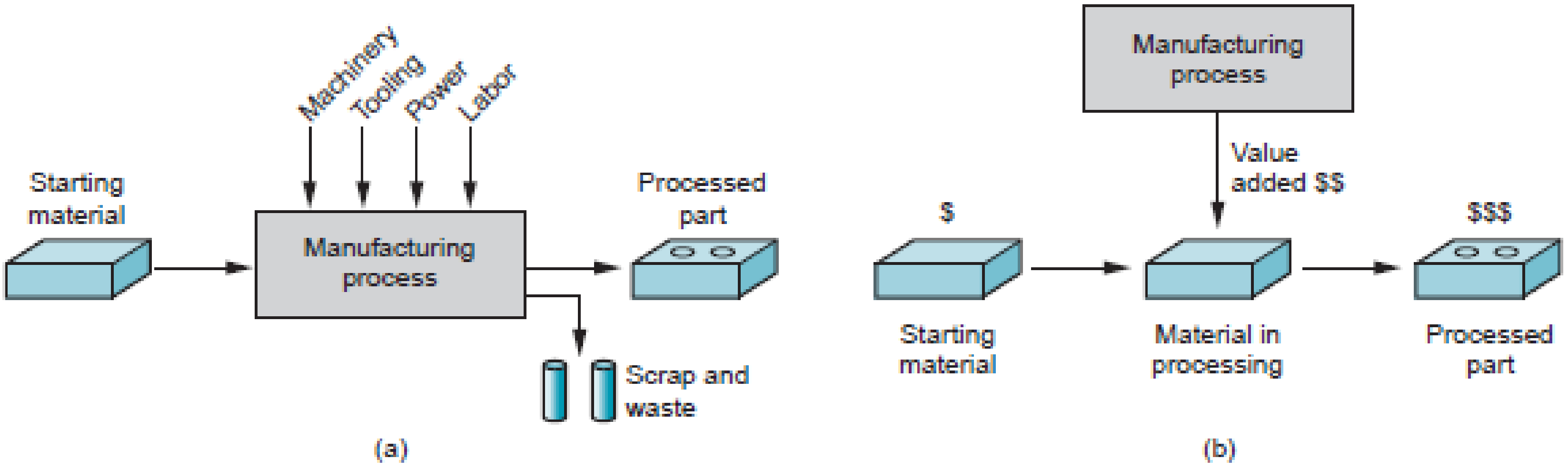
Defination of Manufacturing

In modern context, manufacturing can be defined two ways, one *technologic* and the other *economic*. *Technologically*, manufacturing is the 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 assembly of multiple parts to make products.

The processes to accomplish manufacturing involve a combination of machinery, tools, power, and labor.

Introduction

Defination of Manufaturing

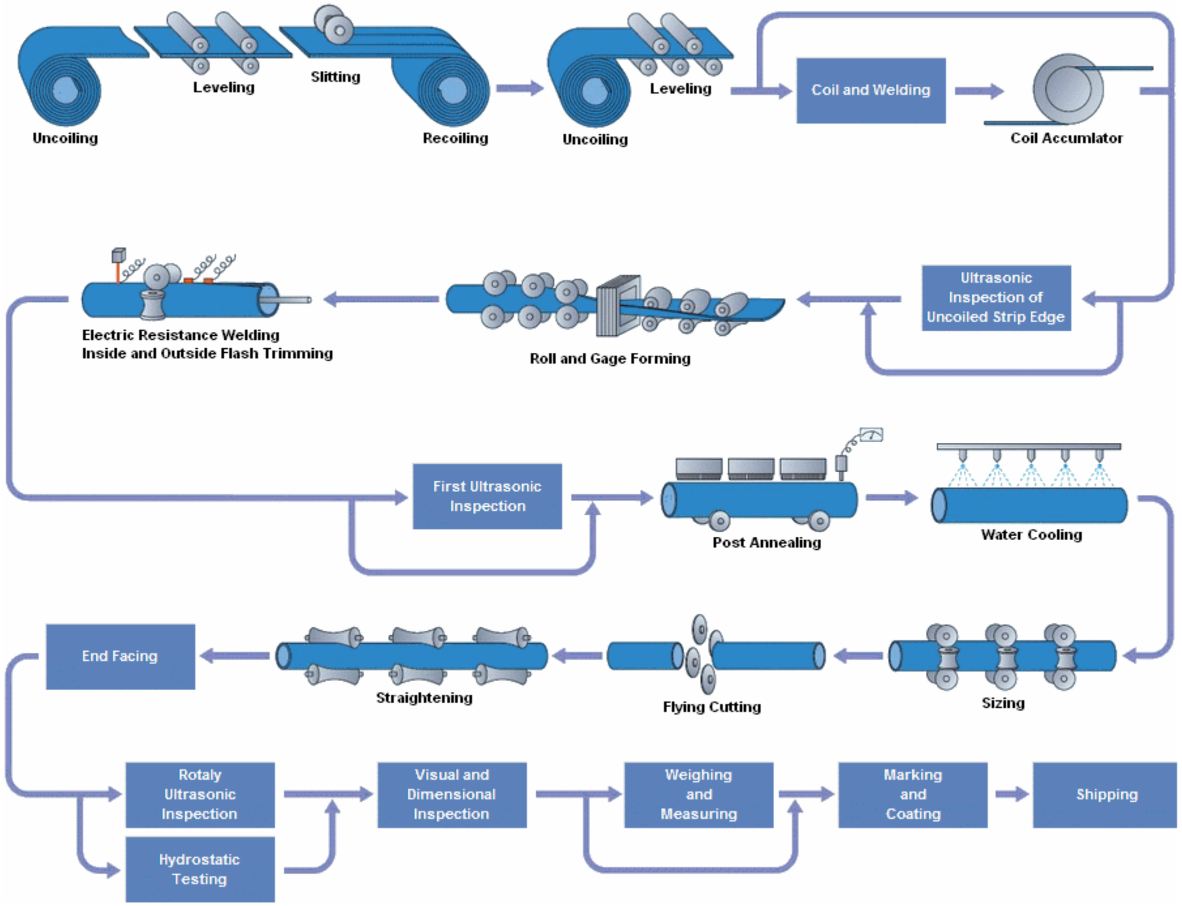


Two ways to define manufacturing: (a) as a technical process, and (b) as an economic process.

Introduction

Defination of Manufaturing

Economically, manufacturing is the transformation of materials into items of greater value by means of one or more processing and/or assembly operations.
The key point is that manufacturing adds value to the material by changing its shape or properties, or by combining it with other materials that have been similarly altered. The material has been made more valuable through the manufacturing operations performed on it. When iron ore is converted into steel, value is added. When sand is transformed into glass, value is added. When petroleum is refined into plastic, value is added. And when plastic is molded into the complex geometry of a patio chair, it is made even more valuable.



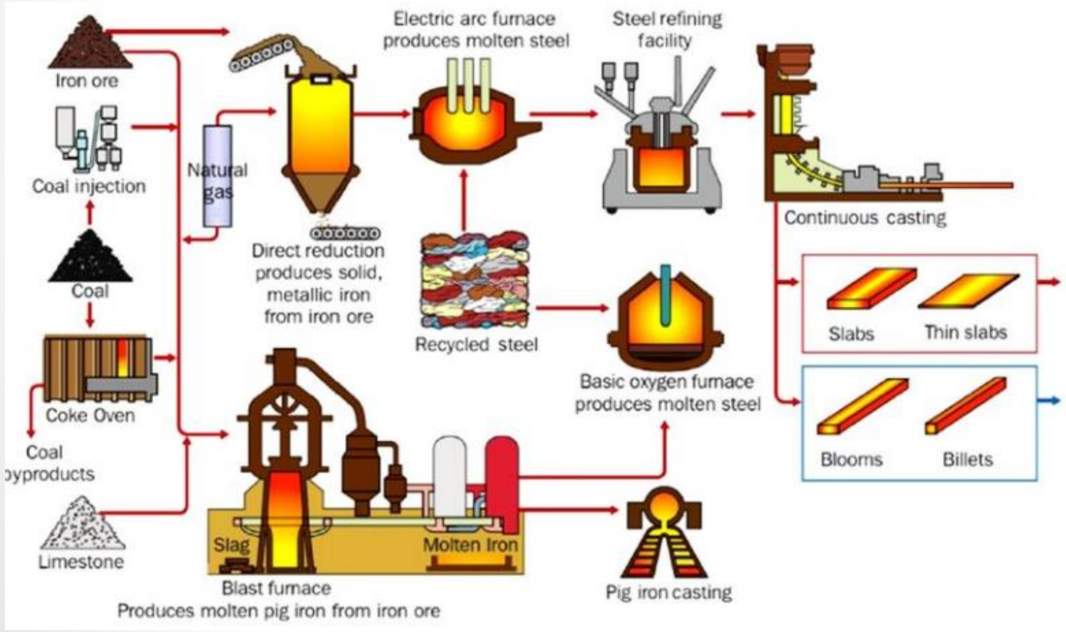
Steel pipe manufaturing*

*http://www.wermac.org/pipes/pipemaking.html

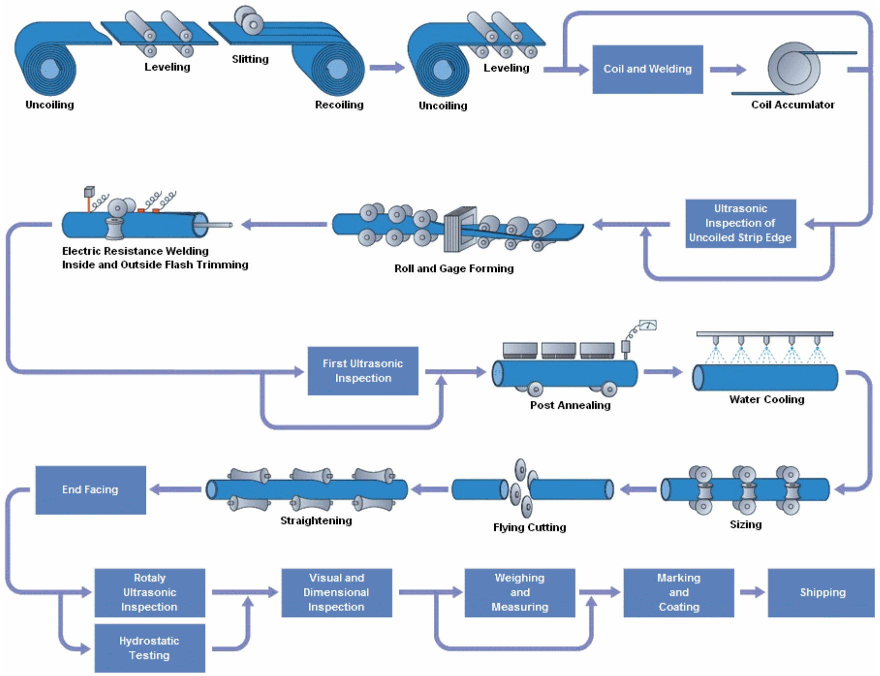
Introduction

Production or Manufacturing?

The words manufacturing and production are often used interchangeably. The production has a broader meaning than manufacturing. To illustrate, one might speak of ‘‘crude oil production,’’ but the phrase ‘‘crude oil manufacturing’’ seems out of place. Yet when used in the context of products such as metal parts or automobiles, either word seems okay.



Production



Manufacturing

*M. Saqlain, M. Owais, +2 authors Timo Fabritius, Desphosphorization in ironmaking and oxygen steelmaking Materials Science, 2018

Introduction

Manufacturing Industries

Industry consists of enterprises and organizations that produce or supply goods and services. Industries can be classified as primary, secondary, or tertiary.

- Primary industries cultivate and exploit natural resources, such as agriculture and mining.
- Secondary industries take the outputs of the primary industries and convert them into consumer and capital goods. Manufacturing is the principal activity in this category, but construction and power utilities are also included.
- Tertiary industries constitute the service sector of the economy.

Specific industries in the primary, secondary, and tertiary categories.

Primary	Secondary		Tertiary (Service)	
Agriculture	Aerospace	Food processing	Banking	Insurance
Forestry	Apparel	Glass, ceramics	Communications	Legal
Fishing	Automotive	Heavy machinery	Education	Real estate
Livestock	Basic metals	Paper	Entertainment	Repair and maintenance
Quarries	Beverages	Petroleum refining	Financial services	Restaurant
Mining	Building materials	Pharmaceuticals	Government	Retail trade
Petroleum	Chemicals	Plastics (shaping)	Health and medical	Tourism
	Computers	Power utilities	Hotel	Transportation
	Construction	Publishing	Information	Wholesale trade
	Consumer appliances	Textiles		
	Electronics	Tire and rubber		
	Equipment	Wood and furniture		
	Fabricated metals			

Introduction

Manufactured Goods

Final products made by the manufacturing industries can be divided into two major classes: *consumer goods and capital goods.*

•*Consumer goods* are products purchased directly by consumers(end users), such as cars, personal computers, TVs, tires, and tennis rackets.

•*Capital goods* are those purchased by companies to produce goods and/or provide services.

Examples of capital goods include aircrafts, computers, communication equipment, medical apparatus, trucks and buses, rail road locomotives, machine tools, and construction equipment.

Introduction

Production Quantity and Product Variety

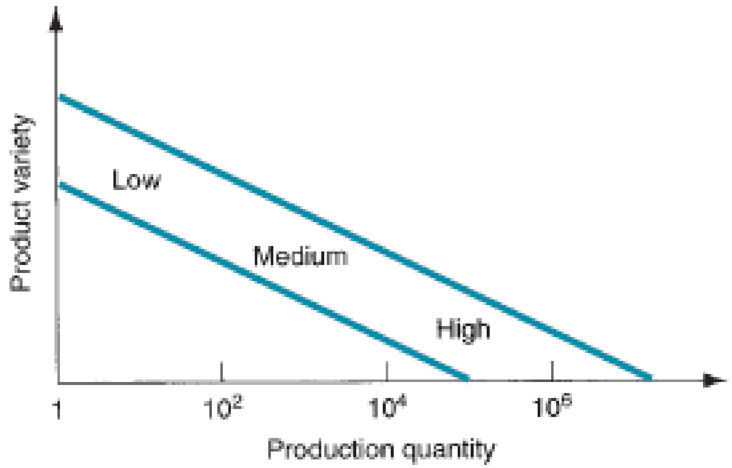
The quantity of products made by a factory has an important influence on the way its people, facilities, and procedures are organized. Annual production quantities can be classified into three ranges:

(1) low production, quantities in the range 1 to 100 units per year;

(2) medium production, from 100 to 10,000 units annually; and

(3) high production, 10,000 to millions of units.

The boundaries between the three ranges are somewhat arbitrary (in the author's judgment). Depending on the kinds of products, these boundaries may shift by an order of magnitude or so.



Relationship between product variety and production quantity in discrete product manufacturing.

Introduction

Production Quantity and Product Variety

Production quantity refers to the number of units produced annually of a particular product type. Some plants produce a variety of different product types, each type being made in low or medium quantities. Other plants specialize in high production of only one product type. It is instructive to identify product variety as a parameter distinct from production quantity.

Product variety refers to different product designs or types that are produced in the plant. Different products have different shapes and sizes; they perform different functions; they are intended for different markets; some have more components than others; and so forth. The number of different product types made each year can be counted. When the number of product types made in the factory is high, this indicates high product variety.

Soft product variety occurs when there are only small differences among products, such as the differences among car models made on the same production line. In an assembled product, soft variety is characterized by a high proportion of common parts among the models.

Hard product variety occurs when the products differ substantially, and there are few common parts, if any. The difference between a car and a truck exemplifies hard variety.

Introduction

Manufacturing Capability

A manufacturing plant consists of a set of processes and systems (and people, of course) designed to transform a certain limited range of materials into products of increased value. These three building blocks—materials, processes, and systems—constitute the subject of modern manufacturing.

Manufacturing capability refers to the technical and physical limitations of a manufacturing firm and each of its plants. Several dimensions of this capability can be identified:
(1) technological processing capability,
(2)physical size and weight of product,
and (3) production capacity.

Introduction

Manufacturing Capability

The technological processing capability of a plant (or company) is its available set of manufacturing processes. Certain plants perform machining operations, others roll steel billets into sheet stock, and others build automobiles. A machine shop cannot roll steel, and a rolling mill cannot build cars. The underlying feature that distinguishes these plants is the processes they can perform. Technological processing capability includes not only the physical processes, but also the expertise possessed by plant personnel in these processing technologies.

Physical Product Limitations A second aspect of manufacturing capability is imposed by the physical product. The limitation on product size and weight extends to the physical capacity of the manufacturing equipment as well.

Production Capacity A third limitation on a plant's manufacturing capability is the production quantity that can be produced in a given time period (e.g., month or year). This quantity limitation is commonly called plant capacity, or production capacity, defined as the maximum rate of production that a plant can achieve under assumed operating conditions. The operating conditions refer to number of shifts per week, hours per shift, direct labor manning levels in the plant, and so on.

Introduction

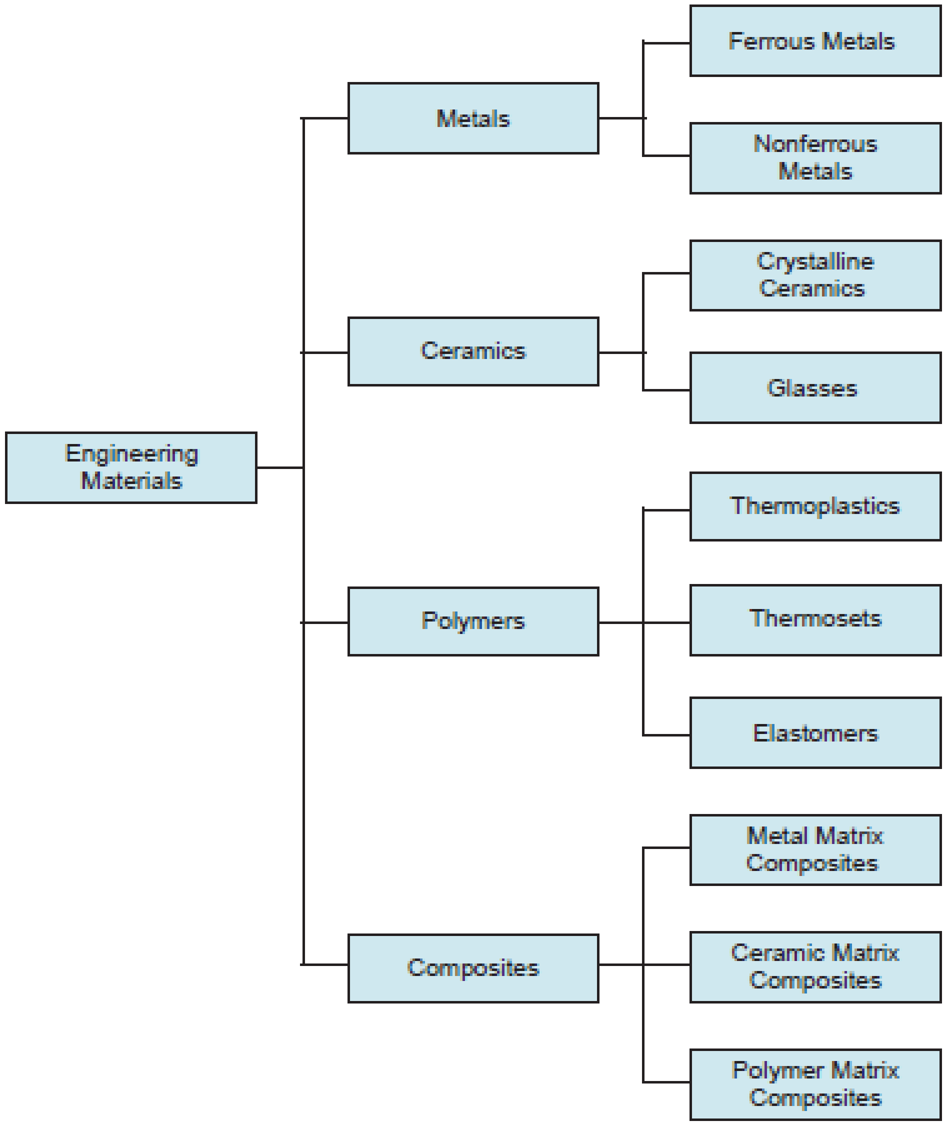
Materials In Manufacturing

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

(1) Metals (Fe (iron) based and non- ferrous)
(2) Ceramics, and (containing metallic (or semi metallic) and nonmetallic elements)
(3) Polymers (thermoplastics, thermsettings, elastomers)
(4) Composites (nonhomogenous mixture of the other three basic types)

Their chemistries are different, their mechanical and physical properties are different, and these differences affect the manufacturing processes that can be used to produce products from them.

Introduction



Classification of the four engineering materials.

Introduction

Metals

Metals used in manufacturing are usually alloys, which are composed of two or more elements, with at least one being a metallic element. Metals and alloys can be divided into two basic groups: (1) ferrous and (2) nonferrous.

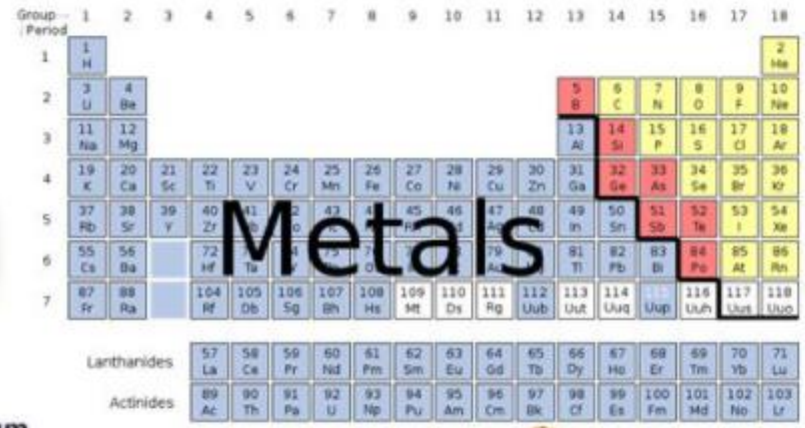
Ferrous Metals are based on iron; the group includes steel and cast iron. These metals constitute the most important group commercially, more than three fourths of the metal tonnage throughout the world. Pure iron has limited commercial use, but when alloyed with carbon, iron has more uses and greater commercial value than any other metal. Alloys of iron and carbon form steel and cast iron.

Steel can be defined as an iron–carbon alloy containing 0.02% to 2.11%carbon. It is the most important category within the ferrous metal group. Its composition often includes other

Alloying elements as well, such as manganese, chromium, nickel, and molybdenum, to enhance the properties of the metal. Applications of steel include construction (bridges, I-beams, and nails), transportation (trucks, rails, and rolling stock for railroads), and consumer products (automobiles and appliances).

Introduction

Metals



Introduction

Ceramics

A ceramic is defined as a compound containing metallic (or semimetallic) and nonmetallic elements. Typical nonmetallic elements are oxygen, nitrogen, and carbon.

Traditional ceramics, some of which have been used for thousands of years, include: clay (kil) (abundantly available, consisting of fine particles of hydrous aluminum silicates and other minerals used in making brick, tile, and pottery); silica (the basis for nearly all glass products); and alumina and silicon carbide (two abrasive materials used in grinding).

Modern ceramics include some of the preceding materials, such as alumina. Carbides—metal carbides such as tungsten carbide and titanium carbide, which are widely used as cutting tool materials; and nitrides—metal and semimetal nitrides such as titanium nitride and boron nitride, used as cutting tools and grinding abrasives

Introduction

Ceramics

Introduction

Polymers

A polymer is a compound formed of repeating structural units called mers, whose atoms share electrons to form very large molecules. Polymers usually consist of carbon plus one or more other elements, such as hydrogen, nitrogen, oxygen, and chlorine. Polymers are divided into three categories:

(1) Thermoplastic polymers,

Subjected to multiple heating and cooling cycles without substantially altering the molecular structure of the polymer. Common thermoplastics include polyethylene, polystyrene, polyvinylchloride, and nylon.

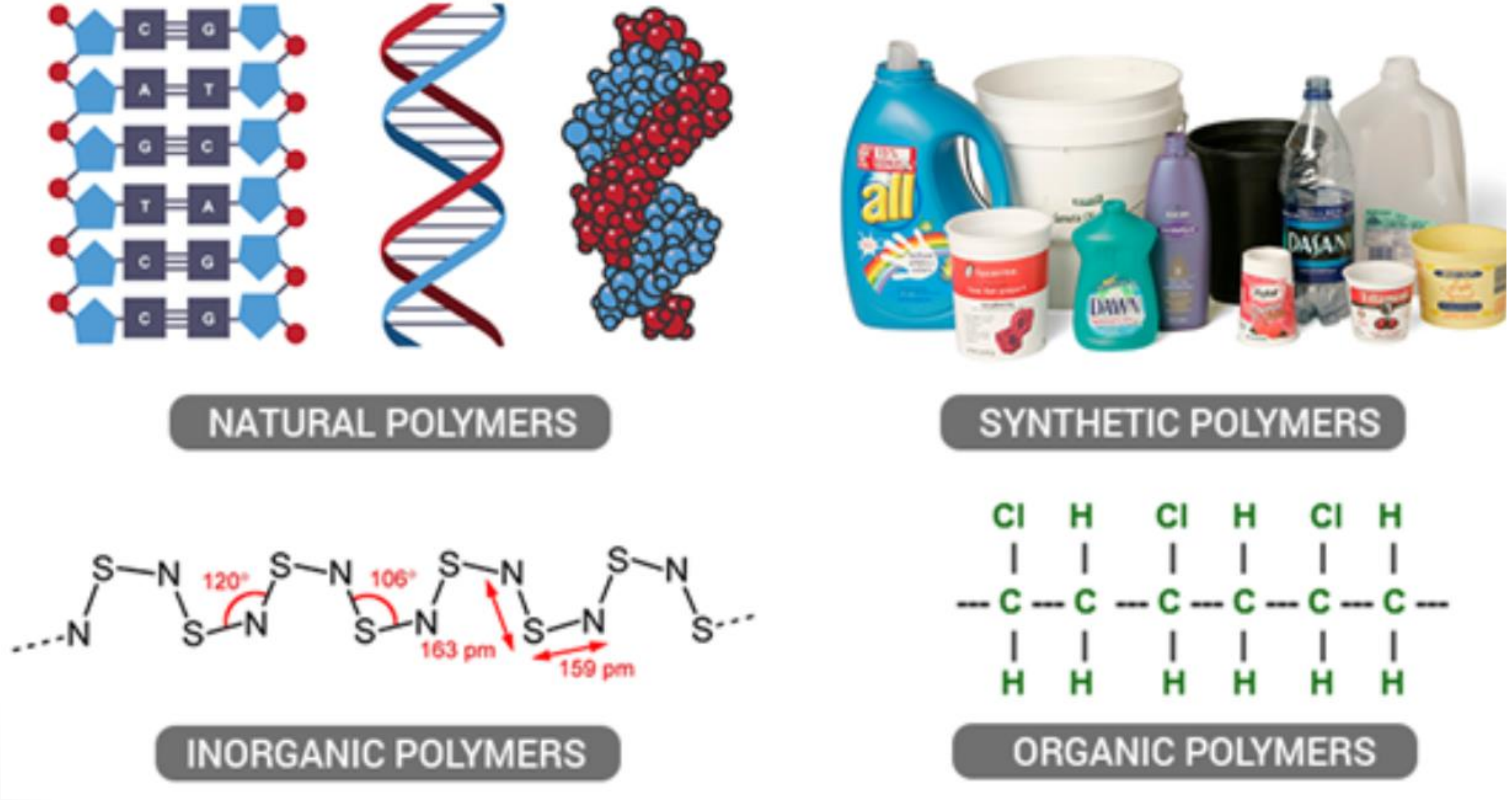
(2) Thermosetting polymers,

Thermosetting polymers chemically transform (cure) into a rigid structure on cooling from a heated plastic condition; hence the name thermosetting.

(3) Elastomers are polymers that exhibit significant elastic behavior; hence the name elastomer. They include natural rubber, neoprene, silicone, and polyurethane

Introduction

Polymers



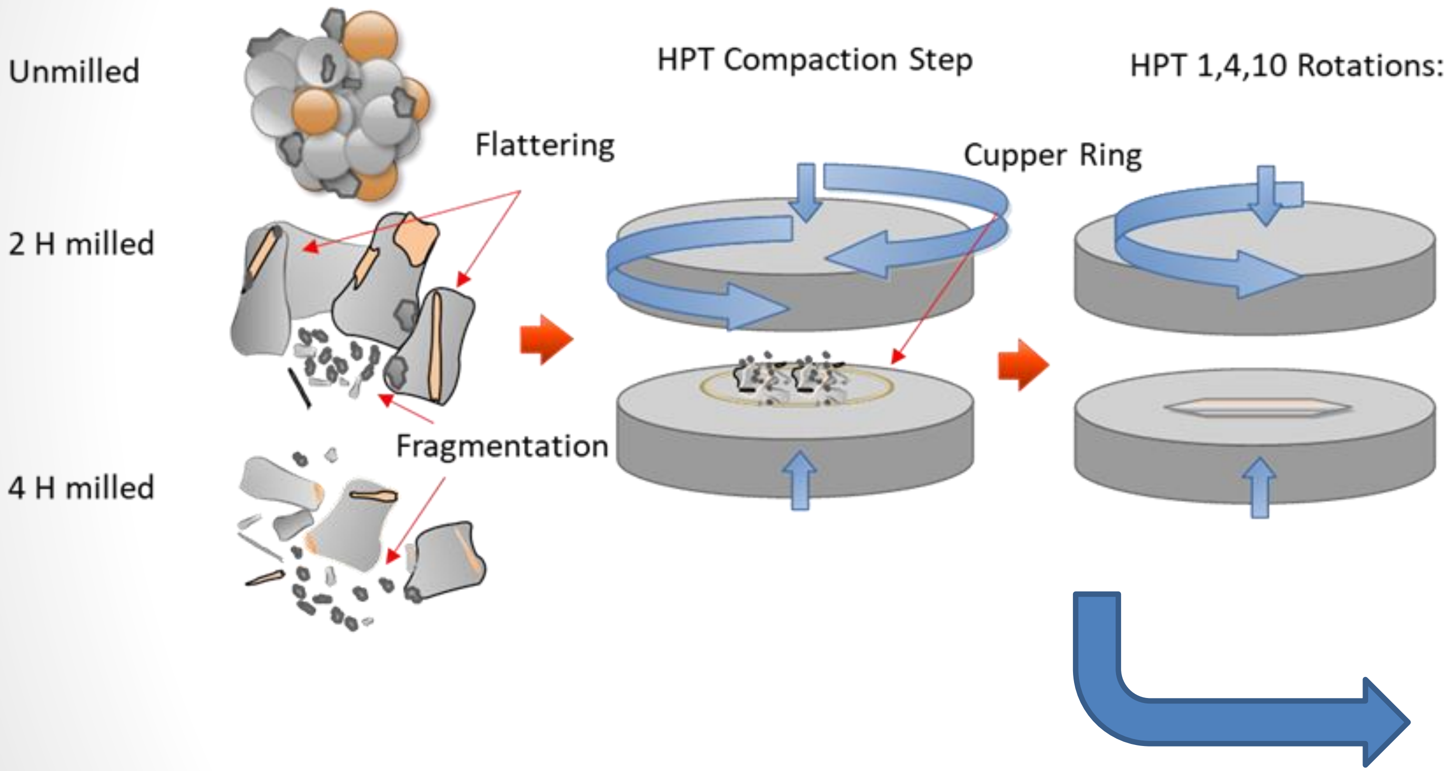
Introduction

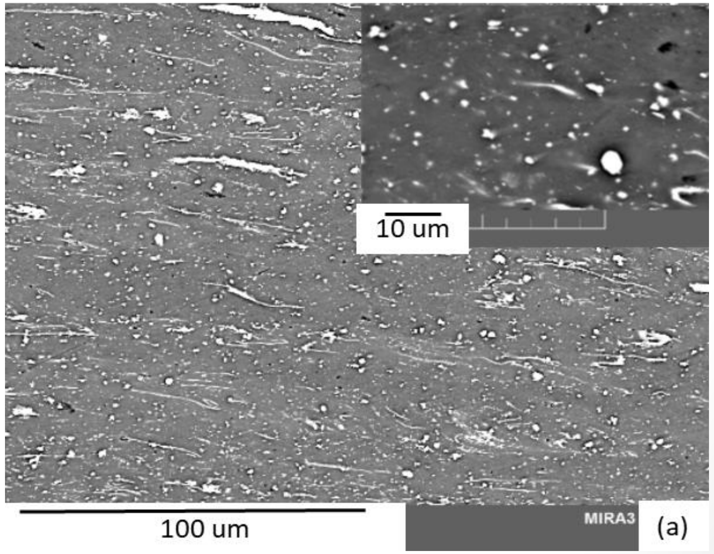
Composites

Composites do not really constitute a separate category of materials; they are mixtures of the other three types. A composite is a material consisting of two or more phases that are processed separately and then bonded together to achieve properties superior to those of its constituents. The term phase refers to a homogeneous mass of material, such as an aggregation of grains of identical unit cell structure in a solid metal. The usual structure of a composite consists of particles or fibers of one phase mixed in a second phase, called the matrix.

Introduction

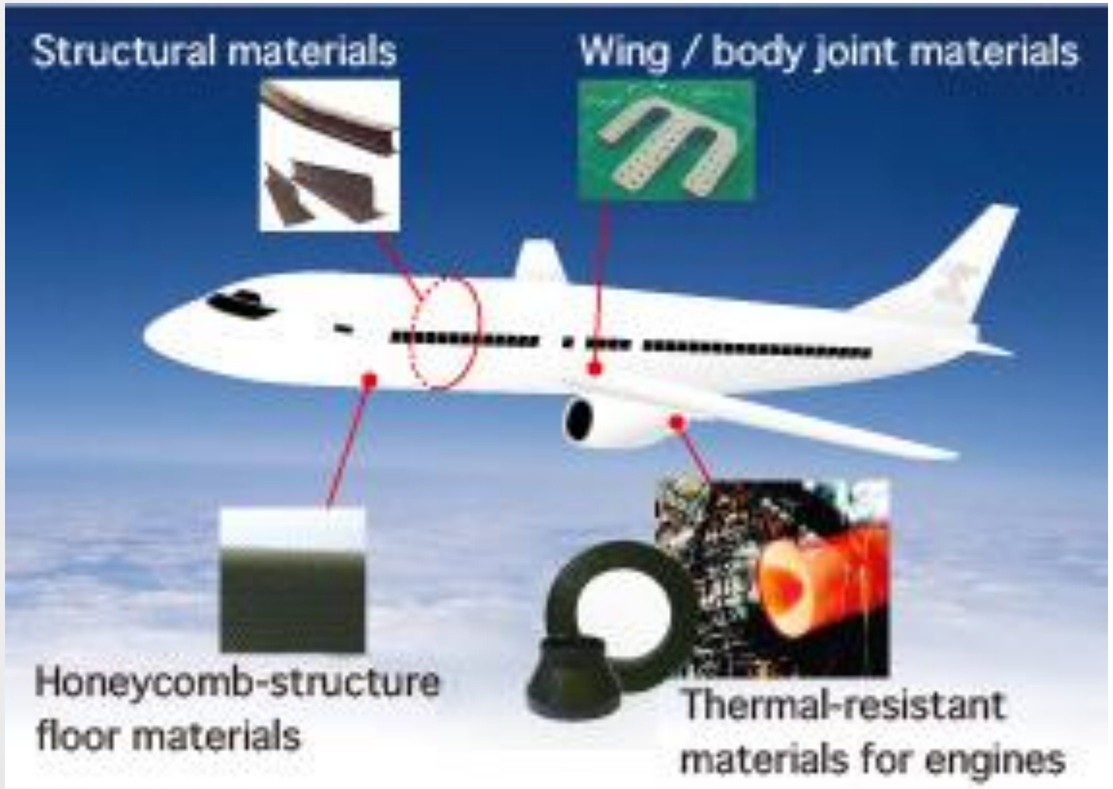
Composites

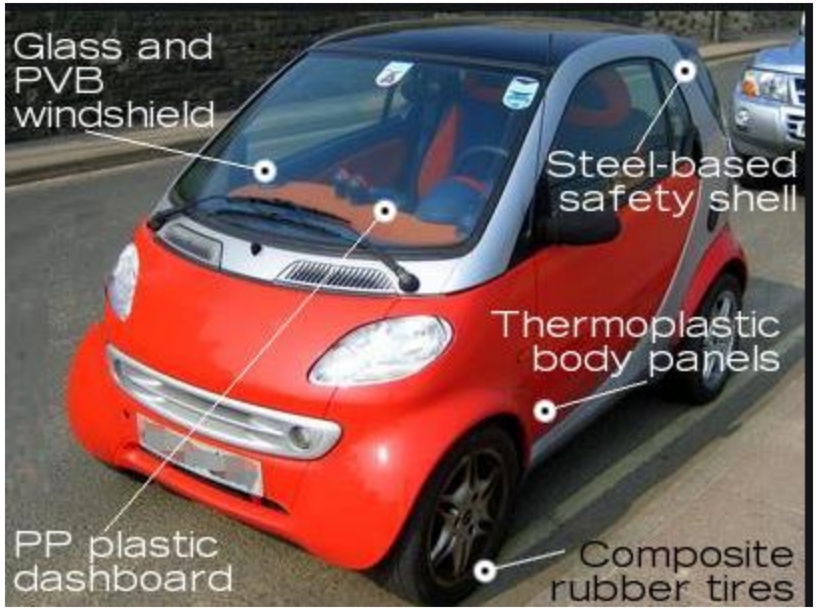




Introduction

Composites





MANUFACTURING PROCESS

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. A manufacturing process is usually carried out as a unit operation ,which means that it is a single step in the sequence of steps required to transform the starting material into a final product. Manufacturing operations can be divided into two basic types:

(1) processing operations

A processing operation transforms a work material from one state of completion to a more advanced state that is closer to the final desired product. It adds value by changing the geometry, properties, or appearance of the starting material. e.g., painting a spot-welded car body).

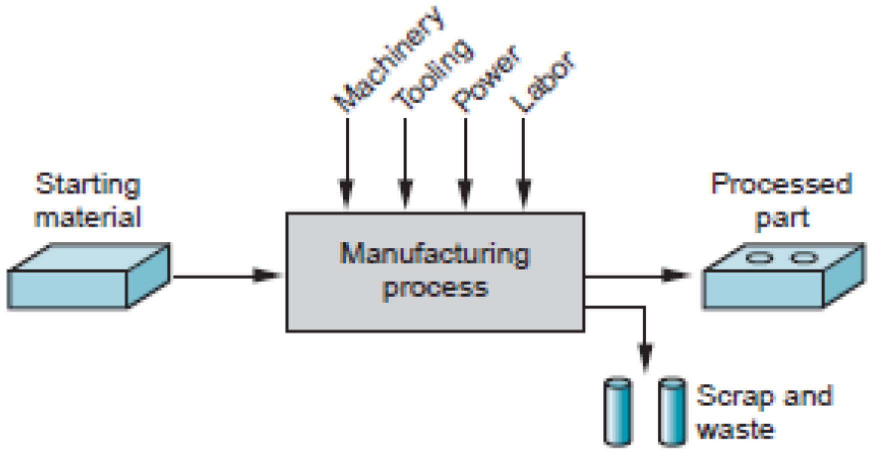
(2) assembly operations

An assembly operation joins two or more components to create a new entity, called an assembly, subassembly, or some other term that refers to the joining process (e.g., a welded assembly is called a weldment).

MANUFACTURING PROCESS

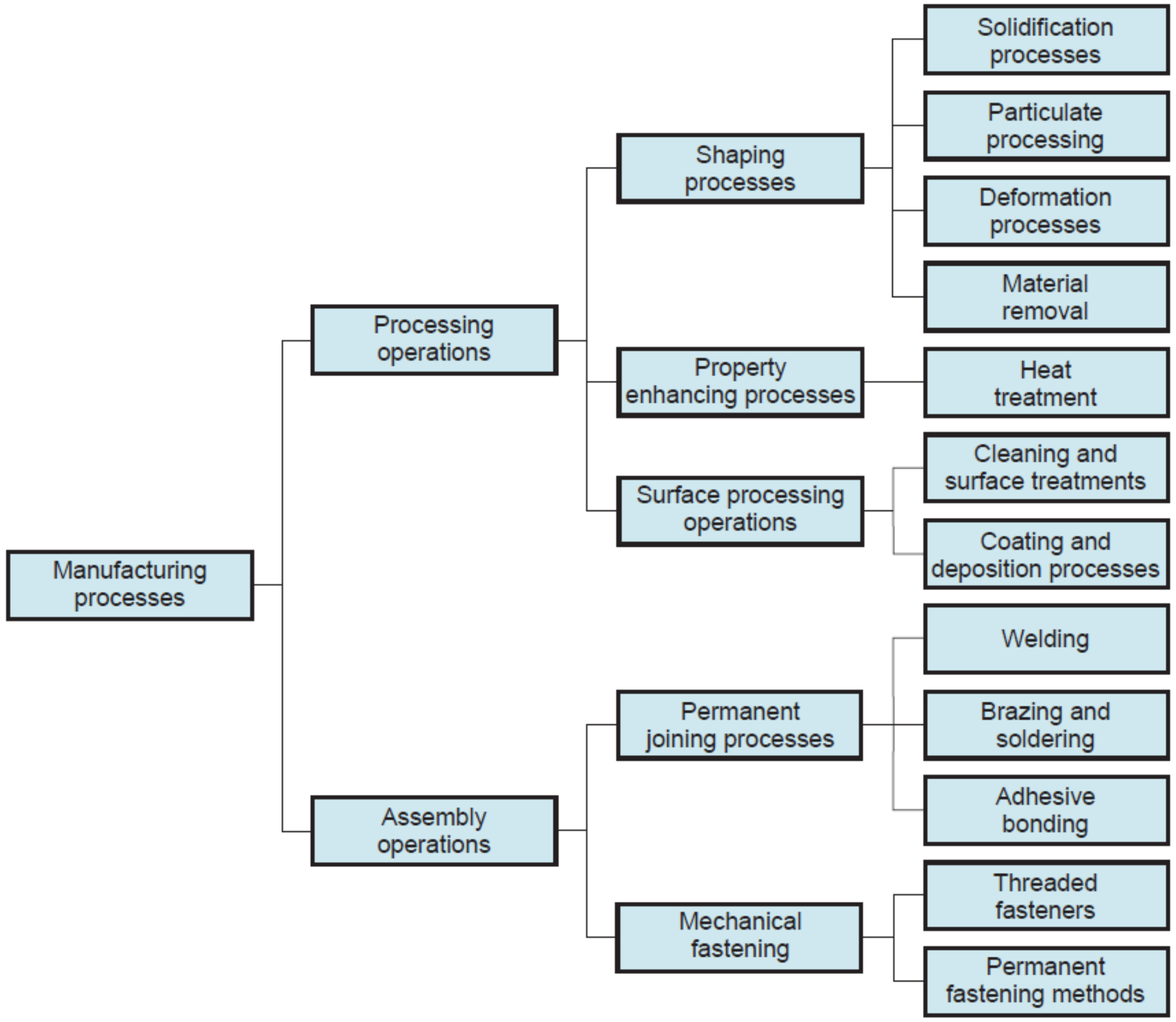
PROCESSING OPERATIONS

A processing operation uses energy to alter a workpart's shape, physical properties, or appearance to add value to the material. The forms of energy include mechanical, thermal, electrical, and chemical. The energy is applied in a controlled way by means of machinery and tooling. Human energy may also be required, but the human workers are generally employed to control the machines, oversee the operations, and load and unload parts before and after each cycle of operation.



MANUFACTURING PROCESS

PROCESSING OPERATIONS



MANUFACTURING PROCESS

PROCESSING OPERATIONS

Three categories of processing operations are distinguished:

(1) Shaping operations

Shaping operations alter the geometry of the starting work material by various methods. Common shaping processes include casting, forging, and machining.

(2) Property-enhancing operations

Property-enhancing operations add value to the material by improving its physical properties without changing its shape. Heat treatment is the most common example.

(3) Surface processing operations

Surface processing operations are performed to clean, treat, coat, or deposit material onto the exterior surface of the work. Common examples of coating are plating and painting.

MANUFACTURING PROCESS

PROCESSING OPERATIONS

Shaping operations

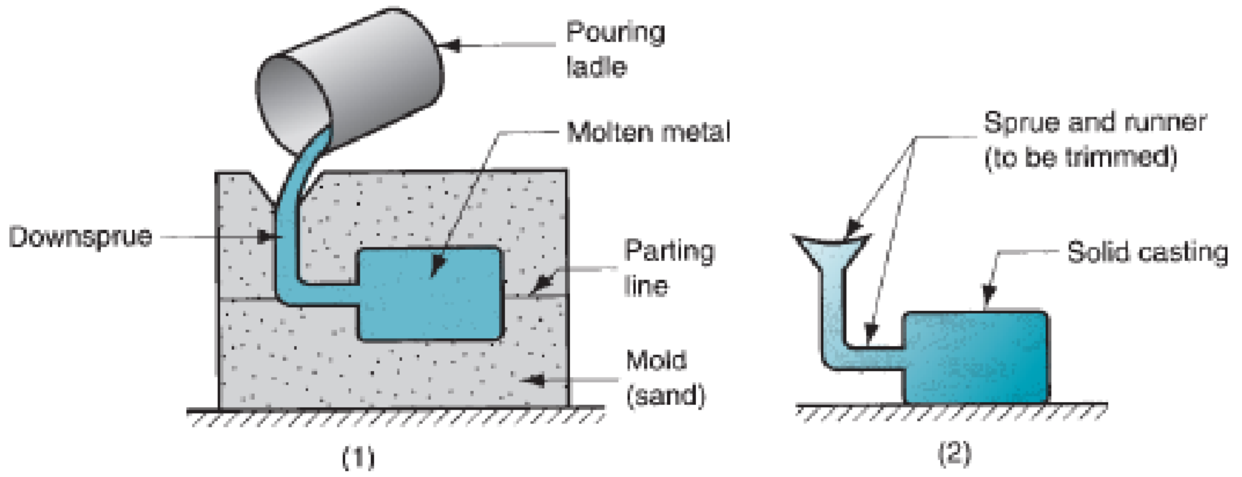
(1) Solidification processes, in which the starting material is a heated liquid or semifluid that cools and solidifies to form the part geometry;
(2) Powder processing, in which the starting material is a powder, and the powders are formed and heated into the desired geometry;
(3) deformation processes, in which the starting material is a ductile solid (commonly metal) that is deformed to shape the part;
(4) material removal processes, in which the starting material is a solid (ductile or brittle), from which material is removed so that the resulting part has the desired geometry.

MANUFACTURING PROCESS-PROCESSING OPERATIONS

Shaping operations
(1) Solidification processes

Metals, ceramic glasses, and plastics can all be heated to sufficiently high temperatures to convert them into liquids. With the material in a liquid or semifluid form, it can be poured or otherwise forced to flow into a mold cavity and allowed to solidify, thus taking a solid shape that is the same as the cavity. Most processes that operate this way are called casting or molding. Casting is the name used for metals, and molding is the common term used for plastics.

Casting and molding processes start with a work material heated to a fluid or semifluid state. The process consists of: (1) pouring the fluid into a mold cavity and (2) allowing the fluid to solidify, after which the solid part is removed from the mold.



MANUFACTURING PROCESS-PROCESSING OPERATIONS

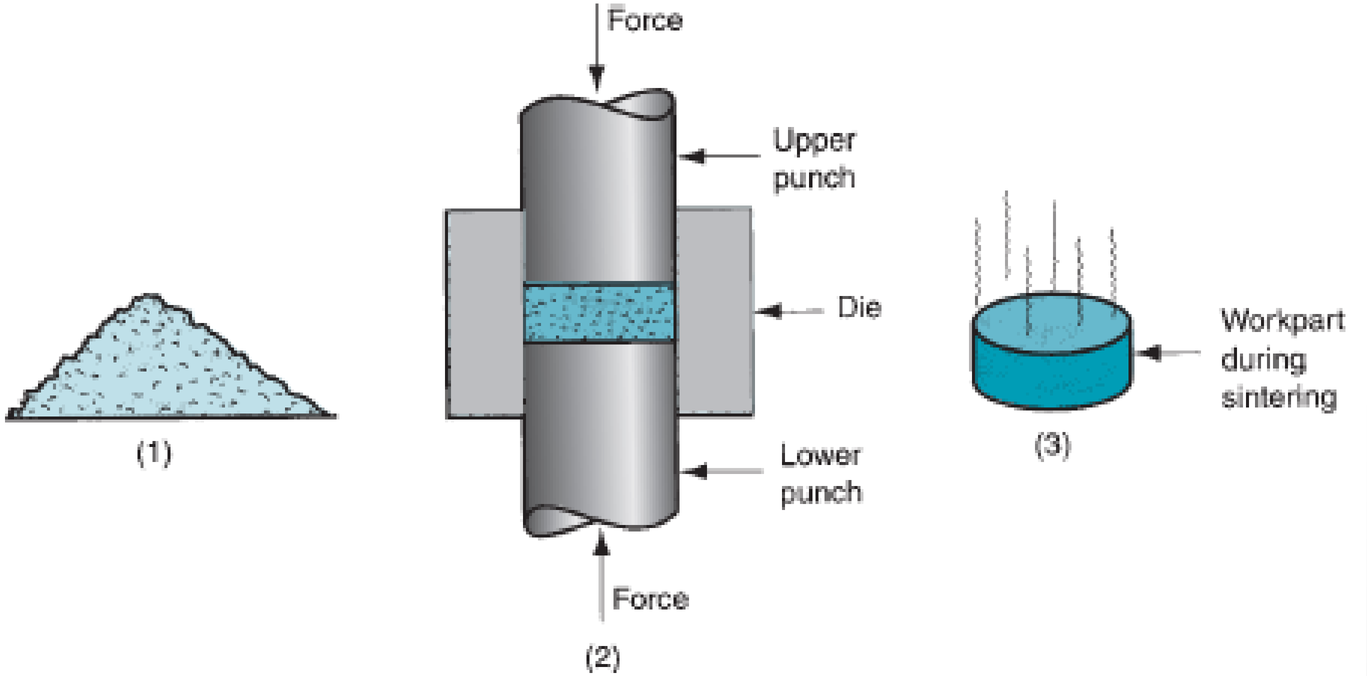
Shaping operations

Powder processing

the starting materials are powders of metals or ceramics.

Although these two materials are quite different, the processes to shape them in particulate processing are quite similar. The common technique involves pressing and sintering, illustrated in Figure, in which the powders are first squeezed into a die cavity under high pressure and then heated to bond the individual particles together.

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



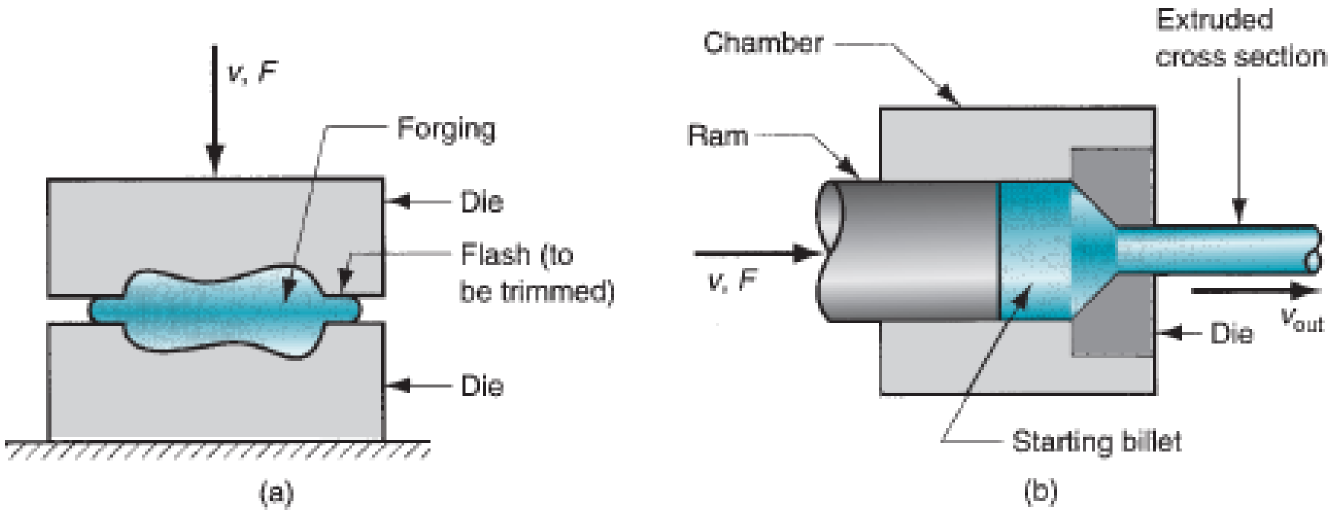
MANUFACTURING PROCESS-PROCESSING OPERATIONS

Shaping operations

(1) Deformation processes

In deformation processes, the starting work part is shaped by the application of forces that exceed the yield strength of the material. For the material to be formed in this way, it must be sufficiently ductile to avoid fracture during deformation. To increase ductility (and for other reasons), the work material is often heated before forming to a temperature below the melting point. Deformation processes are associated most closely with metal working and include operations such as forging and extrusion, shown in Figure

Some common deformation processes: (a) forging, in which two halves of a die squeeze the workpart, causing it to assume the shape of the die cavity; and (b) extrusion, in which a billet is forced to flow through a die orifice, thus taking the crosssectional shape of the orifice.

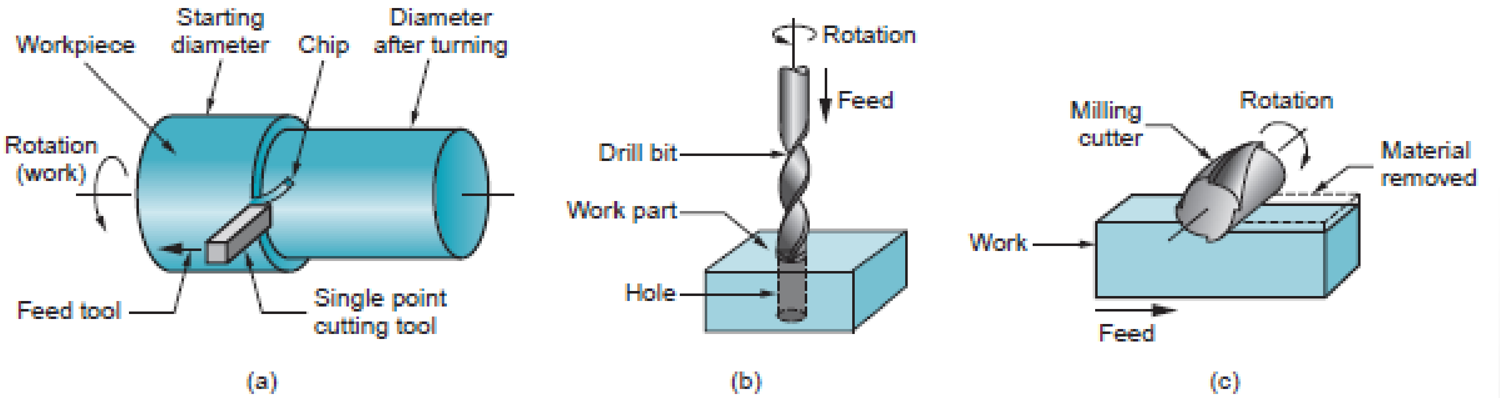


MANUFACTURING PROCESS-PROCESSING OPERATIONS

Material removal processes

These operations remove excess material from the starting workpiece so that the resulting shape is the desired geometry. The most important processes in this category are machining operations such as turning, drilling, and milling, shown in Figure. Grinding is another common process in this category. Other material removal processes are known as nontraditional processes because they use lasers, electron beams, chemical erosion, electric discharges, and electro chemical energy to remove material rather than cutting or grinding tools.

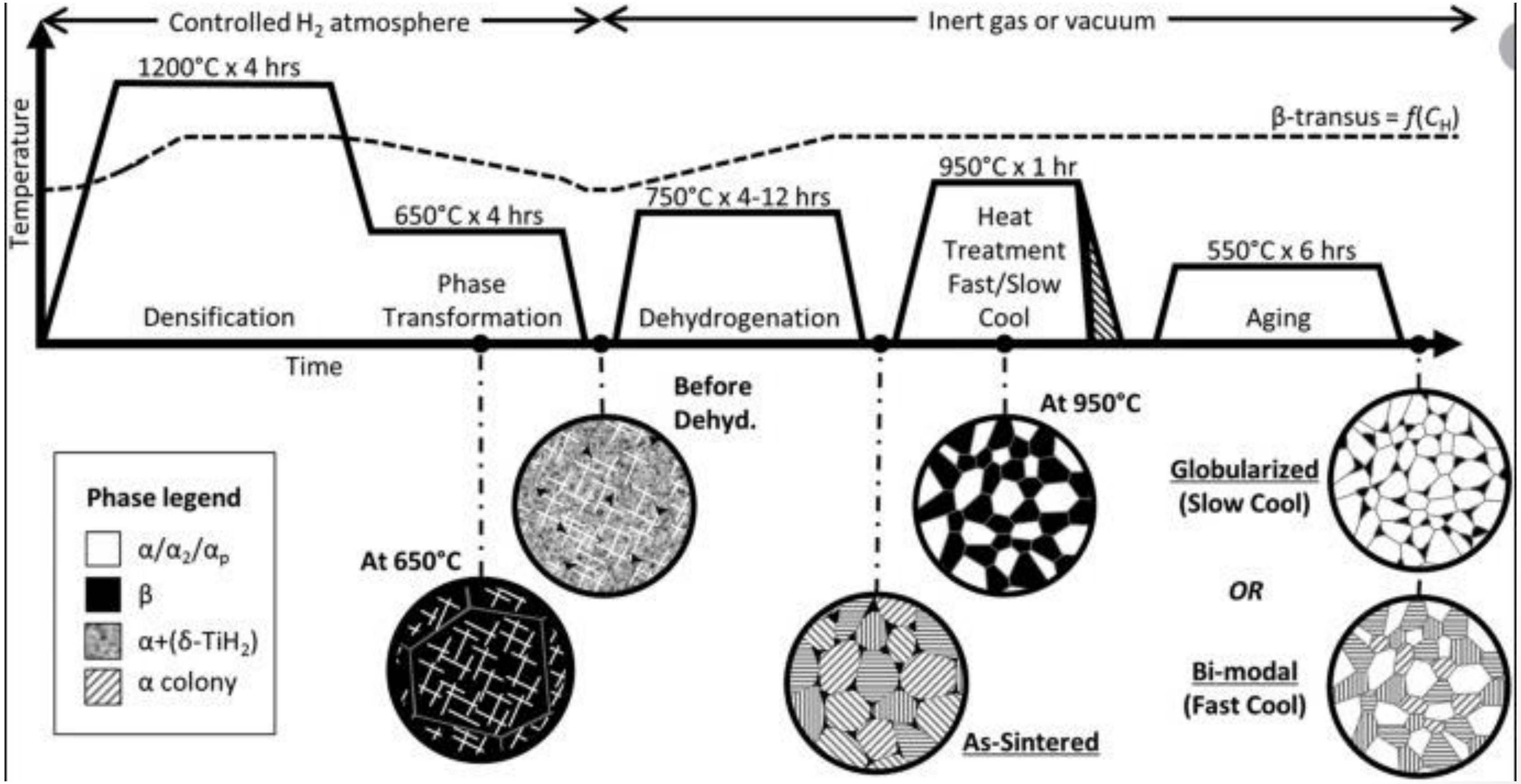
Common machining operations: (a) turning, in which a single-point cutting tool removes metal from a rotating workpiece to reduce its diameter; (b) drilling, in which a rotating drill bit is fed into the work to create a round hole; and (c) milling, in which a workpart is fed past a rotating cutter with multiple edges.



MANUFACTURING PROCESS-PROCESSING OPERATIONS

Property Enhancing Processes

The second major type of part processing is performed to improve mechanical or physical properties of the work material. These processes do not alter the shape of the part, except unintentionally in some cases. The most important property-enhancing processes involve heat treatments, which include various annealing



*J. D. Paramore, Z. Zak Fang, M. Dunstan, P. Sun & B. G. Butler Hydrogen enabled microstructure and fatigue strength engineering of titanium alloys Scientific Reports Vol. 7

MANUFACTURING PROCESS-PROCESSING OPERATIONS

Surface Processesing

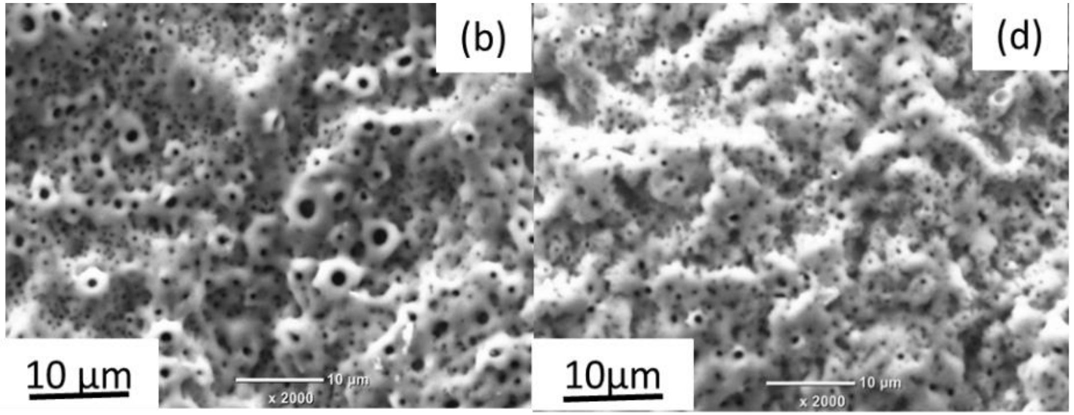
Surface processing operations include (1) cleaning, (2) surface treatments, and(3) coating and thin film deposition processes.

Cleaning includes both chemical and mechanical processes to remove dirt, oil, and other contaminants from the surface.

Surface treatments include mechanical working such as shot peening and sand blasting, and physical processes such as diffusion and ion implantation.

Coating and thin film deposition processes apply a coating of material to the exterior surface of the work part. Common coating processes include electroplating, anodizing of aluminum, organic coating (call it painting), and porcelain enameling.

Thin film deposition processes include physical vapor deposition and chemical vapor deposition to form extremely thin coatings of various substances.



MANUFACTURING PROCESS-PROCESSING OPERATIONS

Production Machines And Tooling

Power-driven machines used to operate cutting tools previously operated by hand. Modern machine tools are described by the same basic definition, except that the power is electrical rather than water or steam, and the level of precision and automation is much greater today. Machine tools are among the most versatile of all production machines. They are used to make not only parts for consumer products, but also components for other production machines. Both in a historic and a reproductive sense, the machine tool is the mother of all machinery.

Production equipment and tooling used for various manufacturing processes.

Process	Equipment	Special Tooling (Function)
Casting	a	Mold (cavity for molten metal)
Molding	Molding machine	Mold (cavity for hot polymer)
Rolling	Rolling mill	Roll (reduce work thickness)
Forging	Forge hammer or press	Die (squeeze work to shape)
Extrusion	Press	Extrusion die (reduce cross-section)
Stamping	Press	Die (shearing, forming sheet metal)
Machining	Machine tool	Cutting tool (material removal)
		Fixture (hold workpart)
		Jig (hold part and guide tool)
Grinding	Grinding machine	Grinding wheel (material removal)
Welding	Welding machine	Electrode (fusion of work metal)
		Fixture (hold parts during welding)

MANUFACTURING PROCESS-PROCESSING OPERATIONS

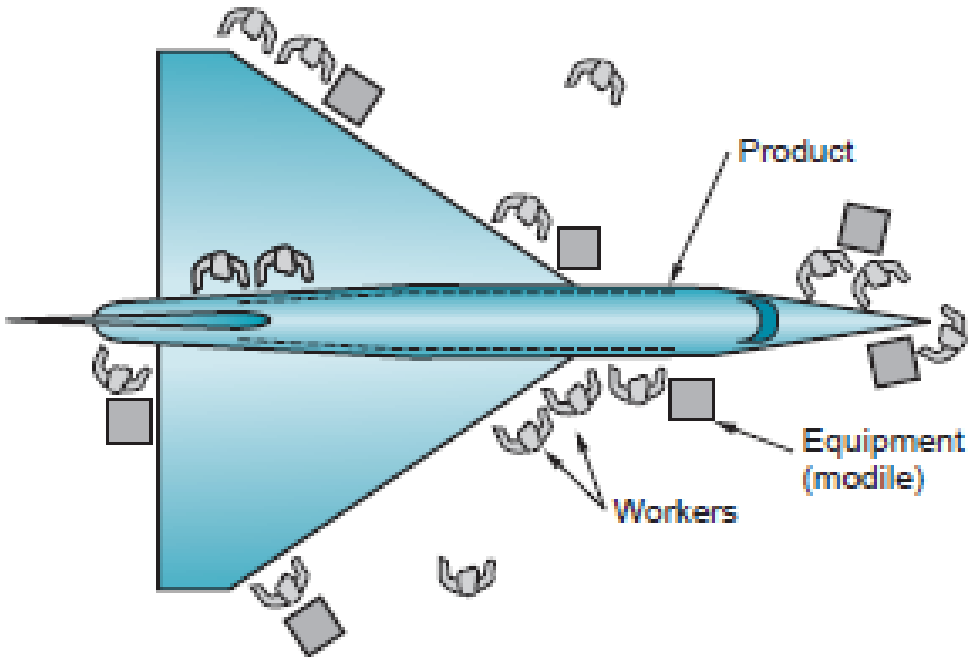
Production Systems

Production systems can be divided into two categories:

1. Production facilities refer to the physical equipment and the arrangement of equipment in the factory.
2. Manufacturing support systems are the procedures used by the company to manage production and solve the technical and logistics problems encountered in ordering materials, moving work through the factory, and ensuring that products meet quality

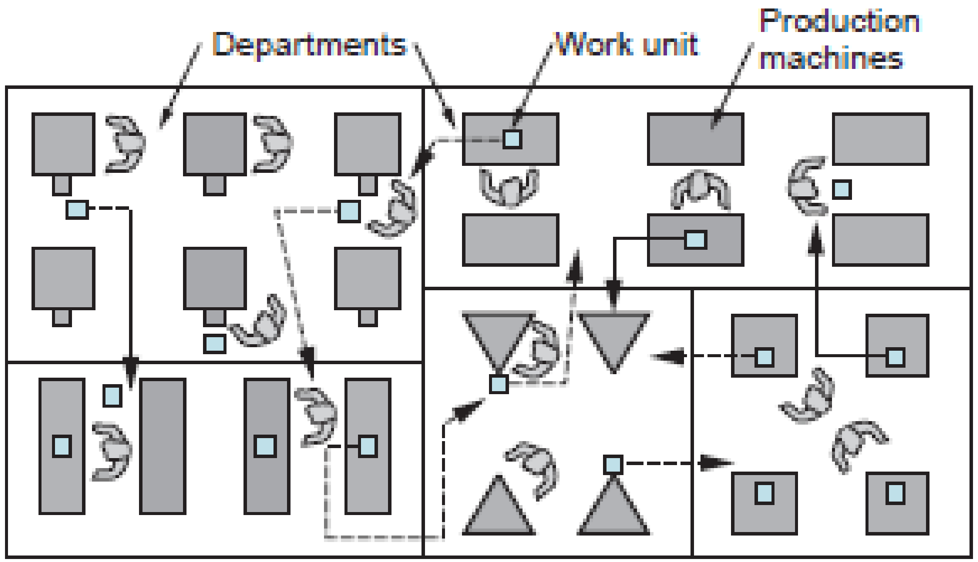
MANUFACTURING PROCESS-PROCESSING OPERATIONS

Fixed-position layout, as shown in Figure. In a pure situation, the product remains in a single location during its entire production. Examples of such products include ships, aircraft, locomotives, and heavy machinery. In actual practice, these items are usually built in large modules at single locations, and then the completed modules are brought together for final assembly using large-capacity cranes.



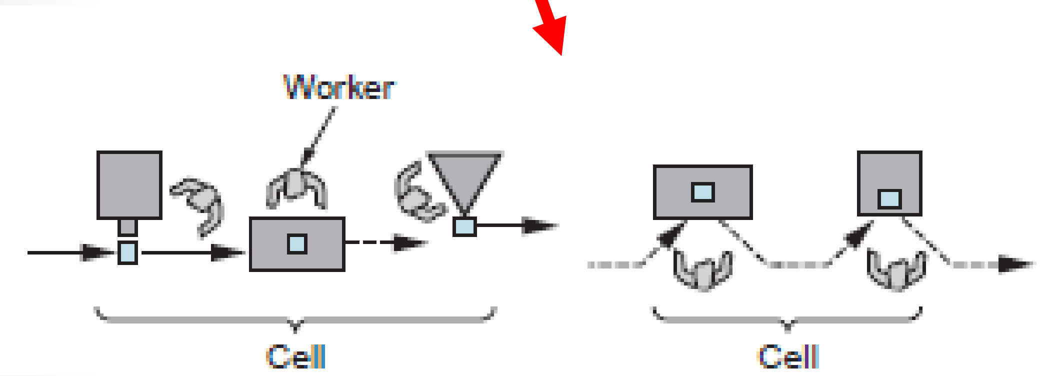
MANUFACTURING PROCESS-PROCESSING OPERATIONS

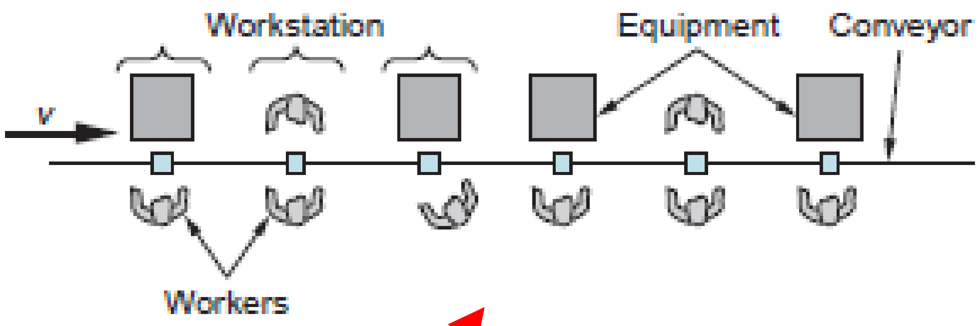
The individual components of these large products are often made in factories in which the equipment is arranged according to function or type. This arrangement is called a process layout. The lathes are in one department, the milling machines are in another department, and so on, as in Figure. Different parts, each requiring a different operation sequence, are routed through the departments in the particular order needed for their processing, usually in batches. The process layout is noted for its flexibility; it can accommodate a great variety of operation sequences for different part configurations.



MANUFACTURING PROCESS-PROCESSING OPERATIONS

The term cellular manufacturing is often associated with this type of production. Each cell is designed to produce a limited variety of part configurations; that is, the cell specializes in the production of a given set of similar parts, according to the principles of group technology.





In the product layout, the workstations and equipment are designed specifically for the product to maximize efficiency. The workstations are arranged into one long line, as in Figure, or into a series of connected line segments. The work is usually moved between stations by mechanized conveyor. At each station, a small amount of the total work is completed on each unit of product.

MANUFACTURING PROCESS-MANUFACTURING SUPPORT SYSTEMS

Manufacturing support functions are often carried out in the firm by people organized into departments such as the following:

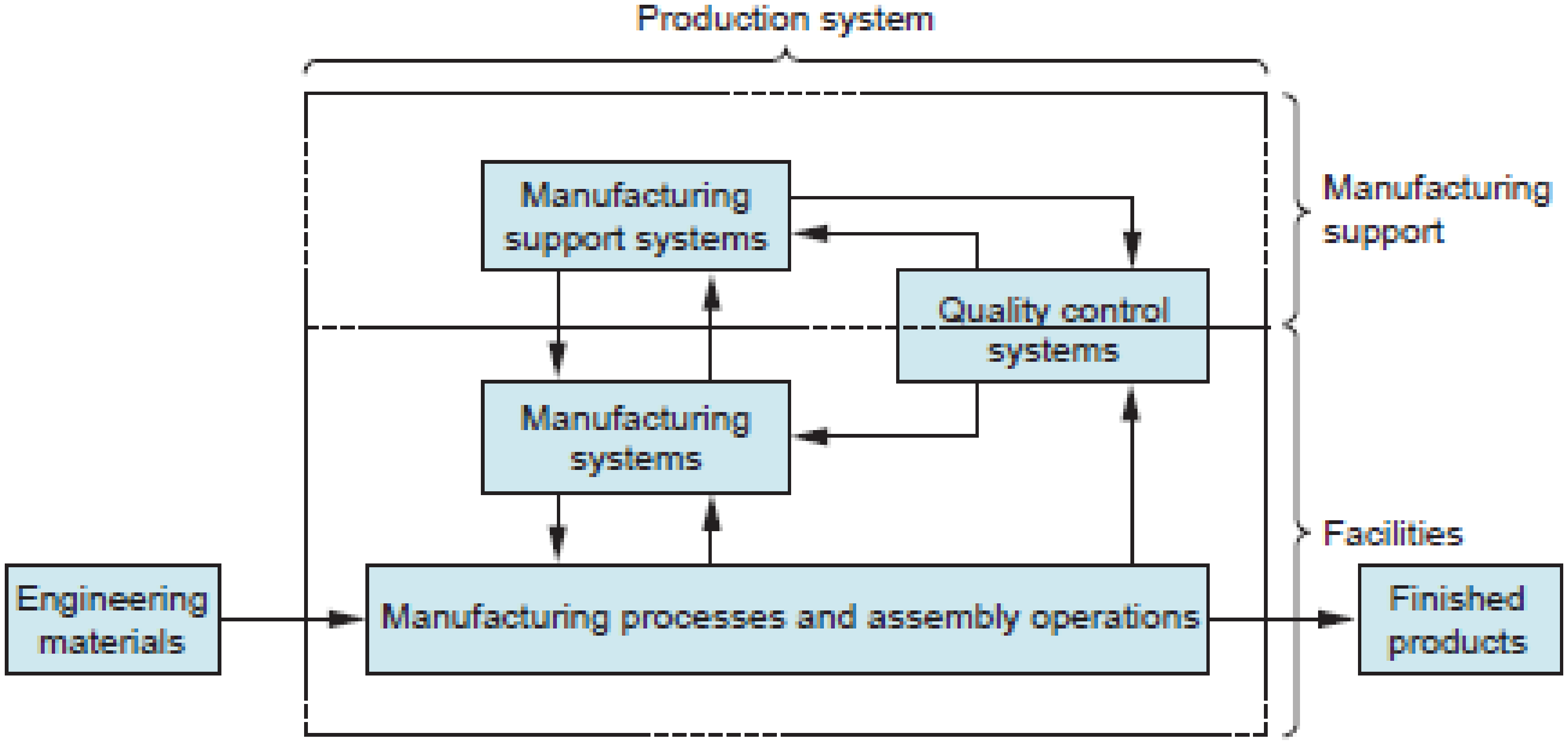
Manufacturing engineering The manufacturing engineering department is responsible for planning the manufacturing processes—deciding what processes should be used to make the parts and assemble the products. This department is also involved in designing and ordering the machine tools and other equipment used by the operating departments to accomplish processing and assembly.

Production planning and control

This department is responsible for solving the logistics problem in manufacturing—ordering materials and purchased parts, scheduling production, and making sure that the operating departments have the necessary capacity to meet the production schedules.

Quality control Producing high-quality products should be a top priority of any manufacturing firm in today's competitive environment. It means designing and

MANUFACTURING PROCESS-MANUFACTURING SUPPORT SYSTEMS



Overview of major topics covered in the lecture

Thanks for your attention!