Industrial Systems Discussion: Sustainable Design and Manufacturing

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SFI Colloquium
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Basis of Discussion

Sustainability in Manufacturing: Recovery of Resources in Product and Material Cycles (2007), Gunther Seliger, Editor

Selections from Chapter 4 and Chapter 8
## Design for Disassembly

<table>
<thead>
<tr>
<th>Cost distribution</th>
<th>Product recycling</th>
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<tbody>
<tr>
<td>Maintenance</td>
<td>Disassembly</td>
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<tr>
<td>Error finding</td>
<td>Cleaning</td>
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<td>10 %</td>
<td>40 %</td>
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<tr>
<td>Disassembly</td>
<td>Inspection</td>
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<td>5 %</td>
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<tr>
<td>Reassembly</td>
<td>Reconditioning</td>
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<td>25 %</td>
<td>10 %</td>
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<tr>
<td>Part costs</td>
<td>Reassembly</td>
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<td>25 %</td>
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<td>Overhead costs</td>
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<td>5 %</td>
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(Seliger 2007, p. 144)
Design for Disassembly

✓ **Materials**
  - Identify materials
    - Use recycled materials, if possible
  - Reduce material variety
    - Use similar materials in assemblies/modules
  - Avoid materials that are pollutants, hazardous, non-recyclable

✓ **Product structures**
  - Reduce the number of parts
  - Create modular, horizontal product structures
  - Allow for reuse of standardized components/assemblies

✓ **Connections**
  - Reduce number/variety of connections
  - Minimize disassembly directions
  - Use fasteners that can be removed with standard tools
  - Avoid requiring destructive separation

(Seliger 2007, p. 144)
Life Cycle Planning and Tracking

- **Goals**
  - Using products longer
  - Using products beyond their original requirements

- **Methods**
  - Maintenance
  - Adaptations
    - Modernization
    - Expansion
Life Cycle Planning and Tracking

(Seliger 2007, p. 190)
Managing Product Development

Product Development Process (PDP)
- Method to develop new products
- Tools used include
  - Quality function deployment (QFD)
  - Failure mode and effect analysis (FMEA)
  - Design for six sigma (DFSS)
- Unique to different companies
- Basis for sustainable product development

Sustainable Product Development (PD)
- Traditional PDP plus Sustainability
- Eco-design tools
  - Design for X (environment, recycling, ...)
  - Life Cycle Analysis
- Business aspects
  - Managing target cost
  - Improvement of work team performance
Managing Product Development

(Seliger 2007, p. 200)
# Managing Product Development

<table>
<thead>
<tr>
<th>Knowledge Areas</th>
<th>Development</th>
<th>Informational Design</th>
<th>Conceptual Design</th>
<th>Detailed Design</th>
<th>Production Preparation</th>
<th>Product Launch</th>
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Sustainable Futures Institute

Dept. of Mechanical Eng. – Eng. Mechanics

(p. 203)
Sustainable Manufacturing

End-of-Pipe Treatment → Pollution Prevention → Design for Environment → Sustainable Development

- Environmental
- Economic
- Social

- Good individual and corporate citizens and government
- Multifaceted accountability for the public and private sectors

- Eco-efficiency
- Triple bottom line
  - Economic
  - Environmental
  - Social

- Design for Environment
  - Proactive
  - Beyond compliance
  - Life cycle analyses
  - ISO 14000
  - Extended responsibility
  - Full cost accounting
  - Benchmarking

- Pollution Prevention
  - Reduce
  - Reuse
  - Recycle

- End-of-Pipe Treatment
  - Reactive
  - Reliance on abatement
  - Driven by regulations
    - Manufacture
    - Product use
    - Disposal
  - No regard for resource consumption
  - Limited accountability

Adapted from GM, Jerry Rogers
Cleaner Production

“...the continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase eco-efficiency and reduce risks for humans and to the environment.”

(Seliger 2007, p. 208)
Cleaner Production Methodology

1. Planning and organization
   - Identify main causes of environmental aspects

2. Opportunity identification
   - Based on main causes

3. Availability analysis
   - Technical – product quality
   - Organizational – ease of implementation into procedures
   - Environmental – impact analysis
   - Economic – value of hidden costs of waste, return on investment
   - Social – generation of jobs, health, safety, quality of life

4. Implementation/monitoring
   - Start simple
   - Performance indicators

(Seliger 2007, p. 210)
Opportunities

(Seliger 2007, p. 209)
Industrial Cases

- **Industrias Romi S.A.**
  - 80% reduction of new casting sand through reuse

- **Ford Motor Company Brasil Ltda.**
  - 88% reduction of oil to treatment through reuse ($67k saved annually)

- **BSH Continental Eletrodomesticos Ltda.**
  - 30% reduction in water use through filtration and reuse in processes and restrooms ($68k savings annually)

- **Eaton Ltda. – Transmission Division**
  - Saved $189k through oil recycling program in 2002

- **Mahle Metal Leve S.A.**
  - Annual reduction of 160 tons of $CO_2$ ($150k) by replacing $CO_2$ cooling atmosphere with air

(Seliger 2007)
Eco-efficiency

“...reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth’s estimated carrying capacity.”

(Seliger 2007, p. 214)
Thoughts on Chap. 4

- Products are necessary in our lives
  - Even if we rely on walking to get there, we need shoes!
- Manufacturing continuous improvement
  - Product quality
  - AND the triple bottom line
- Novel technologies are needed to make a “quantum leap” in cleaner production and eco-efficiency
“Globalization has become an inevitable condition of life…”

Only ¼ of the Earth’s land area is “biologically productive”

Population, water use, and energy use are all increasing
Increase Resource Efficiency

“Researchers from engineering science, e.g. manufacturing, medical, transportation, design, information, process, electrical, and civil engineering, [must] integrate their domain-specific knowledge and experiences thus developing methods and tools in management and technology for useful applications in selected processes and products according to criteria of sustainability.”

(Seliger 2007, p. 421)
<table>
<thead>
<tr>
<th>Enabling Guidelines and Tools</th>
<th>Mathematics</th>
<th>Knowledge</th>
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(Seliger 2007, p. 422)
Summary of Chapter 8

✓ “…crossing disciplinary borders and referring to multiple criteria helps improving the design and valuation of processes and products.”

✓ “Processes and products are adapted to economical, environmental and social conditions in different regions of the globe, thus creating sustainability according to the regional and local conditions…”

(Seliger 2007, p. 422-3)