MET 449 / ME 448 – Design for Manufacturing and Tooling

Introduction to Production Systems
The Production System
(Big Picture)

Customer

Production System

Manufacturing System

Purchasing

Design Engineering

Quality Control

Accounting / Finance

R&D

Transportation / Distribution

Production Planning and Control

Source: Materials and Processes in Manufacturing, ninth ed. (DeGarmo, Black, & Kohser, 2003)
Bigggggger Picture!

Economic System (Capitalism)

Production System
An economic system is a particular set of social institutions which deals with the production, distribution and consumption of goods and services in a particular society. The economic system is composed of people and institutions, including their relationships to productive resources, such as through the convention of property. It addresses the problems of economics, such as the allocation of scarce resources in a given economy.

The Production System

All aspects of workers, machines, and information, considered collectively, needed to manufacture parts or products; integration of all units of the system is critical.

Source: Materials and Processes in Manufacturing, ninth ed. (DeGarmo, Black, & Kohser, 2003)
The Manufacturing System

The collection of manufacturing processes and operations resulting in specific end products.

An arrangement or layout of many processes, materials-handling equipment, and operators.

Examples:

- Manufacture of Automobiles
- Manufacture of Airplanes
- Manufacture of Fast Food

Source: Materials and Processes in Manufacturing, ninth ed. (DeGarmo, Black, & Kohser, 2003)
Discussion Topic

- What automobile do you currently drive?
- What motivated each of you to purchase that particular automobile?
- Do you ever think about what it takes to “manufacture” that automobile?
Example: Car Manufacture

Source: Materials and Processes in Manufacturing, ninth ed. (DeGarmo, Black, & Kohser, 2003)
What is “Value”?

Value = \frac{\text{Product Function and Performance}}{\text{Cost of Product}}

Examples:
- Cars
- Bikes
- Shoes
- Ski Equipment
- Staplers
Design to Build

Product Design:
- ID CUSTOMER REQUIREMENTS
- DEFINE FUNCTIONAL REQUIREMENTS
- DEVELOP DESIGN REQUIREMENTS
- DEVELOP CONCEPTS
- EVALUATE CONCEPTS
- SELECT CONCEPT
- COMPLETION DESIGN
- RECOGNITION OF NEED
- DEFINITION OF PROBLEM
- SYNTHESIS
- ANALYSIS & OPTIMIZATION
- EVALUATION (Prototype Test)
- PRESENTATION
- PRODUCTION/CONTROLLING
- CONTINUOUS IMPROVEMENT

Problem-Solving Process:
- RECOGNIZE AND UNDERSTAND PROBLEM
- ACCUMULATE DATA & VERIFY ACCURACY
- SELECT APPROPRIATE THEORY OR PRINCIPLE
- MAKE NECESSARY ASSUMPTIONS
- SOLVE THE PROBLEM
- VERIFICATION & CHECK RESULTS

Product Build:
- MATERIALS SELECTION/SPECIFICATION
- PRODUCTION PLANNING & SCHED.
- SUPPLY CHAIN MANAGEMENT
- PROCESS DESIGN & SELECTION
- TOOLING TD./DESIGN/CONSTRUCTION
- FACILITIES LAYOUT
- MATERIAL HANDLING
- PRODUCTION/TEST

Toyota Production System
PRODUCT DESIGN

- Functional Requirements
- Customer Requirements
- Cost
- Maintenance
- Assembly
- Manufacturability
- Prototype and Test
- Detail to Assembly Flow
Material Properties
- Mechanical
- Physical
- Etc.

Manufacturing Processes

Availability and Cost

Service Life

Material Compatibility
- Material Characteristics
- Workpiece Characteristics
- Dimensional Requirements
- Tolerance Requirements
- Surface Finish Requirements
- Production Volume
- Production Rate
- Lead Time
- Cost
- Operations Sequencing
- Tooling
  - Design
  - Build
  - Installation and Test
- Facilities and Machines
- Continuous Improvement
Value Engineering: A system that evaluates each step in product design, materials selection, process selection and operations of fabrication so as to manufacture a product that performs its intended functions and has the lowest possible cost.
Manufacturing Processes Flow

Raw Materials

Primary Processes

Secondary Processes

Finishing Processes

Finished Product
### Operations Sequencing

<table>
<thead>
<tr>
<th>OP #</th>
<th>OPERATION</th>
<th>MACHINE</th>
<th>TOOLING</th>
<th>Set-up Time</th>
<th>Cycle Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Saw cut extrusion to 3.7 inch length</td>
<td>Power Saw</td>
<td>End Stop</td>
<td>2 min.</td>
<td>10 sec.</td>
</tr>
<tr>
<td>20</td>
<td>Trench –A- to 0.240 inch minimum thickness</td>
<td>Mill</td>
<td>Vise Cutters</td>
<td>20 min.</td>
<td>5 min.</td>
</tr>
<tr>
<td>30</td>
<td>Load in stage 1 of NC Mill Fixture. Mill Datum –C- to 0.8 inch min. thickness. Mill .322/.312 thick dim. Maintain .26/.21 rad. Mill .60 +/- .01 thick dim. Mill .70 +/- .01 thick dim. Mill base to .13 thickness and to .25 thickness while maintaining proper radius dims. Mill top to 1.14 dim. (.80 + .34 R).</td>
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<tr>
<td>40</td>
<td>Load in stage 2 of NC Mill Fixture. Mill Datum –B-. Mill periphery of flange.</td>
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<td>50</td>
<td>Load in stage 3 of NC Mill Fixture. Finish periphery of base.</td>
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<tr>
<td>60</td>
<td>Dimensionally Inspect</td>
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Machinery and Facilities

- What machines are required for build of each designed component?
- Make of Buy?
- Will assembly be automated?
- Where will machines be located?
- Etc.
# Operations Sequencing

## Operation Sheet - Part # 69-73665-1, Hinge Assembly

<table>
<thead>
<tr>
<th>OP #</th>
<th>Operation</th>
<th>Machine</th>
<th>Tooling</th>
<th>Setup Time</th>
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Tooling

- **Objective** – Increase productivity while decreasing cost and maintaining or improving overall quality of the product.

- What tooling is required to support the overall manufacturing process?
  - Detail
  - Assembly
## Operations Sequencing

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Measurement Parameters

- What set-up time is associated with production of each detail part and assembly?
- What cycle time is associated with each step in the build cycle for each part and assembly?
- What productivity measurements are being used to continuously improve the product design and the build process?
### Operation Sequencing

**OPERATION SHEET – PART # 69-73865-1 HINGE ASSEMBLY**

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Design of Tooling

JIG AND FIXTURE DESIGN PROCESS FLOWCHART
Conclusion

- Product Build is a precision controlled process of making and assembling detail parts or components, all tooled to exacting tolerances, into a final product of total tolerance accumulation equal to, or closer than engineering requirements.
The overall accuracy of a manufactured product is determined by the accuracy of the tooling designed and built to aid the build process of each detail component and the assembly tooling designed and built to hold the components in the correct relation until they are assembled.
Conclusion

- Fit, Performance, and Service Life requirements of a product are defined in the design stage.

- Manufacturing Processes and Tooling ultimately controls:
  - Fit = How efficiently a product can be assembled
  - Performance = Both if and how a product works
  - Service Life = How long a product works
**Value Engineering**: A system that evaluates each step in product design, materials selection, process selection and operations of fabrication so as to manufacture a product that performs its intended functions and has the lowest possible cost.
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History of TPS

- Developed by Sakichi Toyoda and Kiichiro Toyoda of Toyota
- Based largely on ideas / philosophies taught by Juran and W. Edwards Jennings
- Incorporates “supermarket” methodologies to manufacturing sector
Main Ideas

- Design out “muri”, “mura”, and “muda”
- Muda (waste) targets:
  1. Over-production
  2. Motion
  3. Waiting
  4. Conveyance
  5. Processing
  6. Inventory
  7. Correction
Principles

- Long-term philosophy
- The right process to produce the right result
- Develop people and partnerships
- Continuously solve root-problems, thus driving organizational learning
Conclusion

The basis of the toyota production system is to strive (continuously) to eliminate waste and non-value-added activities, as well as improve the efficiency and quality of the processes utilized to make products.