CHAPTER 3
Product Design & Process Planning

Overview

• Introduction
• Product Design
• Process Planning
• Schedule Design
• Layout planning
**Strategy**

Course of action to reach a particular goal

**Resources**

People, material, equipment, capital

**Strategic Facilities Planning**

To determine how to *integrate* the resources to develop a plan that includes facilities *locations & designs* that best support the objectives of the entire organization

---

**Developing The Plan**
**Relationship between Product, Process & Schedule Design and Facilities Design (FD)**

- **Products to be manufactured**
- **Detailed design of individual parts**

Manufacturing processes for each part

- **Lot sizes**
- **Production schedule**
- **Machine requirements**

---

**Product Design**

1. **Functional Requirements**
2. **Manufacturability**

- **Quantity or Production Rate**

**Assembly Drawing**
- Exploded view diagram
- Exploded photograph

**Component Part Drawing**
- Dimensions
- Specifications

**Machine Requirements**
- 1. Machines
- 2. Tools
- 3. Equipment
Exploded View
Hand Crank Ice Cream Freezer

- Shows how to assemble the product
- Omit specs & dimensions
- Drawn to scale

Component Part Drawing

Figure 3.5
Shows dimensions & specifications
Process Design

PC = Process Identification + Process Selection + Process Sequencing

- Parts to be manufactured
- Parts to be purchased
- Part quantities, materials
- Manufacturing processes

- Specific Manufact Operations
- Sequence of ops. for each part
- Machines types & material quantities
- Std. times

Parts List
- Bill of Materials
- Part Drawings

Route Sheets (one per part)

Assembly Chart Op. Process Chart

Parts List

Chart Heading
1. Company
2. Product name
3. Date
4. Prepared by

Chart Body (Column Headings)
1. Part Number
2. Part Name
3. Drawing Number
4. Quantity/Unit
5. Material
6. Size or Weight
7. Make/Buy
8. Remarks
<table>
<thead>
<tr>
<th>Part</th>
<th>Part Name</th>
<th>Description</th>
<th>Quantity</th>
<th>Material</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rear Seat</td>
<td></td>
<td>1</td>
<td></td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>2</td>
<td>Rear Seat</td>
<td></td>
<td>1</td>
<td>Viscose</td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>3</td>
<td>Front Seat</td>
<td></td>
<td>1</td>
<td></td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>4</td>
<td>Front Seat</td>
<td></td>
<td>1</td>
<td>Viscose</td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>5</td>
<td>Side Seat</td>
<td></td>
<td>1</td>
<td></td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>6</td>
<td>Side Seat</td>
<td></td>
<td>1</td>
<td>Viscose</td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>7</td>
<td>Seat Belt</td>
<td></td>
<td>1</td>
<td></td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>8</td>
<td>Seat Belt</td>
<td></td>
<td>1</td>
<td>Viscose</td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>9</td>
<td>Headrest</td>
<td></td>
<td>1</td>
<td></td>
<td>Waypoint, 32-1-15</td>
</tr>
<tr>
<td>10</td>
<td>Headrest</td>
<td></td>
<td>1</td>
<td>Viscose</td>
<td>Waypoint, 32-1-15</td>
</tr>
</tbody>
</table>

**Parts List: Table 3.1**

**Bill of Materials: Table 3.2**
Operational Sequence for Each Part

1. Part number
2. Part name
3. Date
4. Drawing number
5. Drawn by …

Chart Body (Column Headings)
1. Operation Number
2. Operation Description
3. Material Required & Quantity
4. Parts Required & Quantity
5. Machine Assigned
6. Jigs, Tools & Fixtures Required
7. Department
8. Standard Time

Standard time = (observed time x % rating) (1 + % allowances)
### Route Sheet

<table>
<thead>
<tr>
<th>OPER. NO.</th>
<th>OPERATION DESCRIPTION</th>
<th>MACHINE NAME</th>
<th>JIGS, TOOLS &amp; FIXTURES</th>
<th>DEPT. NO.</th>
<th>STD. TIME, MIN.</th>
<th>MACHINE CAPACITY PER HRE.</th>
<th>MATERIAL</th>
<th>PARTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>260-1</td>
<td>Cut to size 4 7/8&quot;</td>
<td>Press Sizer</td>
<td>Edge Locator</td>
<td>84P</td>
<td>0.45</td>
<td>116</td>
<td>Steel Pipe 50' Dia.</td>
<td>80 pcs.</td>
</tr>
<tr>
<td>260-2</td>
<td>File Base</td>
<td>Filing Machine</td>
<td></td>
<td>31P</td>
<td>0.35</td>
<td>158</td>
<td></td>
<td></td>
</tr>
<tr>
<td>260-3</td>
<td>Weld Hole</td>
<td>Drill Press</td>
<td>Drill &amp; 1/16&quot; Bit &amp; Locator Support</td>
<td>69F</td>
<td>0.95</td>
<td>118</td>
<td></td>
<td></td>
</tr>
<tr>
<td>260-4</td>
<td>Weld Gear Box-Weld</td>
<td>Welding Machine</td>
<td>Welding Equipment</td>
<td>68F</td>
<td>0.85</td>
<td>7</td>
<td>Gear Box Weld</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Gear Box Hub-Weld</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gear Box Hub</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Gear Box Rib-Weld</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gear Box Rib</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Weld Screw Support No. 2-Weld</td>
<td></td>
<td>Welding Equipment</td>
<td>68F</td>
<td>0.85</td>
<td>7</td>
<td>Screw Support No. 2</td>
<td>1</td>
</tr>
<tr>
<td>260-9</td>
<td>Assemble Thrust Bearing-Assemble Shaft No. 2</td>
<td>Screw Driver Rubber Bumper</td>
<td>1.05</td>
<td>36</td>
<td>Thrust Bearing Shaft No. 2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assemble Bronze Bearing-Assemble Shaft No. 3</td>
<td></td>
<td></td>
<td></td>
<td>Bronze Bearing Shaft No. 3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assemble Bronze Bearing-Assemble Oil Washer</td>
<td></td>
<td></td>
<td></td>
<td>Oil Washer</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assemble Gear Box Lid-Assembly</td>
<td></td>
<td></td>
<td></td>
<td>Gear Box Lid</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inspection-Assembly (Operation 28-40)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TROPICAL FREEZERS CO.

**ASSEMBLY CHART**

CHARTED: ASSEMBLY 3 - DRIVE SHAFT AND ATTACHMENTS

PART NO: B.8,10.11.12.13.18,19,21,23

DATE CHARTED: ______________

DRAWN NO: B.8,10.11.12.13.18,19,21,23

PREPARED BY: D.H.N.

CHECKED BY: F.A.C.
Schedule Design

SC = \text{Quantities to be produced} \& \text{Machine requirements}

1. How much
2. When

1. Number of @ machine type
2. Fractional machines

\begin{align*}
P_k &= \text{percent defective for machine } k \\
I_k &= \text{number of parts processed by machine } k \\
O_n &= \text{number of acceptable parts after } n \text{ operations}
\end{align*}

\[ I_1 = \frac{O_n}{\prod_{k=1}^{n}(1 - P_k)} \]
EXERCISE

\[
\frac{10,000}{1 - 0.01} = 10,101.01
\]

\[
\frac{10,010.01}{1 - 0.03} = 10,413.41
\]
\[ F = \frac{SQ}{EHR} \]
\( N = \text{number of machines required} \)
\( T = \text{standard time (hours) per unit} \)
\( P = \text{number of units processed per day} \)
\( E = \text{performance level (as a % of std. time)} = 1 \)
\( H = \text{hours available per machine (after set-up) per day} \)
\( C = \text{availability factor (as a fraction)} \)

\[
N = \frac{TP}{60HC}
\]

**EXERCISE**

Find the machine fractions for the data given in the following table. **Part X** is routed from **machine A** to **machine B** and has an annual production volume of 100,000 units. **Part Y** routed from **machine B** to **machine A** and its annual production volume is 200,000 units.

<table>
<thead>
<tr>
<th></th>
<th>Machine A</th>
<th>Machine B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part X standard time (hr)</td>
<td>0.10</td>
<td>0.01</td>
</tr>
<tr>
<td>Part Y standard time (hr)</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Part X scrap estimate (%)</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Part Y scrap estimate (%)</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Historical efficiency (%)</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Reliability factor (%)</td>
<td>94</td>
<td>97</td>
</tr>
<tr>
<td>Equipment availability (hr per yr)</td>
<td>2000</td>
<td>2000</td>
</tr>
</tbody>
</table>
**Method 1**

[Diagram showing a process flow with variables and calculations]

\[ \text{Total machine time required} = \frac{\text{mach}}{\text{prod. time per machine}} \]

\[ X: 10,000 \rightarrow 200,000 \rightarrow 400,000 \rightarrow 1,000,000 \]

\[ Y: 200,000 \rightarrow 400,000 \rightarrow 800,000 \rightarrow 1,000,000 \]

Available: 1,786 hr

\[ \frac{2,000 (0.87)}{1,786} = 1.18 \]

\[ \frac{2,000 (0.86)}{1,786} = 1.18 \]

\[ N_A = \frac{27,372.56}{1,786} = 15.39 \]

\[ N_g = \frac{14.11.75}{1,786} = 8.18 \]

**Method 2**

Using formulas:

\[ N_A = \frac{P_{ax} T_{ax}}{60 H_{ax} C_{ax}} \]

\[ N_{ax} = \frac{100 \times 0.074}{60} \]

\[ N_{ax} = 200 \times \frac{0.10 	imes \text{hours} \times 60}{60} \]

\[ C_{ax} = 0.893 \]

Simulate, \[ M_{ay} = 7.188 \left( \frac{27,372.56}{1786} \right) \]

\[ N_{ax} = N_{ax} + M_{ay} = 6.141 + 7.188 = 13.39 \]
\[ N = \frac{Pt}{(H - s)p} \]

**EXERCISE**

Production volume = 13,000 per year
Standard time = 0.65 hr
Machine utilization = 0.90
Daily shift = 8 hrs
Daily set-up = 0.20 hr
Assume 52 days off per year, 365 days/year
Find the fractional number of machines.

\[ N = \frac{Pt}{(H - s)p} \]

\[ = \frac{(\frac{13,000}{365-52})(0.65)}{(8-0.20)(0.90)} = \frac{27}{7.02} = 3.85 \]