Manufacturing Processes

- Mountain bike example
- Manufacturing process definition
- Deformation processes
- Casting processes
- Sheet metalworking
- Polymer processing

How would we manufacture a mountain bike?

(Courtesy of Trek Bicycle, 2002)
Manufacturing process decisions

- Specific manufacturing processes?
- How do the selected materials influence the choice of manufacturing processes?
- Does product function or performance issues influence our choice of mfg. processes?
- What criteria should we use to select processes?
- Which criteria are more important?
- Who will make the final decisions?

Parts undergo sequence of processes

- Primary - alter the (“raw”) material's basic shape or form.
  - Sand casting
  - Rolling
  - Forging
  - Sheet metalworking
- Secondary - add or remove geometric features from the basic forms
  - Machining of a brake drum casting (flat surfaces)
  - Drilling/punching of refrigerator housings (sheet metal)
  - Trimming of injection molded part flash
- Tertiary - surface treatments
  - Polishing
  - Painting
  - Heat-treating
  - Joining

Changes?
Types of manufacturing processes

How is the input material changed?

Deformation
- Extrusion
- Forging
- Rolling
- Bar drawing
- Wire drawing

Casting
- Centrifugal die casting
- Permanent mold casting
- Sand casting

Sheet Metal Processes
- Bending
- blanking
- Drawing
- punching
- Shearing
- Spinning

Polymer Processes
- Blow molding
- Casting
- Compression molding
- Extrusion
- Injection Molding
- Thermoforming
- Transfer molding

Machining
- Boring
- Drilling
- Facing
- Grinding
- Milling
- Planing
- Turning
- Sawing
- ECM, EDM

Finishing
- Anodizing
- Honing
- Painting
- Plating
- Polishing

Assembly
- Automated bonding
- Brazing
- Manual
- Riveting
- Soldering
- Welding

Manufacturing Process Considerations

1. Production Volume
2. Part Size (overall)
3. Shape Capability (features)
   - boss/depression 1D
   - boss/depression >1D
   - holes
   - undercuts (int./ext.)
   - uniform walls
   - cross sections - uniform/regular
   - rotational symmetry
   - captured cavities
Deformation processes

- Rolling
- Extrusion
- Drawing
- Forging

Rolling (of ductile materials)

Rollers in compression

thick slab

Plastic deformation

thin sheet
Rolling

- ingot
- bloom
- structural
- slab
- sheet
- coil
- billet
- bar
- rod

Extrusion

- Extrusion die
- Ram
- Billet
- Cross sections
Drawing

Forging (closed-die)
Casting Processes

- Sand casting
- Die casting
- Investment casting

Sand casting (closed-mold)

Diagram showing casting process components:
- Core
- Riser
- Sprue
- Runner
- Gate
- Drag
- Parting line
- Cope
- Flask
Die casting

- Stationary die
- Moving die
- Molten metal
- Plunger
- Sprue
- Ejector pins
- Parting line

Investment casting

- Wax pattern is cast
- 4-part pattern tree
- Ceramic mold (hardened slurry)
- Wax removed by melting
- Molten metal solidifies in cast
- Ceramic mold is removed
Sheet Metalworking

- Bending
- Blanking
- Drawing
- Punching
- Shearing
- Spinning

Sheet metal drawing

Punch

Blank holder

Die

Blank

Drawn part

Clamp force

Punch ram
Example sheet metal parts

Commercial Sheet Metal Parts

Types of manufacturing processes

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Polymer Processes
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Machining
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- Drilling
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- Planing
- Turning
- Sawing
- EDM, EDD

Finishing
- Anodizing
- Honing
- Painting
- Plating
- Polishing

Assembly
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- Manual assembly
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- Welding
Polymer Processes

- Compression molding
- Transfer Molding
- Blow molding
- Injection molding

Compression molding
Transfer molding

Blow molding
Injection molding

Cavity half of mold
Core half of mold

Ejector pins

Pellets
Barrel
Shear-heating
Sprue
Parting plane/surface

Fixed
Moving

Mold closure direction

Example of a box ...with no undercuts

parting line
ejector pins
core
cavity

mold closure direction
plastic injection
Internal undercuts

External undercuts
Solidification processes summary

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Recall considerations:
- Flow (voids, flash)
- Cooling time (cycle time)
- Temperature
- Mold complexity
- Warpage
- Post processing
- Costs (materials, tooling, processing)

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