Chapter 1: Manufacturing Technology

Manufacturing. The word **manufacture** first appeared in English in 1567, and is derived from the Latin *manu factus,* meaning "made by hand." The word **manufacturing** first appeared in 1683, and the word **production**, which is often used interchangeably with the word *manufacturing*, first appeared sometime during the 15th century. Manufacturing is concerned with making products. A manufactured **product** may, in turn, itself be used to make other products, i.e. a large press, to shape flat **sheet metal** into automobile **bodies**.

Product Design. **Product** design involves the creative and systematic prescription of the shape and **characteristics** of an **artifact** to achieve specified objectives, while simultaneously satisfying several **constraints**. Design is a critical activity, because it has been estimated that as much as 80% of the cost of **product development** and manufacture is determined by the decisions made in the initial stages of design.

A. Fill in the blanks with the following words.

CAD/CAM, interactive, prototype, component, model, virtual-reality, ceramics

…….. A **prototype** is a physical …….. of an individual **……..** or product. The prototypes are carefully reviewed for possible modifications to the original design, materials, or production methods. An important and continuously evolving technology is **rapid prototyping**. Using **……..** and various specialized technologies, designers can now make prototypes rapidly and at low cost, from metallic or nonmetallic materials such as plastics and …….. . **Virtual prototyping** is a software-based method that uses advanced graphics and **……..** environments to allow designers to view and examine a part in detail. This technology, also known as simulation-based design, uses CAD packages to render a part such that, in a 3D **……** virtual environment, designers can observe and evaluate the part as it is being developed.

Design for manufacture. Design for manufacture (DFM) is a comprehensive approach to **integrating** the design process with production methods, materials, **process planning**, assembly, testing, and **quality assurance**. DFM requires a fundamental understanding of (a) the characteristics and capabilities of materials, manufacturing

processes, **machinery**, **equipment**, and **tooling** and (b) variability in machine performance, dimensional **accuracy** and **surface finish** of the workpiece, processing time, and the effect of processing methods employed on product **quality**. Establishing **quantitative** relationships is essential in order to be able to analyze and **optimize** a design for ease of manufacturing and assembly at the lowest cost.

B. Fill in the blanks with the following words.

pollutants, casting, operations, welding, coolants, waste

Green design and manufacturing. The term **green design and manufacturing** considers all possible **adverse** environmental **impacts** of materials, processes, **……**, and products, so that they can all be taken into account at the earliest **stages** of design and production. Manufacturing operations generally produce some **……**, such as:

1. **Chips** from **machining** and **trimmed** materials from sheet forming, **……**, and **molding** operations
2. **Slag** from **foundries** and **……** operations
3. **Additives** in sand used in sand-casting operations
4. **Hazardous** waste and **toxic** materials used in various products
5. **Lubricants** and **……** in **metalworking** and machining operations
6. Liquids from processes such as **heat treating**
7. **Solvents** from cleaning operations
8. **Smoke** and **……** from **furnaces** and gases from burning fossil fuels

Materials. The general types of materials used, either individually or in combination with other materials, are:

- **Ferrous** metals: Carbon, alloy, **stainless**, and tool and die **steels**
- **Nonferrous** metals: Aluminum, magnesium, copper, nickel, titanium, **superalloys**, **refractory** metals, beryllium, zirconium, low-melting-point alloys, and **precious** metals
- Plastics (**polymers**): **Thermoplastics**, **thermosets**, and **elastomers**
- Ceramics, **glasses**, glass ceramics, graphite, **diamond**, and diamondlike materials

- **Composite** materials: **Reinforced** plastics and **metal-matrix** and **ceramic-matrix** composites
- **Nanomaterials**
- **Shape-memory alloys** (smart materials), **amorphous** alloys, **semiconductors**, and **superconductors**

Net-shape and Near-net-shape Manufacturing. **Net-shape** and **near-net-shape** manufacturing together constitute an important methodology, by which a part is made in only one operation and at or close to the final desired dimensions, **tolerances**, and surface finish. The difference between net shape and near net shape is a matter of degree of how close the product is to its final dimensional and surface finish characteristics.

C. Fill in the blanks with the following words.

lathes, mass production, dedicated, production rate, batch production

Types of Production. The number of parts to be produced (such as the **annual quantity**) and the **……** (the number of pieces made per unit time) are important **economic** considerations in determining the appropriate processes and the types of machinery required. A brief **outline** of the general types of production, in increasing order of annual quantities produced, are:

1. **Job shops**: Small **lot** sizes, typically less than 100, using general-purpose machines, such as **……**, **milling** machines, drill presses, and **grinders**, many now typically **equipped** with computer controls.
2. **Small-batch production**: Quantities from about 10 to 100, using machines similar to those in job shops.
3. **……**: Lot sizes typically between 100 and 5000, using more advanced machinery with computer control.
4. **……**: Lot sizes generally over 100,000, using **special-purpose** machinery, known as **……** machines, and various **automated equipment** in a plant for **transferring** materials and parts in **progress**.

Manufacturing Costs. Always critically important, the economics of manufacturing has become even more so with (a) ever-increasing **global competition** and (b) the demand for high-quality products, generally referred to as **world-class manufacturing**, and at low prices. Typically, the manufacturing cost of a product represents about 40%

of its selling price, which often is the overriding consideration in a product's marketability and general customer satisfaction.

Outsourcing. **Outsourcing** is defined as the purchase by a company of parts and/or labor from an outside source, either from another company or another country, in order to reduce design and manufacturing costs. In theory, this approach allows companies to concentrate on their core competencies, and be able to optimize their critical technologies.

Case Studies

Case study 1. The saltshaker and pepper mill set shown in Fig. 1 consists of metallic as well as nonmetallic components. The main parts (the body) of the set are made by **injection molding** of a thermoplastic, which has both **transparency** and other desirable characteristics for this application and is easy to **mold**. The round metal top of the saltshaker is made of sheet metal, has **punched** holes, and is **electroplated** for improved **appearance**. The **knob** on the top of the pepper mill is made by machining and is **threaded** on the inside to allow it to be **screwed** and unscrewed. The square **rod** connecting the top portion of the pepper mill to the two pieces shown at the bottom of the figure is made by a rolling operation. The two **grinder** components shown at the bottom of the figure are made of stainless steel. A design for manufacturing analysis indicated that casting or machining the two components would be too **costly**; consequently, it was determined that an appropriate and economical method would be the powder metallurgy **technique**.

Fig. 1 A saltshaker and pepper mill set. The two metal pieces (at the bottom) for the pepper mill are made by powder metallurgy techniques.

Case study 2. Car Tire

How It's Made Car Tires.mp4

D. Translate the following sentences into English.

۱. به طور سنتی، فعالیت های طراحی و ساخت به صورت متوالی انجام می شوند.

۲. نمونه سازی سریع، هزینه ها و زمان توسعه محصول را به طور قابل توجهی کاهش می دهد.

۳. در حال حاضر طیف گسترده ای از مواد موجود هستند که هر کدام از آنها خواص، مشخصات تولید، مزایا، محدودیت ها و هزینه های خاص خود را دارند.