

ME 355: Introduction to Manufacturing Processes

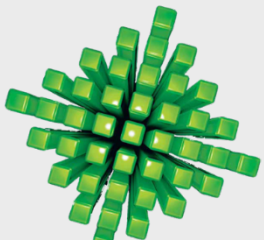
Lecture Notes Prepared by

Junlan Wang

Associate Professor of Mechanical Engineering

University of Washington

Figure Courtesy:



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Chapter I Introduction

Manufacturing

Design and 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

Definition and Importance of Manufacturing

Manufacturing: the process of converting raw materials into products; encompasses the design and manufacturing of goods using various production methods and techniques.

~ came from Latin “manu factus” – made by hand

interchangeably used with “production”

“discrete” vs “continuous” products

Manufactured item has monetary worth (added value) than raw materials

Manufacturing is closely linked to national and global economy

Design and Manufacturing

Sequential Process

Design -> Manufacturing

Waste resource, waste time

Concurrent Process

All disciplines are involved in the earliest stages of product design

Progress concurrently so iterations results in less wasted effort and time

Key to success: well-recognized communication among and within disciplines

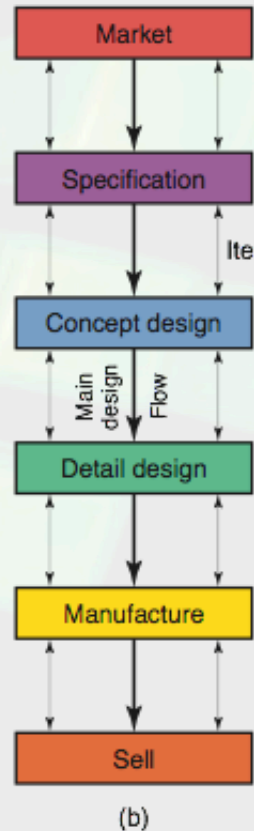
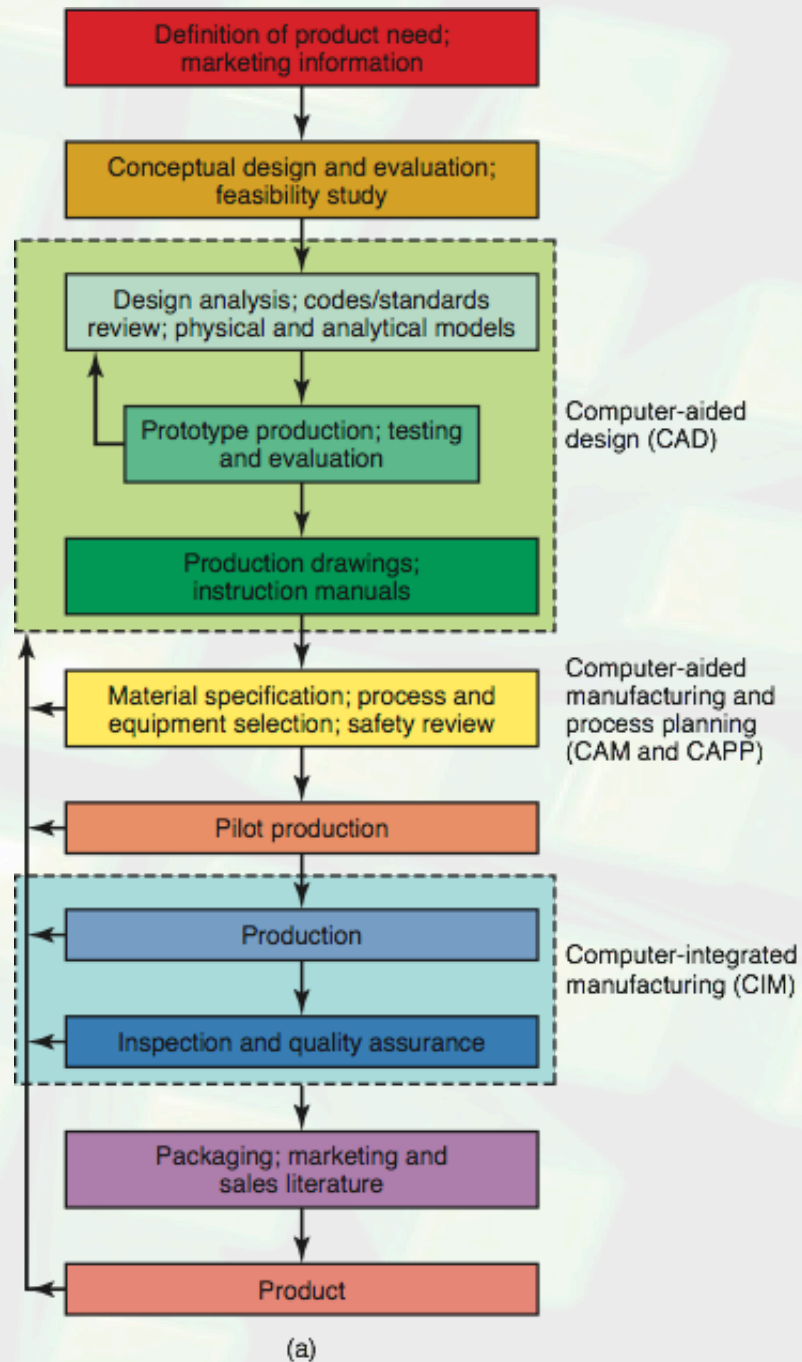


FIGURE 1.3 (a) Chart showing various steps involved in design and manufacturing a product. Depending on the complexity of the product and the type of materials used, the time span between the original concept and the market launch can vary significantly.

~ 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

Basic goal

- Minimize design and manufacture changes
- Minimize time and cost in taking the product from conceptual design to production and introduction of the product to market

Key to success:

- Full support of an organization's top management
- Multifunctional and interacting work team, including support groups
- Utilization of all available state-of-the-art technologies

Design for Manufacture, Assembly, Disassembly, and Service

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 assembled with relative ease.

Product must be designed that individual parts can be assembled together with 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, service, or recycling of their components.

Product must be designed so that individual parts are easy to reach and service.

Design Principle for Economic Production

Designs should be as simple as possible to manufacture, assembly, disassemble, service and recycle.

Materials should be chosen for their appropriate design and manufacturing characteristics as well as their service life.

Dimensional accuracy and surface finish specified should be as broad as permissible.

Secondary and finishing operations should be avoided or minimized to reduce cost.

Green Design - Design for Recycling (DFR) - Design for Environment (DFE)

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
- Making improvements in waste treatment and recycling and reuse of materials

Product Life Cycle (PLC)

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

Materials used in today's manufacturing

- **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 (Mo, Nb, W, 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 substitution

Material properties: mechanical, physical, chemical, manufacturing

Cost and availability

Categories of manufacturing processes

- **Casting:** expandable molding and permanent molding
- **Forming and shaping:** rolling, forging, extrusion, drawing, sheet forming, powder metallurgy molding
- **Machining:** turning, boring, drilling, milling, planing, shaping, broaching, grinding, ultrasonic machining; chemical, electrical, and electrochemical machining and high energy electron beam machining
- **Joining:** welding, brazing, soldering, diffusion bonding, adhesive bonding and mechanical joining
- **Micro and nano manufacturing:** surface micromachining, dry and wet etching, and electroforming
- **Finishing:** honing, lapping, polishing, burnishing, deburring, surface treating, coating and plating

Factors affecting process selection

- Component/part shape
- Materials characteristics – castability, formability, machinability, weldability, etc
- Part size and dimensional accuracy
- Manufacturing and operational cost

CIM applications

- Control and optimization of manufacturing process
- Materials handling
- Assembly
- Automated inspection and testing of products
- Inventory control
- Management

Advantages

- Improved responsiveness
- Better use of materials, machinery and personnel, reduction in inventory
- Better control of production and management
- Manufacturing high-quality at low-cost

Lean Production and Agile Manufacturing

Lean Production (also called lean manufacturing)

- A major assessment of each activity of a company regarding the efficiency and effectiveness of its operations
- The efficiency of the machinery and equipment used in the operation while maintaining and improving quality
- The number of personnel involved in a particular operation
- A thorough analysis in order to reduce the cost of each activity, including both productive and nonproductive labor

— Goal: continuously improving the efficiency and profitability by reducing all types of waste from its operations (0-base waste) and dealing with problems asap.

Agile Manufacturing

- Ensuring **flexibility (agility)** in the manufacturing enterprise so that it can quickly respond to changing product variety and demand and customer needs
- To be achieved through machines and equipment with **built-in flexibility** (reconfigurable machines, modular components that can be arranged and rearranged in different ways, advanced computer hardware, software, reduced changeover time and implementing advanced communication systems).

Management

Product quality affects marketability and customer satisfaction

Quality Assurance (QA) is now part of the concurrent engineering process and built into every stage of the manufacturing process

Total Quality Management (TQM) and QA are the responsibility of everyone involved in the design and manufacturing of a product

Statistical Process Control is part of the TQM techniques

Product liability

Competitiveness

Manufacturing cost

- ~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.

Global competitiveness impacts manufacturing

- Markets become multinational and dynamic
- Market condition fluctuates widely
- Demand for high-quality, low-cost and timely delivery
- Increased product variety, complexity and shorter product life cycle

Wide disparity in manufacturing labor cost leads to outsourcing

outsourcing – a practice of taking internal company activities and paying outside firms to perform them.

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 concerns over energy and material saving

Better tool, die and mold materials with better resistance to process variable, 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 robot, automated inspection, handling and assembly, and sensor technology

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and Global Economy

In 1982, wealth is closely tied with level of manufacturing.

Trend is no longer clear

- Abundant natural resources
- % contribution may not reflect the absolute level of manufacturing
- Global trading leads to increased wealth in all participating countries

Nations with higher GDP have economic activity concentrated on high value-added produces, e.g, airplanes, automobiles, electronics.

Labor intensive manufacturing is associated with countries who follow

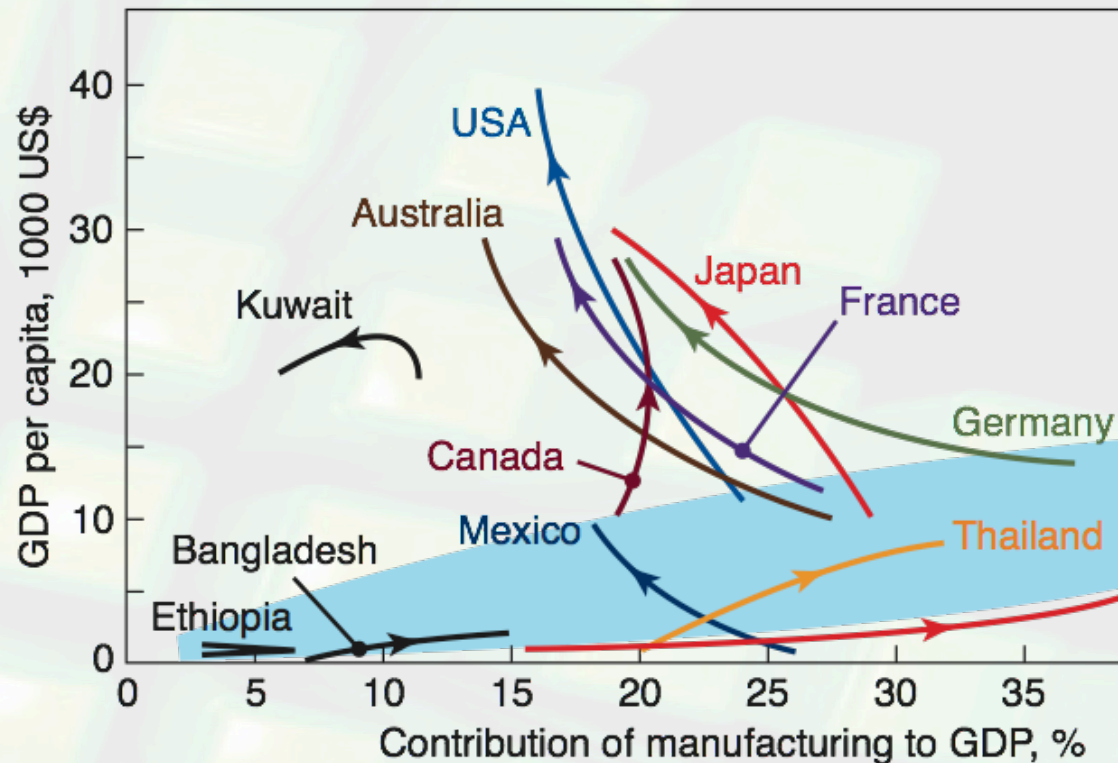


FIGURE 1.2 Importance of manufacturing to economies. The trends shown are from 1982 until... Source: After J.A. Schey with data from the Development Report, World Bank, various years.

Component/part shape

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

Part size and dimensional accuracy

Manufacturing and operational
cost

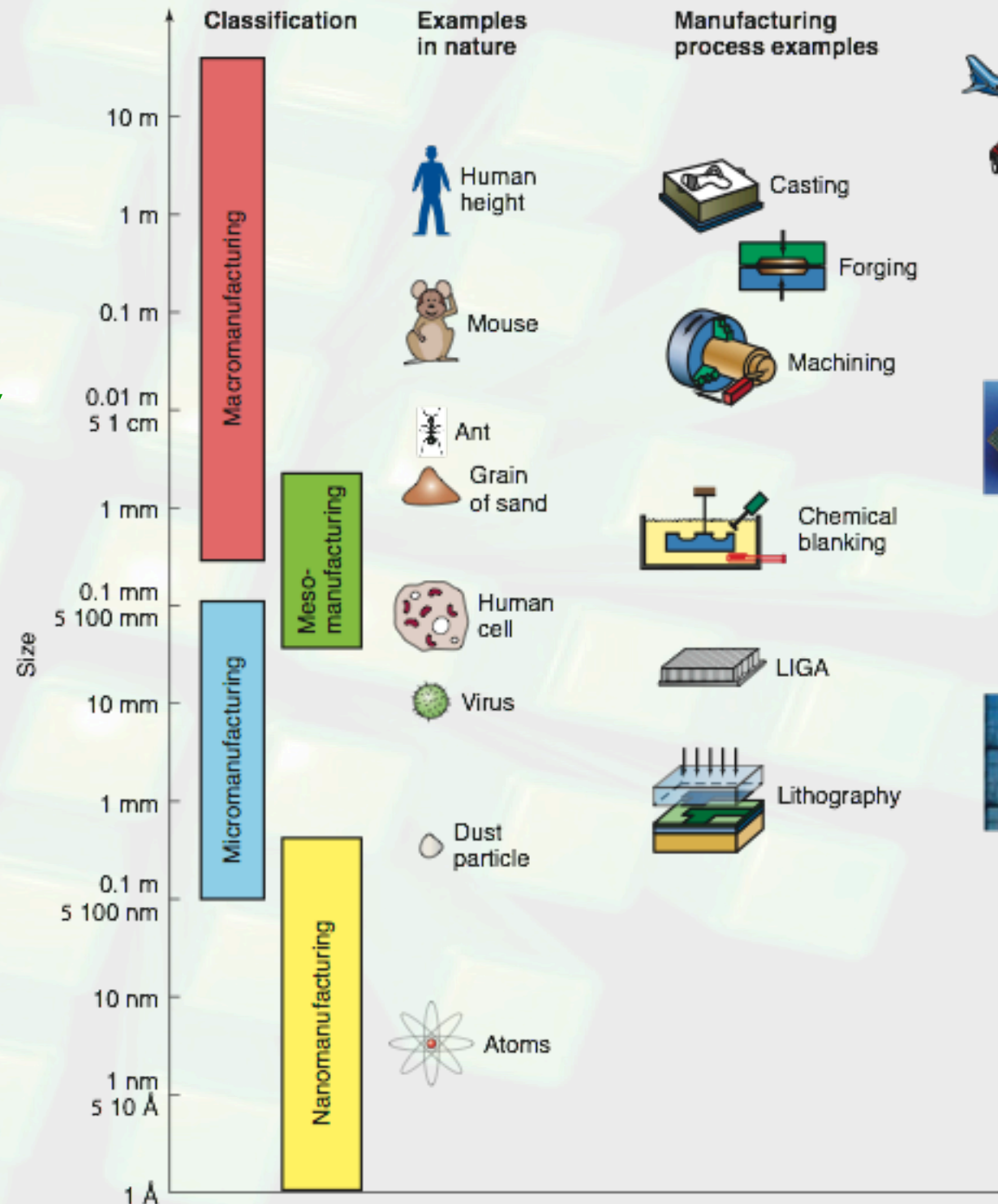


FIGURE 1.7 Illustration of the range of common

Range of Materials & Processes in a Tractor

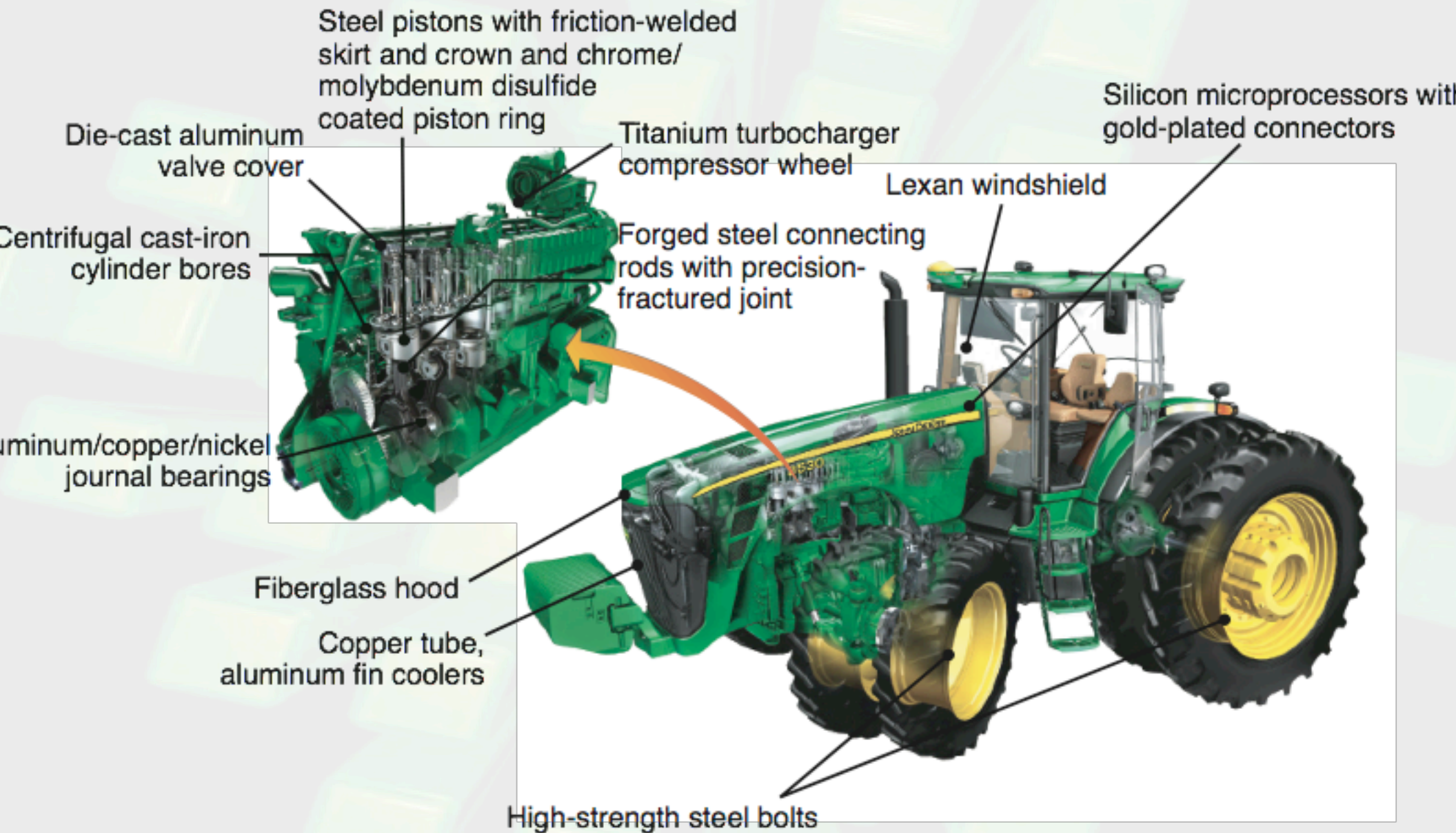


FIGURE 1.1 Model 8430 tractor, with detailed illustration of diesel engine, showing the variety of materials and processes incorporated. *Source:* Courtesy of John Deere Company