

## Engineering Design *An Introduction*

### The Industrial Revolution

- Began in the mid-1700s in England
- Spread across Europe and North America
- Fundamentally changed how we live, work, travel, and communicate today
- Responsible for growth of human population size

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### The Agrarian Revolution

- Food supply
  - Limiting factor on population size
- Development of agriculture
  - Decreased amount of land required per person
    - Allowed more people to live in towns and cities
  - New methods of farming allowed sufficient food supply

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### The Steam Engine

- Key to mechanized farming
- Steam turbine invented in the first century B.C.
- First working steam pump
  - Developed in 1698
- First true steam engine
  - Developed in 1712

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### Principles of the Steam Engine

- Piston slides back and forth in a cylinder:
  - When pressure of steam is applied
  - Valves control the movement of steam into and out of the cylinder
- Double-acting steam engine
  - Steam pushes the piston in both directions

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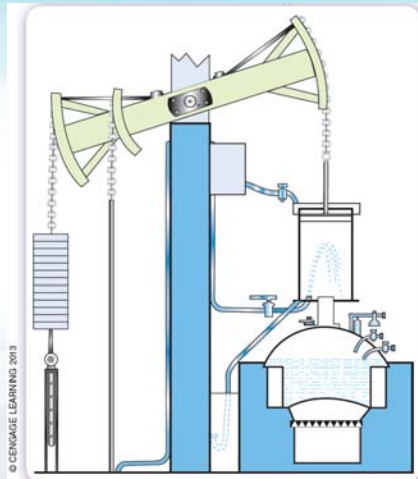


Figure 10-3: Thomas Newcomen's beam steam engine of 1712.

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### Interchangeable Parts

- Parts made by hand
  - Difficult to keep tight tolerances
- Higher tolerance parts
  - Less variation in dimensions among several examples of the same part
- Machines
  - Increased precision for making parts

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### The Assembly Line

- Developed in 1801 to produce blocks (pulley housing on a ship)
  - Need to produce blocks in great numbers
- Henry Ford
  - Adapted assembly line principles to whole factories

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### Material Processing

- Most designs call for changes in materials:
  - To allow desired function
- Example: body or shell for a new camera
  - Plastics
  - Metal

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### Material Production Cycle

- Raw materials
  - Most basic form of materials
- Standard industry materials
  - Raw materials processed into a standard size, shape, or composition
- Recycled materials
  - Must be processed to return them to a raw state

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### Material Production Cycle (cont'd.)

- Manufacturing process
  - Transformation of raw material into finished goods
  - Through some process
- Assembly
  - Combining components together

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### The Importance of Materials

- Choice of material
  - Very important in the manufacture of a product
- Materials science and materials engineering
  - Specialized field of study
  - Focuses on materials selection and manufacturing

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### Forming Materials

- Forming
  - Changing a material's shape
- Two primary means of forming
  - Compressing or stretching
  - Casting

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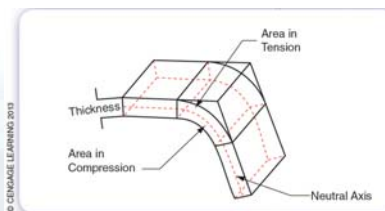
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## Forming Materials (cont'd.)

- Bending
  - Compressing and stretching a material
  - Changes material shape in one direction



**Figure 10-10:** When a material is bent, the outer part of the bend is under tension and the inner part of the bend is under compression.

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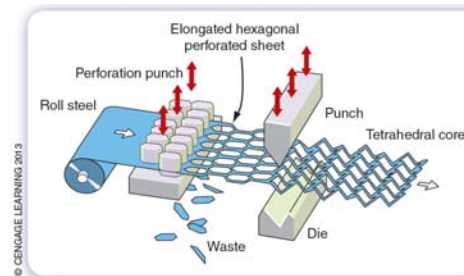
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## Forming Materials (cont'd.)

- Pressing
  - Uses male and female molds called dies
  - Most materials pressed cold



**Figure 10-11:** A punch and die is used to make a series of corrugations in metal.

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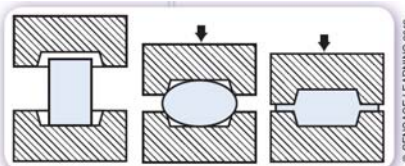
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### Forming Materials (cont'd.)

- Forging
  - Uses a solid material
  - Processes into desired shape under very high pressure



**Figure 10-15:** Impression-die forging. Two dies are brought together to change the shape of a metal billet.

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### Forming Materials (cont'd.)

- Extruding
  - Forcing a material through a die
  - Imparts a predetermined shape
  - Example: toothpaste coming out of a tube

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### Forming Materials (cont'd.)

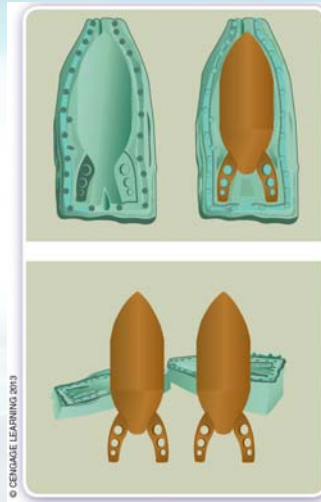
- Drawing
  - Opposite of extruding
  - Material is pulled instead of pushed through the die
  - Example: forming wire

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### Forming Materials (cont'd.)

- Casting
  - Pouring liquid material into a mold
  - Pattern makers produce the mold to exact specifications
  - Material shrinks as it solidifies

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**Figure 10-17:** Resin casting of a model spaceship. The two-piece mold is clamped together while the liquid resin is poured and cures. The mold is taken apart so the ship can be removed.

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### Forming Materials (cont'd.)

- Types of molds
  - One-shot molds are only used once
  - Permanent molds can be reused
- Gate marks often remain on the finished product
- Casting produces complex shapes at relatively low cost

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### Separating Materials

- Taking something away from the material being processed
- Minimize amount of wasted material
- Removing material can be expensive

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### Separating Materials (cont'd.)

- Types of separating processes
  - Mechanical
    - Most common process
  - Electrical
  - Chemical
  - Thermal

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### Separating Materials (cont'd.)

- Mechanical separating techniques
  - Shearing
  - Piercing
  - Blanking
  - Die-cutting
  - Slitting
  - Perforating
  - Chip removal (milling, lathe, saw)

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### Combining Materials

- Methods of joining components
  - Mechanical
  - Chemical
- Mechanical fastening
  - Mortise and tenon joints
  - Mechanical fasteners

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### Combining Materials (cont'd.)

- Chemical fastening
  - Thermal bonding
  - Adhesives
- Thermal fastening
  - Welding

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### Organizing for Production

- Transition from craft to factory production
  - Workers formed labor unions
  - Working conditions improved
  - Production became more efficient
  - New, more complex machines were introduced

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### Computer-Integrated Manufacturing

- Modern manufacturing techniques
  - Computer-aided design
  - Computer-aided manufacturing
  - Automated material handling
  - Total quality control
  - Just-in-time
  - Flexible manufacturing system

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### Designing for Manufacture

- Rapid prototyping
  - Uses geometry files from CAD programs
    - Mathematically slice them up
  - Produce thin cross-sections of the part
- Evolution of rapid prototyping processes
  - Stereolithography
  - Plaster or starch
  - Fused deposition modeling

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### Future Impacts

- Society must be concerned with depletion of natural resources
  - Conserve materials that exist
  - Find alternative materials
- Other concerns
  - Air and water quality
  - Global climate change