Mechanical Manufacturing Process

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OUTLINE

• Material
• Manufacturing processes
Materials in Manufacturing

• Most engineering materials can be classified into one of three basic categories:
  1. Metals (金属) → 延展性好，導電導熱好
  2. Ceramics (陶瓷) → 硬度高，塑性低 (e.g., 玻璃)
  3. Polymers (高分子) → (e.g., 塑膠)
• Their chemistries are different, their mechanical and physical properties are dissimilar, and these differences affect the manufacturing processes that can be used to produce products from them

• In addition to the three basic categories, there are:
  4. Composites - nonhomogeneous mixtures of the other three basic types rather than a unique category
Manufacturing Processes

Two basic types:
1. Processing operations
   • transform a work material from one state of completion to a more advanced state
2. Assembly operations
   • join two or more components in order to create a new entity

Processing Operations

Alters a workpart's shape, physical properties, or appearance in order to add value to the material

• Three categories of processing operations:
  1. Shaping operations - alter the geometry of the starting work material
  2. Property-enhancing operations - improve physical properties of the material without changing its shape
  3. Surface processing operations - performed to clean, treat, coat, or deposit material onto the exterior surface of the work
Shaping Processes – Four Categories

1. **Solidification processes** - starting material is a heated liquid or semifluid that solidifies to form part geometry

2. **Particulate processing** - starting material is a powder, and the powders are formed into desired geometry and then sintered to harden

3. **Deformation processes** - starting material is a ductile solid (commonly metal) that is deformed

4. **Material removal processes** - starting material is a solid (ductile or brittle), from which material is removed so resulting part has desired geometry

**Shaping Process: Solidification Process**
- Starting material is heated sufficiently to transform it into a liquid or highly plastic state
- Examples: Casting for metals, molding for plastics
**Shaping Process:**

**Particulate Processing**
- Starting materials are powders of metals or ceramics
- Usually involves pressing (壓) and sintering (燒結), in which powders are first squeezed in a die cavity and then heated to bond the individual particles

![Particulate Processing Diagram](image)

**Shaping Process:**

**Deformation Processes**
Starting workpart is shaped by application of forces that exceed the yield strength of the material
- Examples: (a) forging (鍛造) (b) extrusion (擠壓成形)
**Shaping Process:**

**Material Removal Processes**

Excess material removed from the starting workpiece so what remains is the desired geometry

- Examples: machining such as turning (車), drilling (鉆), and milling (铣); also grinding (磨) and nontraditional processes

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**Property-Enhancing Processes**

- Performed to improve mechanical or physical properties of the work material
- Part shape is not altered, except unintentionally
- Examples:
  - Heat treatment of metals and glasses
  - Sintering of powdered metals and ceramics
Surface Processing Operations

1. **Cleaning** - chemical and mechanical processes to remove dirt, oil, and other contaminants from the surface
2. **Surface treatments** - mechanical working such as sand blasting, and physical processes like diffusion
3. **Coating and thin film deposition** - coating exterior surface of the workpart
   - Several surface processing operations can be used to fabricate integrated circuits

Assembly Operations

**Two or more separate parts joined to form a new entity**

• Types of assembly operations:
  1. **Joining processes** – create a permanent joint.
     • Examples: welding (焊接), brazing (钎焊), soldering (熔焊), and adhesive bonding
  2. **Mechanical assembly** – fastening by mechanical methods
     • Examples: use of screws, bolts, nuts, other threaded fasteners; press fitting…
Other Important Manufacturing Tools

- CNC
- ROBOT
- Injection Molding Machine
- EDM
- AGV
- Hydraulic Press

Computer Numerically Controlled Machines (CNC)

- Difference: In terms of the controller!!

Human vs. Computer
Computer Numerically Controlled Machines (CNC)

• Elements of NC system
  – Part program
  – Machine control unit (MCU)
  – The machine tool

• Capabilities of Machine control unit (MCU) of a NC machine:
  – Positioning the tool
  – Turning the spindle ON/OFF
  – Setting cutting speeds/feed rates
  – Turning coolant ON/OFF
  – Direction and rate of slide motion, spindle rotation, etc.
CAD/CAM based Part Programming:

- Direct use the CAD database for geometric description of parts.
- Generate tool path information from the geometric model of the part in the CAD database.
- Commercial CAD/CAM systems with NC program generation: CATIA, CADAM, Pro/E.

Robots

- Robot -- a programmable, multifunction manipulator designed to move and manipulate material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of specified tasks. (by Robotics Industries Association)
- The most common tasks:
  - Those that require demeaning or drudging effort, frequently on a repeating basis
  - Tasks performed in hazardous environments
Some old robots

ADEPT
PUMA 560
IBM SCARA

Some new robots

Honda
Motoman
injection molding machine (射出成型機)

Figure 13.20 - A large (3000 ton capacity) injection molding machine (courtesy Cincinnati Milacron)

Figure 13.22 - Typical molding cycle:
(1) mold is closed
Figure 13.22 - Typical molding cycle:
(2) melt is injected into cavity

Figure 13.22 - Typical molding cycle:
(3) screw is retracted
Figure 13.22 - Typical molding cycle:
(4) mold opens and part is ejected

Blow-and-blow forming sequence:
(1) gob is fed into inverted mold cavity; (2) mold is covered; (3) first blowing step; (4) partially formed piece is reoriented and transferred to second blow mold, and (5) blown to final shape
Wire EDM (放電線切割機)
Special form of EDM that uses small diameter wire as electrode to cut a narrow kerf in work

Electric discharge wire cutting (EDWC), also called wire EDM
Wire EDM (放電線切割機)
AGV (Automated Guided Vehicles)
無人搬運車

- Driverless Vehicle
- Electric motors, battery powered
- Programming capabilities
  - Destination
  - Path selection
  - Positioning
  - Collision avoidance
- System Discipline

Modern AGVS

- Modern AGVs are computer-controlled vehicles with onboard microprocessors.
- Position feedback system to correct path
- Communication between vehicles via system controller
  - RF communication
  - Electric signals
- System management computers
- Optimising the AGV utilisation
- Tracking the material in transfer and directing the AGV traffic.
press
衝壓機 (衝床)