Understanding Manufacturing

• Manufacturing involves making products from raw materials by various processes, machinery, and operations
• Manufacturing has the important function of adding value
• Manufacturing may produce either discrete or continuous products

Understanding Manufacturing

• Manufacturing activities include:
  – Product design
  – Purchasing
  – Marketing
  – Machinery and tooling
  – Manufacturing
  – Sales
  – Process planning

Understanding Manufacturing

• Manufacturing activities include (cont.):
  – Production control
  – Shipping
  – Materials
  – Support services
  – Customer service

Understanding Manufacturing

• For manufacturing activities to be responsive to demands and trends:
  – A product must fully meet design requirements and product specifications and standards
  – A product must be manufactured by the most environmentally friendly and economical methods

Understanding Manufacturing

– Quality must be built into the product at each stage, from design to assembly, rather than relying on quality testing after the product is made
– Quality must be appropriate to the product’s use
The Design Process and Concurrent Engineering

- The design process for a product requires a clear understanding of the functions and performance expected of that product
- Product design is a critical activity because 70-80% of the cost of product development and manufacture is determined at the design stage

The Design Process and Concurrent Engineering

- Concurrent, or simultaneous, engineering is a more modern approach and all disciplines are involved in the early design stages so iterations result in less wasted effort and lost time
- The key to success is communication between and within the disciplines

The Design Process and Concurrent Engineering

- Concurrent engineering is a systematic approach to integrating the design and manufacture of products with the view of optimizing all elements involved in the life cycle of the product

The Design Process and Concurrent Engineering

- Life cycle means that all aspects of the product from design to disposal and recycling are considered simultaneously
- The basic goals are to minimize product design and engineering changes and the time and costs involved in taking a product through the life cycle

The Design Process and Concurrent Engineering

- For concurrent engineering to succeed it must:
  - Have the support of upper management
  - Have multifunctional and interactive teamwork, including support groups
  - Utilize all available technologies
Computer-Aided Design and Product Development

- Computer-aided design (CAD) allows the designer to conceptualize objects more easily without having to make costly illustrations, models, or prototypes

- Computer-aided engineering (CAE) allows the performance of structures subjected to static or fluctuating loads and various temperatures to be analyzed and tested efficiently, accurately, and quickly
- Designs can be optimized and modified

The Role of Prototypes

- Computer-aided manufacturing (CAM) involves all phases of manufacturing by utilizing and processing further the information on materials and processes collected and stored in a database

Types of Rapid Prototyping Systems

- Rapid prototyping can cut both the costs and time associated with prototyping
- Tests of prototypes must be designed to simulate as closely as possible the conditions under which the product is to be used

The Role of Prototypes

- Virtual prototypes can serve many of the purpose of physical models
  - 3D solid models can be used to evaluate appearance, customer appeal, fit and clearance for assembled parts, mass properties, kinematics, and other characteristics of the design

Types of Rapid Prototyping Systems

- Stereolithography apparatus (SLA) uses laser-hardened resins to form models
  - A laser hardens each layer in the shape of the cross section of a part
  - Holes and pockets in the model are formed by uncured resin
Types of Rapid Prototyping Systems

- Solid ground curing (SGC) systems are similar to SLA systems except they use ultraviolet light to cure an entire cross section at once in a polymer pool
  - A negative of the shape of the cross section is created on a glass plate using electrostatic toner that masks ultraviolet light in the shape of the cross section
  - These systems are not common

- Selective laser sintering (SLS) uses a focused laser to fuse powdered metals, plastics or ceramics
  - The fused layers is covered with additional powder and the next layer fused to it
  - To form a hole, the powdered material is simply not fused in that area

- Fused deposition modeling (FDM) systems use molten plastic deposited in layers corresponding to cross sections on the part
  - To make holes, a second type of plastic is used to create a support structure that is later separated from the actual part

- Laminated object manufacturing (LOM) produces solid parts from sheets of material such as paper or vinyl
  - Software generates cross-sectional slices, a laser cuts it from the sheet of material and a heated roller bonds the next sheet to the previous layer
  - LOM can make larger parts than some other systems

- Topographic shell fabrication (TSF) uses layers of high-quality silica sand fused together with wax to build shells that can be used to mold rapid prototypes of large-scale parts
  - The shell is used as a temporary mold for creating parts of fiberglass, epoxy, foam, concrete or other materials

- 3D printing systems “print” layers of molten thermoplastic material
- These low-cost machines were designed to enable the use of prototypes early and often in the design cycle
Rapid Tooling
- Rapid tooling creates a tool (usually a mold for molded plastic or cast metal parts) through a rapid prototyping process
- Rapid tools can be used to produce test products and get products to market early

Cores and Cavities
- The cavity is the part of the mold that forms the outside shape of an object
- A core is a solid shape that fits inside the mold and forms a hole in a cooled cast metal or molten plastic object

Direct Shell Production Casting
- Direct shell production casting (DSPC) is used in directly creating molds for metal casting
- It is based on 3D printing technologies and uses 3D digital models to produce molds

Design for Manufacture
- Design for manufacture (DFM) is a comprehensive approach to produce goods and integrate the design process with materials, manufacturing methods, process planning, assembly, testing, and quality assurance

Design for Assembly
- Design for assembly (DFA) is recognized as an important part of manufacturing because assembly operations can contribute significantly to product cost

Design for Manufacturing and Assembly
- Design for manufacture and assembly (DMFA) recognizes the inherent interrelationships between design and manufacturing
Material Selection

- General types of materials used in modern manufacturing, individually or in combination:
  - Ferrous materials
  - Nonferrous materials
  - Plastics
  - Ceramics
  - Composite materials
  - Nanomaterials

Properties of Materials

- When selecting materials for products, the following properties are considered:
  - Mechanical properties
  - Chemical properties
  - Manufacturing properties

Cost and Availability of Materials

- Cost and availability of raw and processed materials and manufactured components are major concerns in manufacturing
  - The economic aspects of material selection are as important as technological considerations of properties and characteristics of materials

Appearance, Service Life, and Recycling

- The appearance of manufactured materials influences their appeal to the consumer
- Wear, fatigue, creep and dimensional stability are important to product performance and affect product life
- Recycling or proper disposal has become increasingly important

Manufacturing Processes

- Categories of processing methods:
  - Casting
  - Forming and shaping
  - Machining
  - Joining
  - Finishing

Dimensional Accuracy and Surface Finish

- Size, thickness, and shape complexity of the part have a major bearing on the manufacturing process selected to produce it
  - Nanotechnology or nanofabrication are terms used to describe extremely small-scale operations
Measuring Devices

- The machinist uses various measuring devices depending on the kind of dimensions shown on the drawing
  - Machinists scale
  - Dial or digital calipers
  - Fixed gages

Operational and Manufacturing Costs

- The design and cost of tooling, the lead time required to begin production, and the effect of workpiece material on tool and die life are major considerations

Consequences of Materials and Process Selection

- A component or product is generally considered to have failed when:
  - It stops functioning
  - It does not function properly or perform within required specification limits
  - It becomes unreliable or unsafe for further use

Net-shape Manufacturing

- In net-shape or near-net-shape manufacturing, the part is made as close to the final desired dimensions, tolerances, surface finish, and specifications as possible to cut down on the cost of finishing operations

Computer-Integrated Manufacturing

- Computer-integrated manufacturing (CIM) is particularly effective because of its capability for:
  - Responsiveness to rapid changes
  - Better use of materials, machinery and personnel, and reduced inventory
  - Better control and management of production and manufacturing operations
  - High quality products at low cost

Shared Manufacturing

- Shared manufacturing consists of a regional or nationwide network of manufacturing facilities with state-of-the-art equipment for training, prototype development, and small scale production runs to help small companies develop products that compete in the global marketplace