Mechatronics – Manufacturing Technology

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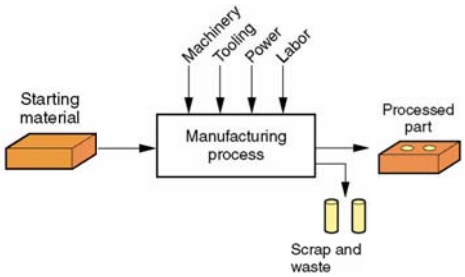
Outline

- Overview of manufacturing technology - 1
- Overview of manufacturing technology - 2
- CNC machine
- Intelligent machining

- Home work

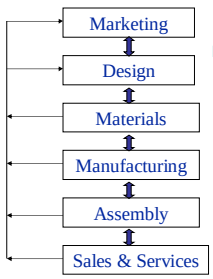
What is manufacturing ?



Sequential Manufacturing Activities

Marketing
⇩
Design (function & performance)
⇩
Select materials
⇩
Manufacturing (sequence & parameters)
⇩
Assembly
⇩
Sales & services

Concurrent Manufacturing Activities

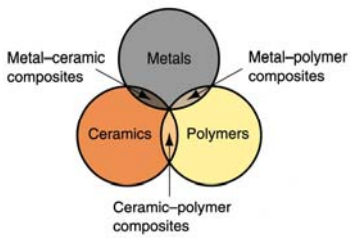


Design for Manufacturing and Assembly — DFMA

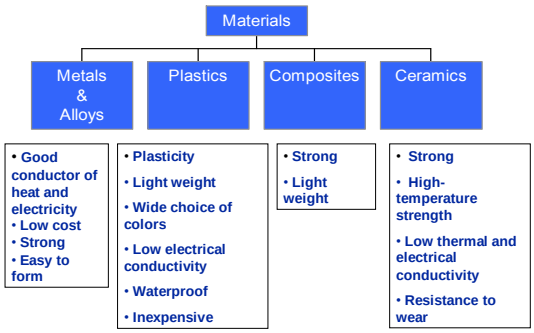
Reduce cost
Improve quality
Speed time to market

- Design for Manufacture
- Design for Assembly
- Design for Disassembly
- Design for Services

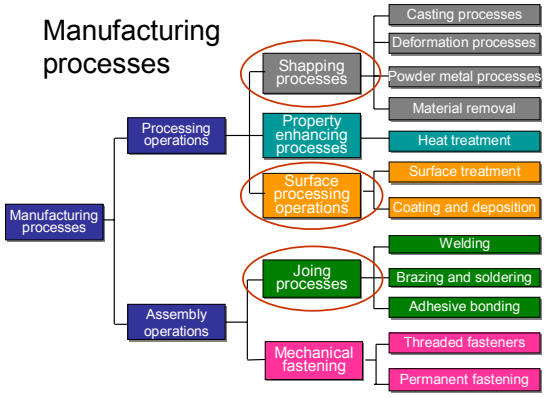
Engineering Materials



Materials Selections

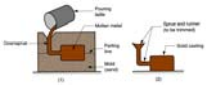


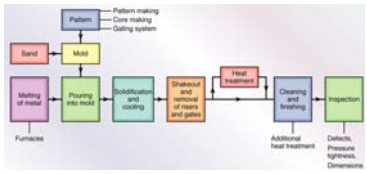
Manufacturing processes



Casting, Molding Processes

- Starting material is heated sufficiently to transform it into a liquid or highly plastic state.
- Examples: Casting for metals, molding for plastics
- Processes:
  - *Expendable mold, permanent pattern*
  - *Expendable pattern, mold*
  - *Permanent mold*

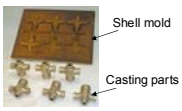




Expendable mold, permanent pattern casting

Pattern:
A full size of model of the part made of wood plastic or metal
Mold:
• Sand casting:
90% of Silica(SiO2) + 3% of water + 7% of clay
Typical part: all metal, no size limit, poor surface
• Shell mold casting
Mold is a thin shell, typically 9mm.
Sand + thermosetting resin binder
Ceramic + thermosetting resin binder
Typical part: good surface, high production


pattern



Expendable pattern, mold casting

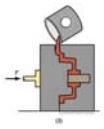
Pattern:
A full size of model of the part made of wax, polystyrene
Mold:
• **Investment casting: Wax**
Typical applications: Parts with great complexity, intricacy and small volume

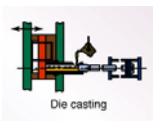
• **Lost foam casting: Polystyrene**
Typical applications: Parts with great complexity, intricacy

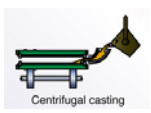
Permanent mold casting

• In permanent mold casting, the mold is reused many times
• The processes include:
- Basic permanent mold casting
- Die casting
- Centrifugal casting

Typical applications:
Good dimensional control, surface finish and high production rate with low melting temperature metals such as Al, Zin, Mg







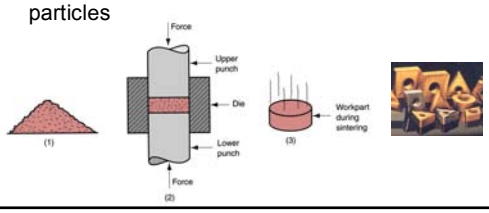
How do we manufacturing this?

Material: Magnesium

Sand casting
Shell mold casting
Investment casting
Lost foam casting
Die casting

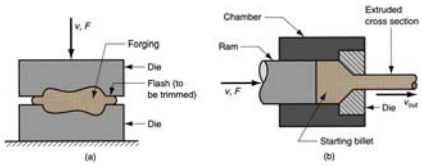
Powder Metal Processing

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

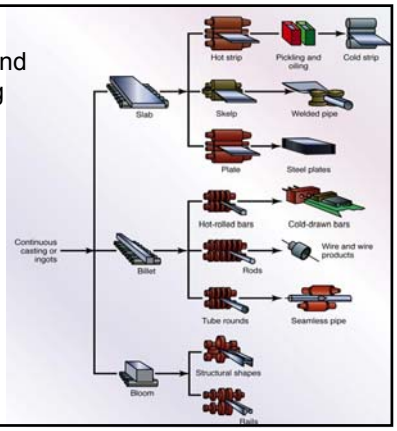


Bulk Deformation Processes

- Starting workpart is shaped by application of forces that exceed the yield strength of the material
- Processes:
  - *Rolling*
  - *Forging*
  - *Extrusion and drawing*

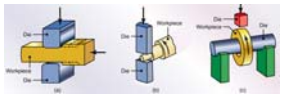


Flat rolling and shape rolling products

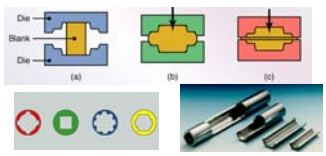


Forging

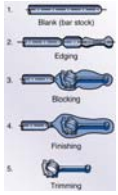
Open die forging: change the cross section of part



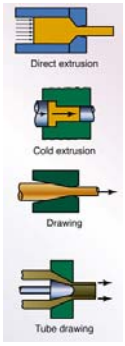
Close die forging: get the shape of part



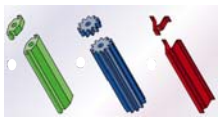
Forging connecting rod



Extrusion and drawing



A billet (generally round) is forced through a die which has an aperture shape cut into it. This produces the shape of the extrusion which exists from the die.



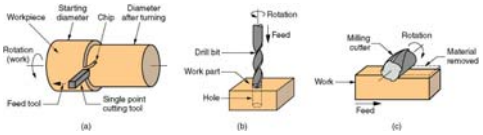
How do we manufacturing this?

Material: Middle carbon steel

Sand casting
Rolling
Open die forging
Close die forging

Material Removal Processes

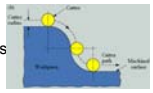
- Excess material removed from the starting workpiece so what remains is the desired geometry
- Processes
  - Machining, such as turning, drilling, and milling;
  - Advanced machining, such as EDM
  - Finishing machining, such as grinding, honing



Why Machine ?

- ***Very accurate***
  - highest of all manufacturing processes
  - small amounts of materials removed
  - precise tools, dies, molds can be made
  - mirrors can be cut to nanometer
- ***Highly Flexible***
  - shape is programmed
  - many different parts can be made on one machine
  - any arbitrary shape can be machined
- ***Low cost tooling***
  - contour is generated by path of tool, rather than its shape, in most cases
  - cutting tools are mass-produced in standardized shapes

MotorZeiss - GermanyMicro-parts



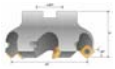
Machine Tools and Processes

- Turning(Svarvning)
- Boring(Borrning)
- Drilling(Borrning)
- Reaming(Brotschning)
- Milling(Fräsning)
- Planing(hyvling)
- Shaping(avhyvling)
- Broaching(Driftning)
- Sawing(Sågning)

Cutting Tool Classification

- ***Single-Point Tools***
  - One cutting edge
  - *Turning* uses single point tools
  - Point is usually rounded to form a *nose radius*

- ***Multiple Cutting Edge Tools***
  - More than one cutting edge
  - Motion relative to work usually achieved by rotating
  - *Drilling* and *milling* use rotating multiple cutting edge tools.

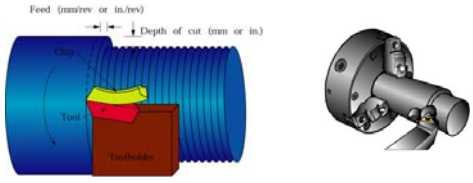


Cutting tool materials

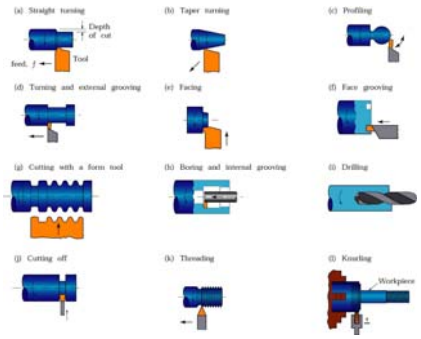
Tool steels	Cemented carbides	Ceramics	Super-hard cutting materials
• Cold working steel • High speed steel (HSS)	WC-Co WC-(Ti, Ta, Nb)C-Co TiC/TiN-Co, Ni	Al2O3 ceramic Silicom-nitride ceramic	Cubic Boron nitride (CBN) Diamond (PCD)

Produce Round Shape - Turning (Svarvning)

Single point cutting tool removes material from a rotating workpiece to form a cylindrical shape



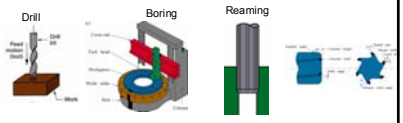
Different Type of Turnning Processes



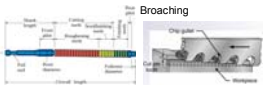
Holemaking Operations

Typical holemaking operations:

- Drill
- Boring
- Reaming
- Broach

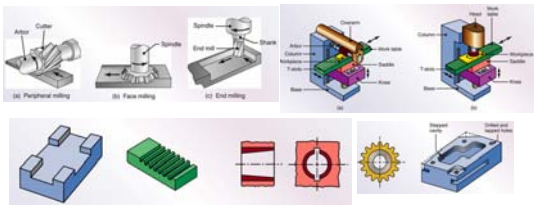


Drilling accounts for the majority of holemaking operation due to its simple, quick and economic



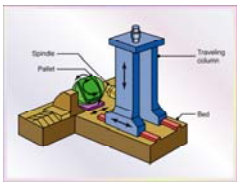
Machining various shape - milling

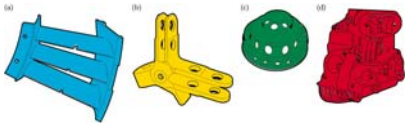
- Milling tool is a multi-tooth cutting tool.
- The characteristic feature of the milling process is that each milling cutter tooth removes its share in form of small individual chips.
- In milling operation, workpiece is usually stationary while miller is rotate.



Machining complex profile

CNC Milling center with 5 axis





Abrasive machining

Abrasive machining

Material removal by the action of hard, abrasive particles that are usually in the form of bonded wheel.

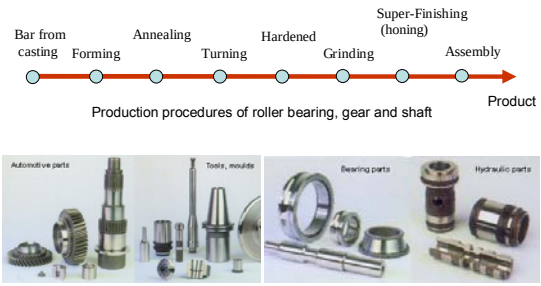
Abrasive processes include

- Grinding
- Honing
- Lapping
- Polishing

When do we need Abrasive machining?

- High surface finishing and dimensional accuracy
- Hard workpiece
- Brittle workpiece

Grinding in Manufacturing Process

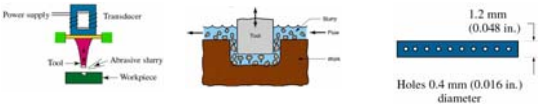


Advanced machining

- ***Mechanical Energy Processes***
  - Ultrasonic machining, Water jet cutting, Abrasive jet machining and Abrasive water jet cutting
- ***Thermal Energy process***
  - Electric Discharge Machining (EDM), Wire EDM, Electron Beam, Laser Beam, Arc Cutting
- ***Chemical Machining***
  - Chemical Milling, Blanking, Engraving and Photochemical Machining

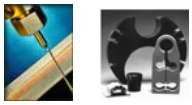
Ultrasonic Machining

- High frequency vibration (20kHz) + abrasives
- Workpiece: hard, brittle materials such as ceramics, glass and carbides



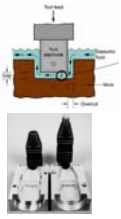
Water Jet Cutting (WJC)

- High pressure 400 MPa and high speed 900m/s water



Electrical discharge machining (EDM)

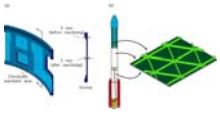
- Sparks (lightening: 500 - 5,000 sparks per second) across a small gap between tool and work to remove material, thus slow
- Tooling for many mechanical processes: molds for plastic injection molding, extrusion dies, wire drawing dies, forging and heading dies, and sheet metal stamping dies



Laser Beam Machining

Chemical Machining (CHM)

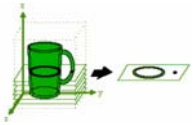
- Material removal through contact with a strong chemical etchant (controlled etching process), such as acids and alkaline. This process is carried out by chemical dissolution.
- Applications:
  - Aerospace industry
  - Circuit boards



Rapid Prototyping and Rapid Tooling

Rapid Prototyping (RP)

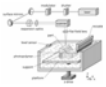
- Generative (layer-by-layer) build up of parts directly from CAD-data
- Usually no molds or tools required
- Accessing of high economic potentials while producing complex geometries in small batches



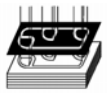
Rapid Tooling (RT)

- Same principles and characteristics as for Rapid Prototyping
- Layer-by-layer build up of molds and dies (direct RT)
- Shaping of molds and dies from RP-made master patterns (indirect RT)

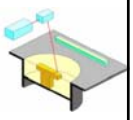
Stereolithography (SL)
– Layer-by-layer curing of a liquid photopolymer by a laser
– Control of laser by a scan-mirror system

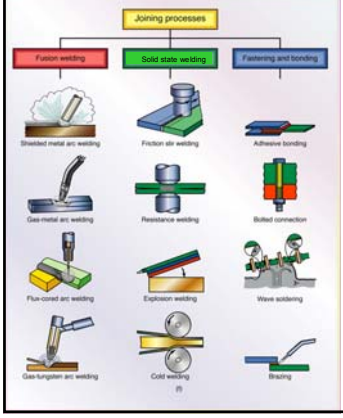


Solid Ground Curing (SGC)
– Layer-by-layer curing of a liquid photopolymer through a mask by an UV-lamp
– Exposure of each layer in one step



Selective Laser Sintering
– Local melting/sintering of a powder by a laser
– Direct: the powder particles melt together





Joining Processes

• ***Fusion welding***
- Joining is accomplished by melting the two parts to be joined, in some cases adding filler metal to the join.

• ***Solid state welding***
- Joining is accomplished through the application of pressure at a temperature below the melting temperature of the base material; no filler metal is used.

• ***Brazing and soldering***

Surface treatment processes

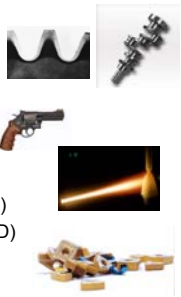
• Performed to improve mechanical or physical properties of the work material
• Part shape is not altered, except unintentionally

Why surface treatment ?

• Improve mechanical properties
• Provide corrosion protection of the substrate
• Enhance product appearance, e.g., color or texture
• Increase wear resistance and/or reduce friction
• Increase electrical conductivity or resistance
• Nonmetallic materials are coated for:
  - metallica appearance
  - antireflection coating
  - printed circuited boards

Surface treatment processes

• Mechanical processes: steel
  - Peening, roller burnishing
• Thermal surface treatment: steel
  - Case hardening, carbonizing
• Anodizing: Al, Mg, Ti and Zin
• Thermal spray coating
• Vapor deposition (coating)
  - Physical vapor deposition (PVD)
  - Chemical vapor deposition (CVD)
• Electroplating
• Painting



Summary

- Casting processes
  Sand casting, shell molding casting, die casting ...
- Deformation processes
  Rolling, forging, extrusion
- Powder metal processes
- Material removal processes
  Turning, milling, grinding, advanced machining ...
- Joining processes
- Surface treatment processes