# Lecture #16

# ERDM


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# Product Design

**So far.....**

- **The impact of material selection on the environment - material related issues**
- **Specifications**
- **Use of QFD to hear “voice of the environment” during concept design.**
- **Effect of geometric features on reprocessability.**
- **Selection of product dimensions based on value model. Multiple use cycles.**

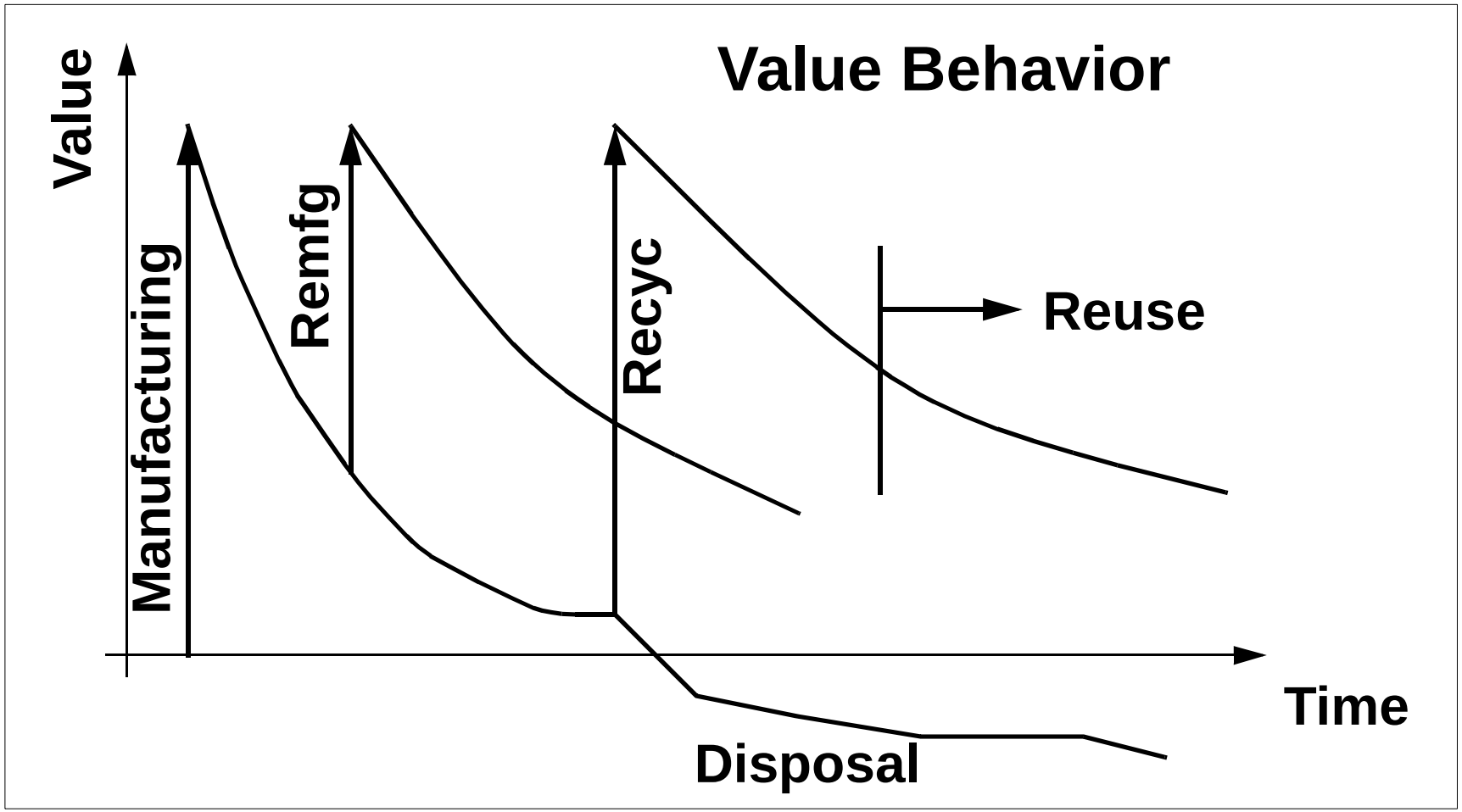
# Coming Soon

- **Assembly & disassembly**
- **Fasteners**

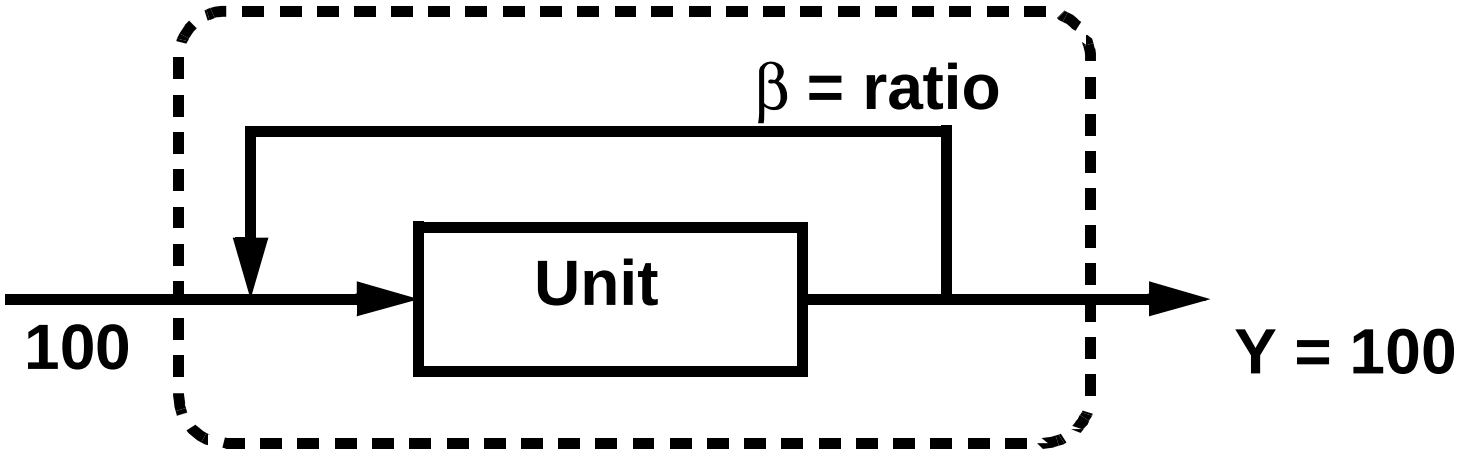
- **Improving things....**
  **What actions can we take?**
  - **Design for recycling**
  - **Design for the environment**
  - **etc.**

- **Then...**
  - **Process issues**
  - **System issues**

# Some Loose Ends



# Flow Chart

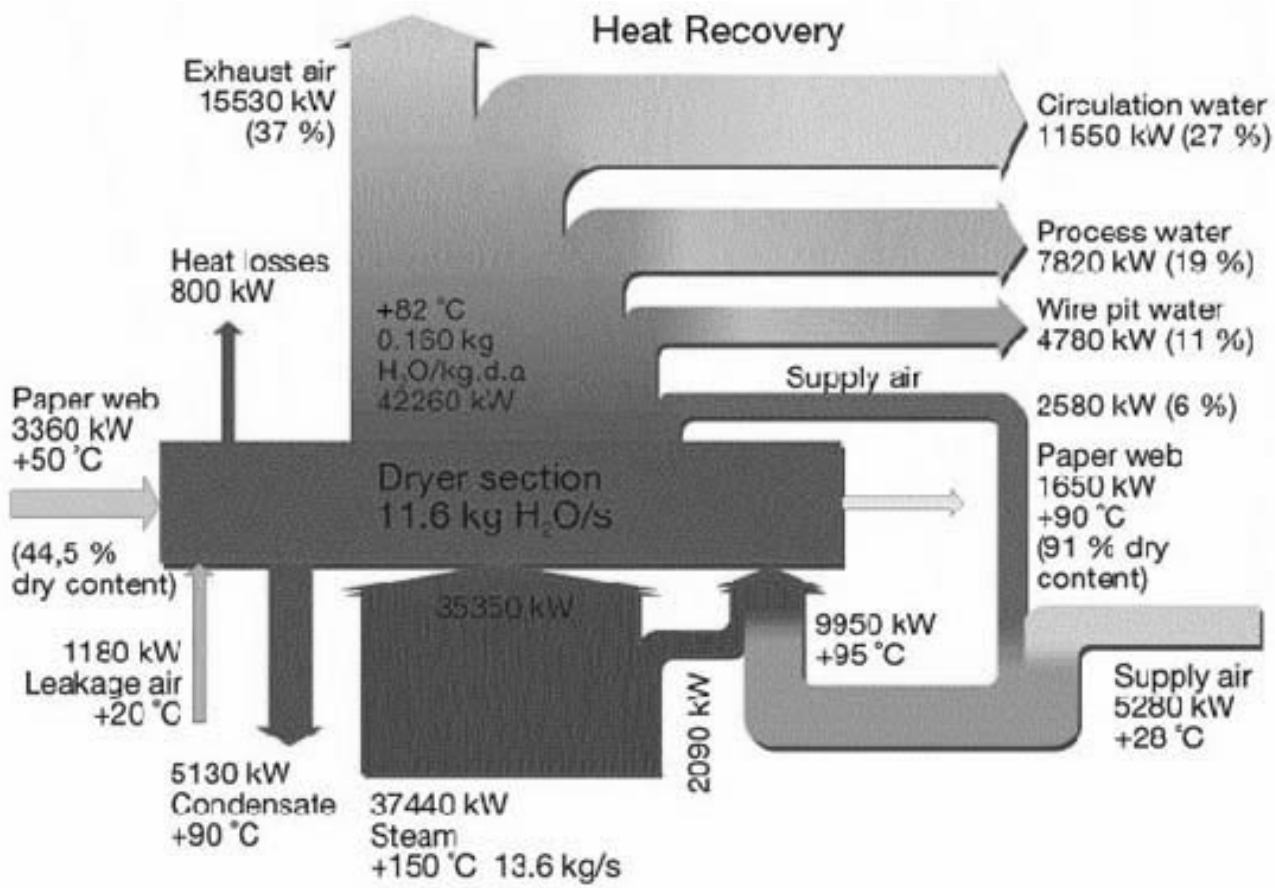



**But, unit must process: 100/(1-β)**

**If β=.25, unit must process 133**

# Sankey Diagram

**Sankey diagrams are used for displaying flows through a system. They are especially useful for displaying mass, energy, and cash flows.**



# Shifting Gears

**We now are going to begin looking at products with more than one part.**

**Examples: vehicle, washing machine, mechanical pencil, computer, etc.**

**Products consist of components, parts, sub-assemblies**

**What are the issues?**

# Principles (from Graedel & Allenby)

- **All material that enters a manf. process should leave as part of a product.**
- **All energy should result in useful work.**
- **Products should be made of abundant, nontoxic materials.**
- **Products should be designed so that useful products can be made from them at the end of their life.**
- **Pursue min. packaging & max. matl. recycling/reuse.**

# Trends (Graedel & Allenby)

- **Environmental constraints -- energy and resource conservation. Opportunity for competitive advantage.**

- **Price structures - undergo evolution - more externalities become captured through market mechanisms, fees, & taxes. Corp. that fail to internalize env. considerations - costs escalate wildly/ unpredictably - few options under rapid changes.**

- **Governments will place responsibility for products on manufacturers - product stewardship. 1990's product take-back legislation in Germany & Japan.**

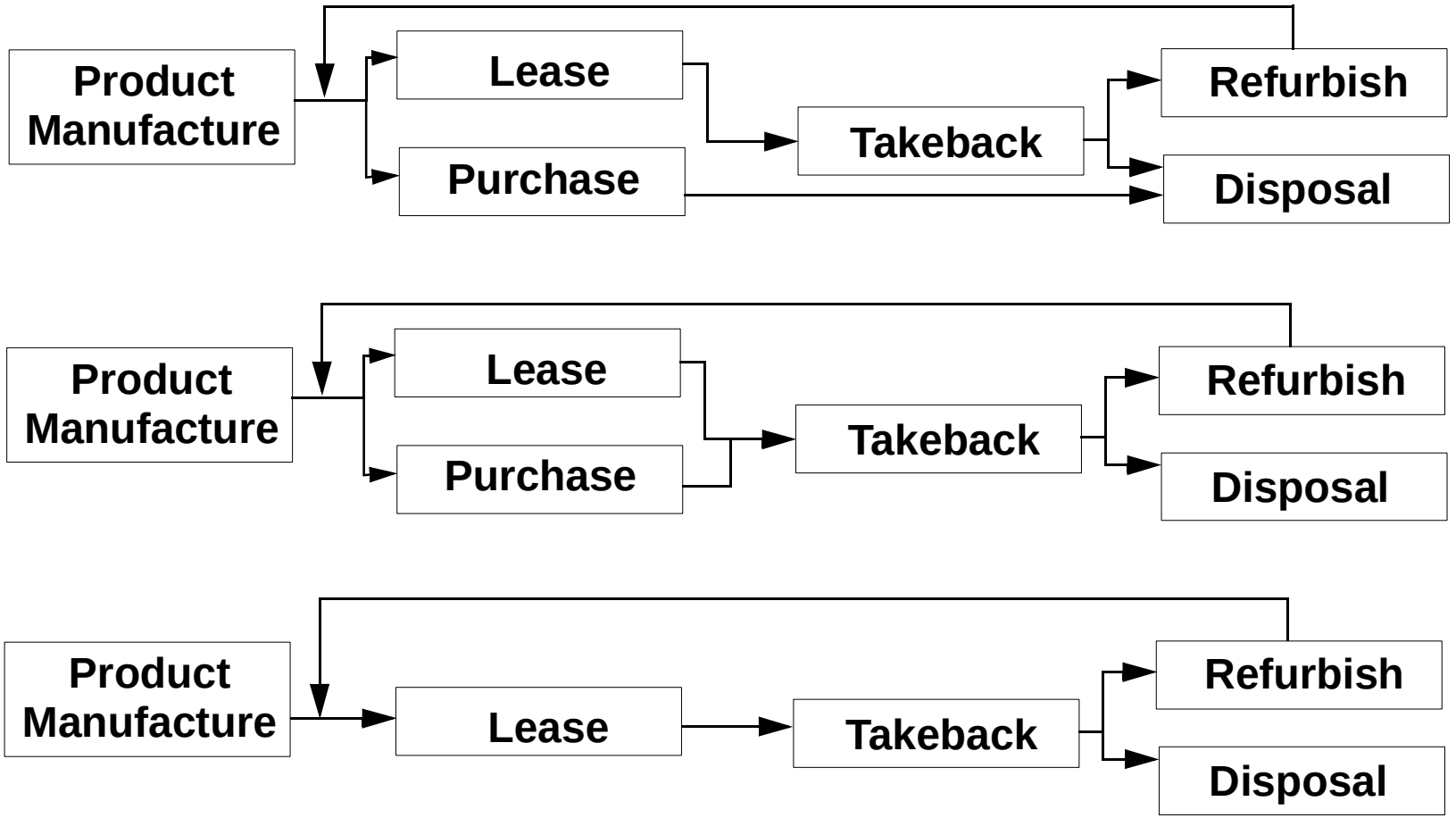
# Take-Back

- **Government policies are in effect (in some locations) that require take-back. Company is "on its own" to figure out what to do with the returned products.**

- **Some companies have products that naturally fit with the take-back concept.**
  - **"Single-use" cameras**
  - **Toner Cartridge**

- **Take-back concept is consistent with leasing/selling use concept (computers, locomotive engine, cable box, automobiles)**

# Evolving View of Take-back



# Take-Back

**It is likely that "take-back" will involve some form of disassembly.**

- **Reversible disassembly**
- **Irreversible (destructive) disassembly**

  - **Critical operations**
  - **Hazardous components / materials**
  - **Separation and part control**

# Disassembly - Recycling

- **Obviously, some disassembly is required if the intention is to rework, refurbish, remanufacture, etc. a product.**

- **If an "end-of-life" product is to be recycled, i.e., material recovery, it may also require disassembly. Why?**

  **May be easier/less costly to recover materials in component form rather than in small shredded bits.**

# Disassembly Researchers

- **J. Nevins & D. Whitney**
- **G. Boothroyd & P. Dewhurst**
- **Surendra Gupta**
- **Bert Bras**
- **Rajit Gadh**
- **Ad de Ron**
- **Xirouchakis**
- **Navin Chandra**
- **R. Caudill**

# Disassembly Operations

- **Collection, transportation, & handling**
- **Storage of products / components (pre- and post-disassembly)**
- **Positioning & fixturing**
- **Separation of fasteners / joints**
- **Fixturing**

***Remove hazardous materials & components as early as possible.***

# Separation & Part Control

- **Design parts for quick identification - product labeling**
- **Provide for gripping surfaces / stacking surfaces**
- **Simplify fasteners - promote easy separation - minimum parts and minimum tools**
- **Modular designs preferred**
- **Quick removal (& replacement) of parts that are likely to have failed or seen excessive wear.**

# Disassembly

**Discussing role of geometry, fasteners, and materials on the environment. Disassembly focuses on the relationship between the parts within a product.**