IE 309 Manufacturing Processes I
Introduction

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Course Objectives

This course is designed to provide students with an overview of a wide variety of manufacturing processes.

The fundamental principles behind the processes will be discussed with the intent of providing a working knowledge of a broad range of manufacturing processes.

You should be able to:

• Define manufacturing and all the correlated its activities.
• Describe importance of manufacturing.
• Describe important trends in manufacturing to minimize cost and hence successfully compete at global level.
Instructor

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Textbook


Yes, it is required.

Additional sources

Grading

Group project: 20%
  • There will be a semester-project and groups of four will be formed to work on the projects

Two midterm exam: 2×20%
  • Closed book, closed notes, no cheat sheet

Final exam: 40%
  • Closed book, closed notes, no cheat sheet
Tips for Success

Come to class.
  • Stay awake in class.
  • Ask questions and give an honest attempt to get interested in the subject.

Think big picture.
  • Try to understand the principles and the details will follow.
  • Don’t make things complicated. Even complex things are usually a composite of individual simple items

Review previous lecture and read the chapters in advance if possible.
  • If you have a clue going in, you will get much more out of class.
  • You will more likely need to study less and still get better grades.
Course Contents

Introduction (Half or 1 Lecture)

Fundamental properties of materials (1.5 Lecture)
  • Mechanical behavior
  • Structure and manufacturing properties

Manufacturing processes
  • Metal casting (2 lectures)
  • Bulk and sheet deformation (3 lectures)
  • Machining (3 lectures)
  • Grinding and non-traditional machining (1 lecture)
  • Joining and surface tribology (1 lecture)
  • Polymers, plastics and composites, additive manufacturing (2 lectures)
General Terminology

Manufacturing
Concurrent Engineering
Design for Manufacturing, Assembly, Disassembly, Service
Green Design, Sustainable Manufacturing, Product Life Cycle
Materials Selection, Process Selection
Computer Integrated Manufacturing
Lean Production, Agile Manufacturing
Quality Control, Total Quality Assurance
Manufacturing Cost, Global Competitiveness
What is Manufacturing?

Manufacturing: is a set of correlated operations and activities which includes product design, material selection, planning, production, inspection, management, and marketing of the products, for the manufacturing industries.

Manufacturing is the process of converting raw materials into products.

- came from Latin “manufactus” – made by hand
- Interchangeably used with “production”
- Manufactured item has monetary worth (added value) than raw materials
- Manufacturing is closely linked to national and global economy
Importance of Manufacturing to Economy

Traditionally, higher % contribution of manufacturing, higher GDP

Expectations:
• Nations with abundant natural resources.
• Nations with largest GDP growth concentrated on high value-added products, such as automobiles and machinery.

Labour intensive products such as clothing and toys are concentrated in countries where labour rates are lower.

![Graph showing the contribution of manufacturing to GDP for various countries](image-url)
Traditionally design and manufacturing activities have taken place sequentially.

Sequential Process
- Design for Manufacturing
- Waste resource, waste time

Design process requires a clear understanding of the functions and the performance expected of that product.

**Simultaneous Engineering:** A systematic approach integrating the design and manufacture of the products with the view toward optimizing all elements involved in the life cycle of the product.
Product Design and Concurrent Engineering

Concurrent or simultaneous process:
- All disciplines are involved in the earliest stages of product design
- Optimization: progress concurrently so iterations result in less wasted effort and time
- Key to success: well-recognized communication among and within disciplines
Each part or component of a product must be designed to not only meet design requirements and specifications, but also to be manufactured economically and with relative ease.

Product must be designed so that individual parts can be assembled together with ease, speed, and minimum cost.

Product must also be designed so that disassembly is possible with relative ease and require little time, enabling the product to be taken apart for maintenance, servicing, or recycling of their components.

Product must be designed so that individual parts are easy to reach and service.
Green Design and Sustainable Manufacturing

Design for recycling (DFR) and Design for the environment (DFE) anticipates the negative environmental impact during initial stages of design.

Sustainable Manufacturing:

• Reducing waste of materials at their source by refinement in product design and the amount of materials used
• Reducing the use of hazardous materials in products and processes
• Ensuring proper handling and disposal of all waste
• Improving waste treatment and recycling and reuse of materials
Product Life Cycle

Product Life Cycle (PLC): Consists of the stages that a product goes through to its ultimate disposal and recycling.

- Product development
- Market Introduction
- Growth
- Maturation
- Decline

Product Life Cycle Management (PLCM) is defined as the strategies employed by the manufacturer as the product goes through its life cycle.
Selecting Materials

Material Substitution

- Metals
  - Ferrous metals: carbon steels, alloy steels, stainless steels, and tool and die steels
  - Nonferrous metals and alloys: Al, Mg, Cu, Ni, superalloys, Ti, refractory metals (Mb, Nb, W, Ta), beryllium, Zr, low melting alloys (lead, zinc and tin), and precious metals
- Plastics: Thermosets, thermoplastics, and elastomers
- Ceramics: Glass ceramics, glasses, graphite, and diamond
- Composites: Reinforced plastics, metal-matrix and ceramics-matrix composites, and honeycomb structures
- Nanomaterials, shape-memory alloys, metal foams, amorphous alloys, super conductors and semiconductors

Material Properties: Mechanical, physical, chemical, manufacturing

Cost and Availability, Service Life and Recycling
## Categories of Manufacturing Processes

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<th>Creation of Cohesion</th>
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<tr>
<td><strong>1. Primary Forming</strong></td>
<td><strong>Shape (Form) Modification</strong></td>
<td><strong>2. Deforming</strong></td>
<td><strong>4. Joining</strong></td>
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Manufacturing Processes

**Primary Forming:** Casting (expandable/permanent molding), powder metallurgy

**Deforming:** Metal forming processes (bulk and sheet forming: rolling, forging, extrusion, drawing)

**Separating:** Machining
- Conventional machining (turning, milling, grinding, etc.)
- Non-traditional machining (EDM, ECM, EBM, LBM, etc.)

**Joining:** Welding, brazing, riveting, soldering, diffusion bonding, adhesive bonding and mechanical joining, etc.

**Coating:** Painting, electroplating, etc.

**Changing Material Properties:** Heat treatments.

**Finishing:** Honing, lapping, polishing, burnishing, deburring, surface treating, coating and plating
Factors affecting Process Selection

Component/part shape
• **Net-Shape Manufacturing**: Additional finishing operations might be needed for finished parts or products to desired specifications

Part size and dimensional accuracy
• Size, thickness and shape complexity of a part have a major bearing on the process selected.
• The size and shape of manufactured products also vary widely.

Materials characteristics – castability, formability, machinability, weldability, etc.

Manufacturing and operational cost
• Lead time required to begin production and the tool and die life are of major importance.
• Quantity of parts and production rates determine the processes that are used and the economics of production.
Factors affecting Process Selection

- **Classification**: Micro- and nano-manufacturing
- **Examples in nature**: Human height, Mouse, Ant, Grain of sand, Human cell, Virus, Dust particle, Atoms
- **Manufacturing process examples**: Casting, Forging, Machining, Chemical blanking, LIGA, Lithography
- **Applications**: Aircraft, Automobile, Machinery gears, Integrated circuit package, Gear for MEMS, Features in integrated circuit
Computer-Integrated Manufacturing

CIM applications:
• Control and optimization of manufacturing process
• Materials handling
• Assembly
• Automated inspection and testing of products
• Inventory control
• Management

CIM has the capability for:
• improved responsiveness to demand and product modification
• better use of materials and resources
• better control of manufacturing operation
• manufacturing of high quality products at a lower cost
Computer-Integrated Manufacturing

Some examples:

- Computer numerical control (CNC)
- Adaptive control (AC)
- Industrial robots
- Automated handling
- Automated and robotic assembly systems
- Computer-aided process planning (CAPP)
- Group technology (GT)
- Just-in-time production (JIT)
Lean Production and Agile Manufacturing

Lean production or lean manufacturing involves a manufacturing practice that considers the expenditure of resources for any goals other than creating values for the end customer as wasteful, thus a target for elimination.

- assessment of each activity regarding the efficiency and effectiveness of its operations
- efficiency of the machinery and equipment used in the operation
- number of personnel involved in a particular operation
- thorough analysis to reduce cost of each activity

Agile manufacturing is ensuring flexibility in manufacturing so that it can respond to changes in demand and customer needs.
Quality is defined at the design stage and is built into the product during manufacturing.

- Design quality: Specifications for material and tolerances.
- Manufacturing quality: Degree of conformity to the design specifications.

Product quality influences the marketability of a product and customer satisfaction.

Product integrity is defined by the degree to which a product is suitable for its purpose, market need, life expectancy and ease of use.

**Product liability:** consequence of using a product that has malfunctioned, causing bodily injury, or even death, and the financial loss to a person as well as the organization manufacturing the product.
Manufacturing Costs and Global Competitiveness

Cost of a product is taking into consideration the product’s marketability and customer satisfaction.

- 40% of product selling price
- Includes cost of materials, tooling and labor, as well fixed and capital costs
- Can be minimized by optimizing design, least cost material, while maintaining the intended function and characteristics, and materials substitution

Major impact on manufacturing includes:

- Global competition
- Market conditions fluctuated widely
- Customers demand
- Product complexity

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General Trends in Manufacturing

Better Materials
  • Better control of composition, purity, and defects to enhance their overall properties, manufacturing characteristics, reliability, and service life while keeping cost low
  • Better recyclability, and higher strength-, stiffness-to-weight ratio materials due to concerns over energy and material saving

Better tool, die and mold materials with better resistance to process variable, thus higher efficiency and economics of manufacturing processes

Improved efficiency and reliability of all manufacturing processes, equipment and systems due to continuing development in computers, controls, industrial robots, automated inspection, handling and assembly, and sensor technology
Trends

Complex, customized, and computerized
  • Boeing 777 created all in digital environment

Macro, Meso, Micro, Nano-manufacturing
  • e.g., micro-bull, 10 micro-meter long (resolution: 120 nm)