Lecture #26

ERDM

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Manufacturing Specifications

What must the process (or processes) do?

Design places many requirements on manufacturing.

- **Surface finish**
- **Dimensions (flatness, perpendicularity, straightness, cylindricity)**
- **Metallurgy / microstructure**
- **Allowable deviations from the desired values**

Manufacturing Specifications - cont.

In addition to the requirements specified by design that are needed to achieve product function, there are other specifications:

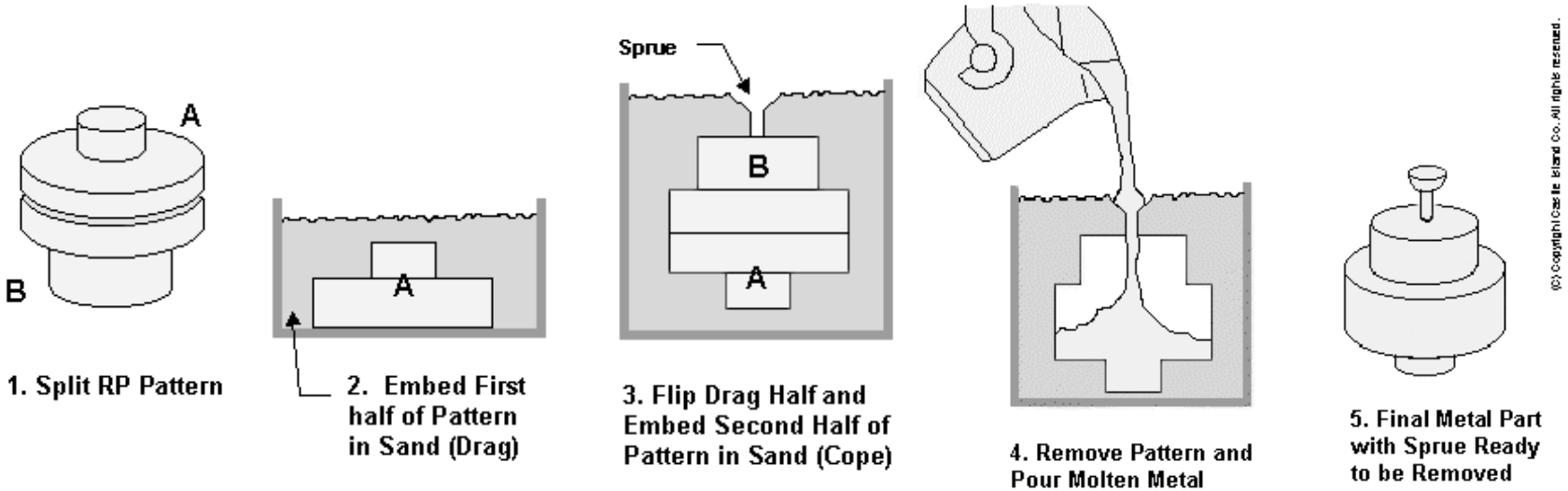
- **Cost - may have goal specified**
- **Productivity**
- **Profit**
- **Environmental impact and efficient use of resources**

Manufacturing Process Classifications

- **Solidification Processes**
  - **Casting**
  - **Polymer processing operations**
- **Forming Processes (Bulk Deformation & Sheet Working Operations)**
- **Particulate Processing Operations**
- **Material Removal Processes**
  - **Cutting Processes**
  - **Non-Traditional Material Removal Operations**
- **Joining Processes**
- **Surface Treatment Processes**

Casting

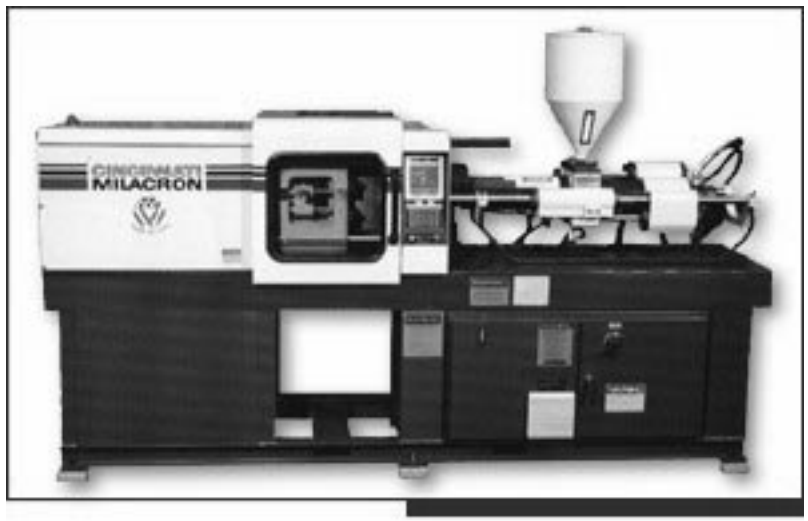
- Sand Casting
- Permanent - Mold Casting
- Die Casting
- Centrifugal Casting

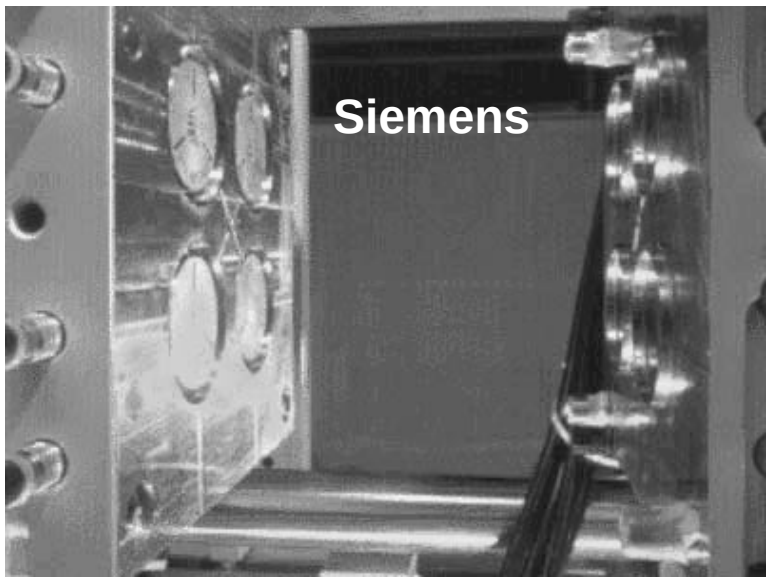


Ed Grenda, Castle Island Co.

Polymer Processing

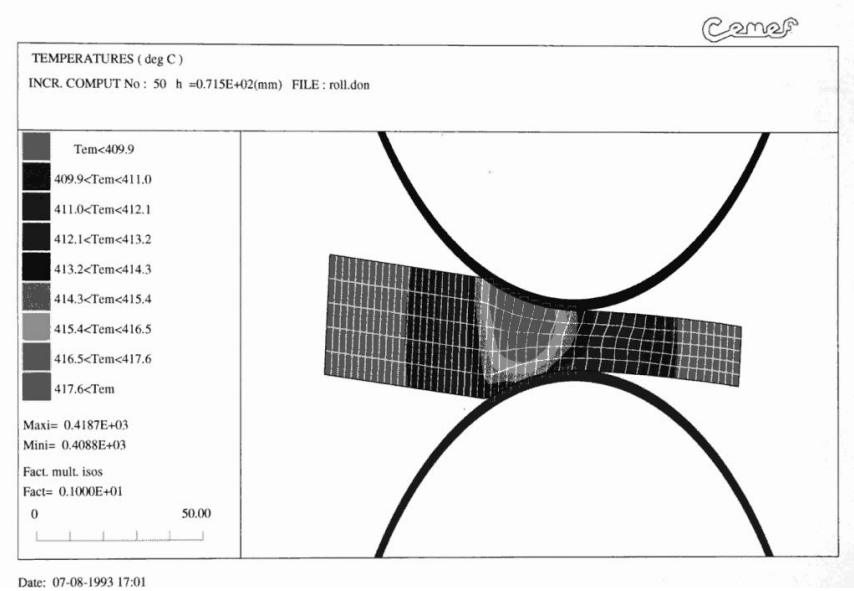
- **Injection Molding**
- **Blow Molding**
- **Compression Molding**
- **Transfer Molding**





Bulk Deformation Processes

- **Rolling**
- **Forging**
- **Extrusion**
- **Wire Drawing**



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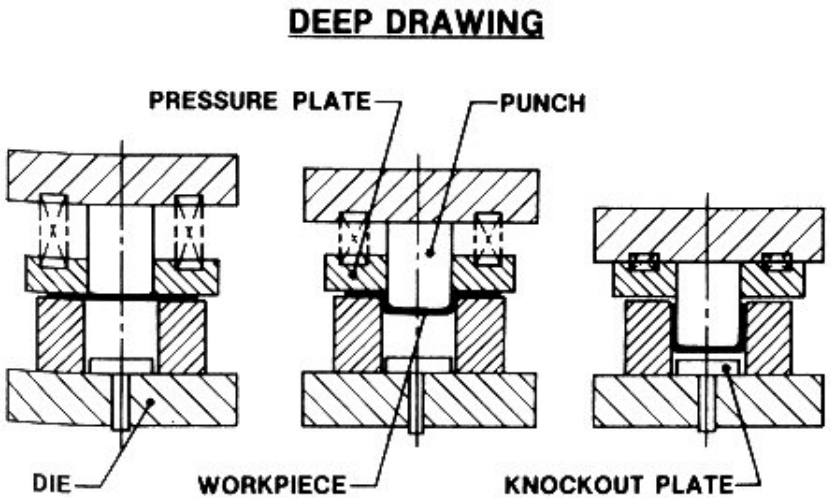
Sheet Working Operations

- **Bending**
- **Deep Drawing**
- **Blanking**
- **Stamping**



Val Hawks, BYU

Particulate Processing (Powder Metallurgy)

Steps include:

- **Powder production**
- **Blending**
- **Compaction (green compact)**
- **Sintering**
- **Finishing**

Cutting Processes

- **Turning**
- **Boring**
- **Drilling/Tapping/Reaming**
- **Face Milling**
- **End Milling**
- **Shaping/Planing**
- **Broaching**

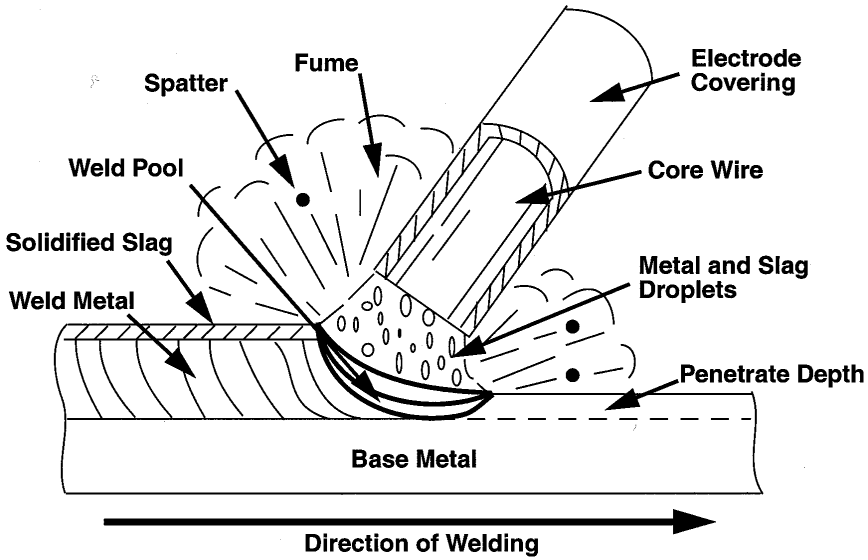
- **Surface Grinding**
- **Cylindrical Grinding**
- **Deburring**

Non-Traditional Material Removal Operations

- **Electrochemical Machining**
- **Electrical Discharge Machining**
- **Chemical Machining (PCM)**
- **Laser Beam Machining**
- **Rapid Prototyping**

Joining Processes

- Mechanical Joining (screws, rivets, staples)
- Brazing, Soldering
- Adhesive Bonding
- Arc Welding
- Resistance Welding
- Ultrasonic Welding
- Friction Welding
- Oxyacetylene Welding



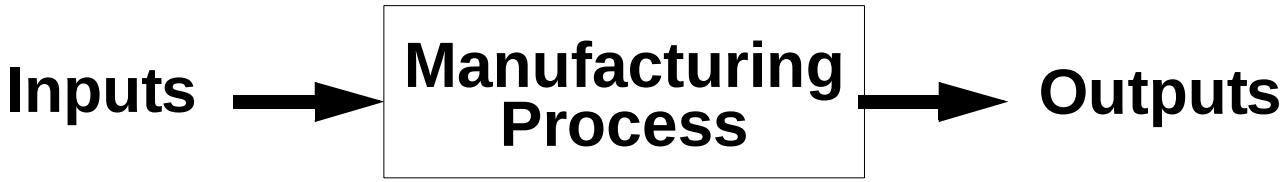
Surface Treatment Processes

- **Vapor Deposition**
- **Electrochemical Plating**
- **Anodizing**
- **Painting**

- **Heat Treatment**
- **Carburizing**
- **Nitriding**

Big Picture Thinking

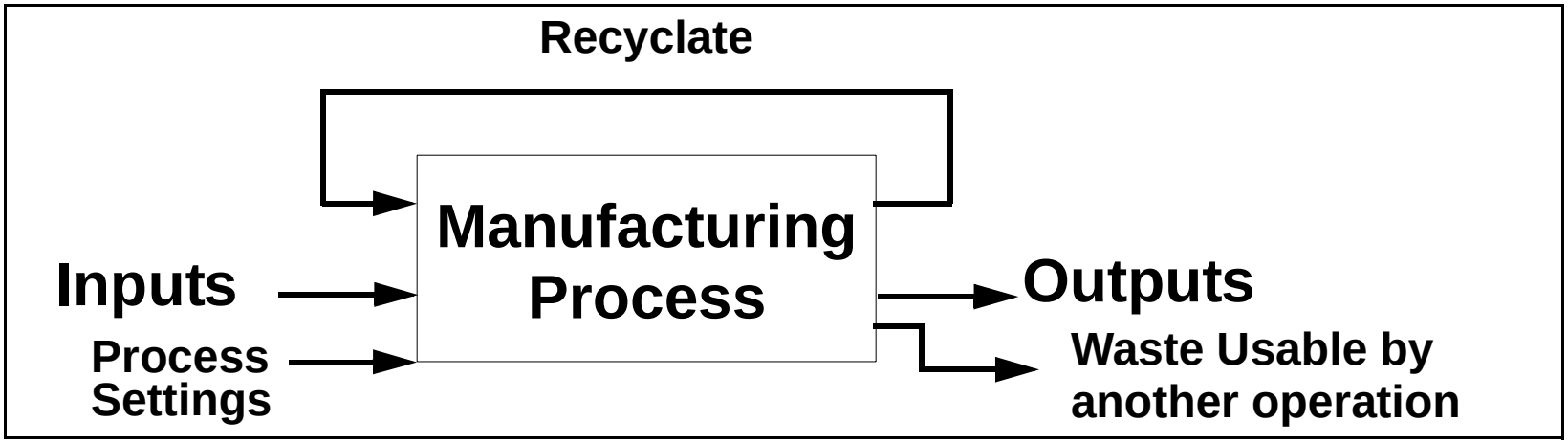
For every process of interest we need to understand the inputs, outputs, & their relationship(s).



Inputs: Raw material / workpiece, energy, secondary materials, machinery.

Outputs: Finished part, heat, spent secondary materials, scrap raw materials, non-conforming finished parts, used machinery.

Manf. Processes - Input/Output View



Inputs: Raw material, energy, secondary materials, machinery, air.

Outputs: Product, heat, by-products, scrap, used machinery, gaseous/liquid emissions.

Handling Waste Streams

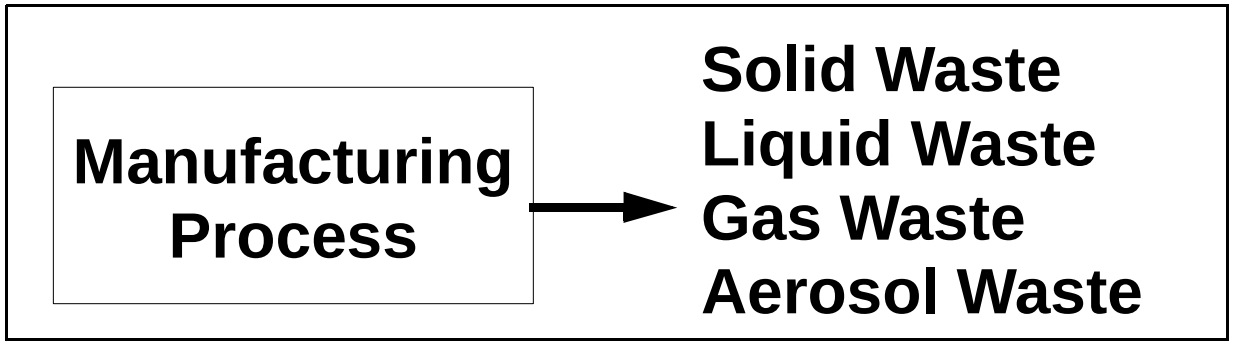
- **Store waste**
- **Treat waste**
- **Recycle waste**
- **Find a way to use the waste as an input to another process**
- **Prevent/avoid waste**

Waste Stream Prediction

For each type of process apply engineering knowledge/models to predict the quantity and character of the waste streams.

- **Statics/dynamics**
- **Mechanics of materials**
- **Heat transfer/thermodynamics**
- **Fluid mechanics**
- **Chemistry**
- **Physics**

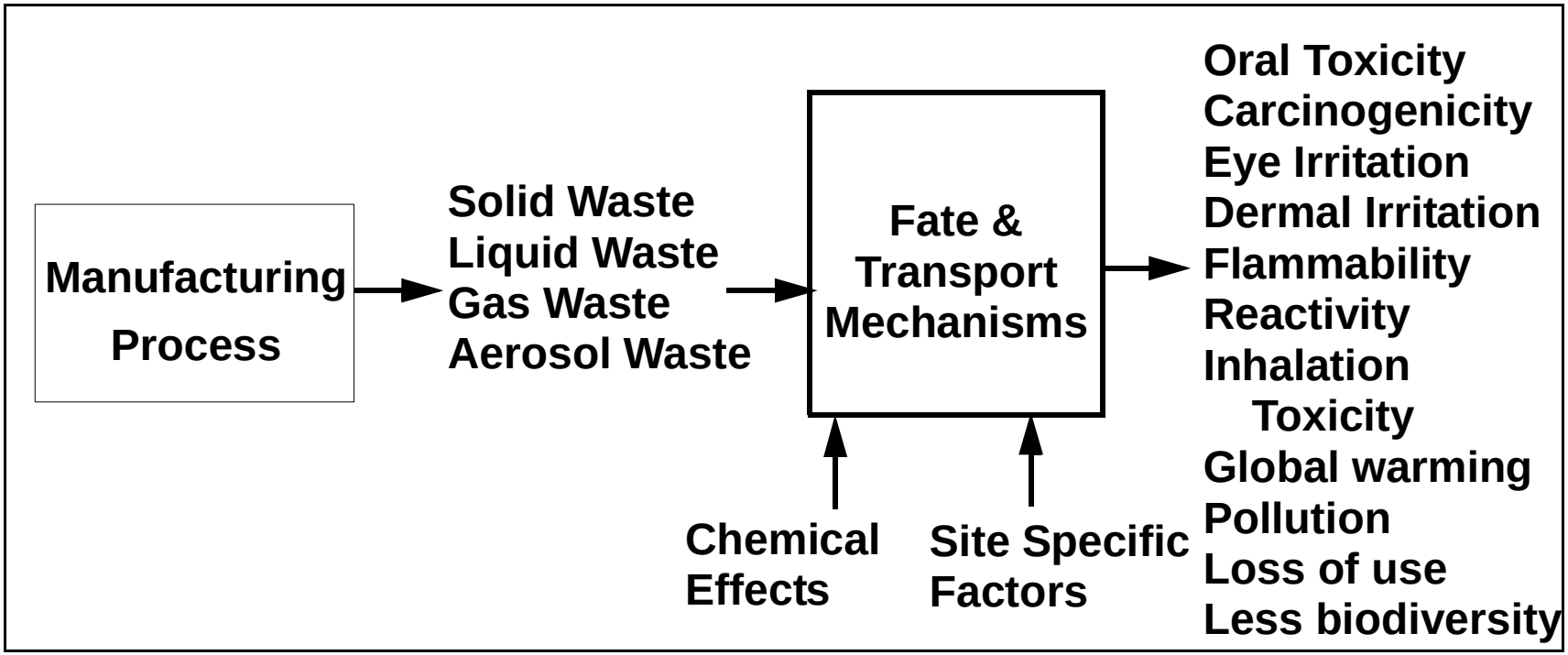
Waste Stream Types



For a given process, we need to have models that can predict both the mass flow rate and character of the waste stream.

Character: Size of solid waste stream elements, components mixed with the liquid waste, particle sizes with the aerosol.

Effect of Waste Streams



Let's look at some of these things a bit more closely.
Munoz, Sheng, Trans. of NAMRI / SME, 1995.

EHS Effects

Toxicological Effects:

Oral toxicity **Inhalation toxicity**

Dermal irritation **Eye irritation**

<u>Cancer Effects:</u> Carcinogenicity

<u>Safety Concerns:</u> Flammability, Reactivity

Pollution:

Global warming **Loss of use**

Less biodiversity **Chronic effects**

Fate and Transport

For each type of waste -- need to understand the mechanism that relates the waste to the undesired effect.

Physical and chemical transformations and pathways. Genetic change initiation.

One substance can form several different waste streams: e.g., cutting fluid can be a liquid waste, gas waste (fluid vapor), aerosol waste (mist). The effect of these streams can be different.

Characterizing the EHS effects?

- **Toxicological effects: Dose-response curve, LD50, LC50**
- **Cancer effects: clinical (laboratory) and epidemiological (statistical) data**
- **Physical effects: flash point (upper and lower explosion limits), reactivity (number of substances that react with it)**
- **Pollution effects (environmental): difficult - amount of greenhouse gases, FOG, BOD, COG**

Site Specific Effects

Let's say a process produces a toxic gas. Will operators working near the process be affected??

Depends on what hazard protection is available at the process, or what actions have been taken to diminish the hazard. These site specific factors disrupt the fate and transport mechanisms.

Examples: Shielding, ventilation, gloves, masks, safety glasses, inert environment

Calculating the EHS Effect

$$HHS = H^T \bullet F$$

where, H is the health hazard vector for a given waste stream, and F is a vector for the site specific factors.

$$\text{weighted mass flow} = HHS \bullet m = \text{weighted hazard}$$

where m is the mass flow rate.

May need to use AHP (?) to develop H and F vectors

Refer to Sheng et al. for additional detail.