Production Systems

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Production Systems
Operations Processes

In the previous we identified the critical factors in providing value to the customer. Here we discuss the selection and design of the transformation process that can deliver those factors—low cost, high quality, enhanced functionality, speed, and so on—in an efficient and effective manner.
Fender’s Custom Shop

- Customers include Eric Clapton, John Deacon (Queen), David Gilmour, Yngwie Malmsteen and Stevie Ray Vaughn
- Production Steps:
  - computer controlled routers and lathes shape guitar bodies and necks
  - also have Neck Duplicator
  - necks and bodies hand and machine sanded
Fender’s Custom Shop continue

- detailed inlay work done with Hegner precision scroll saw
- paint and finishing operations in special room where air is re-circulated 10 times/minute
- buffed
- hung up and seasoned for two weeks
- final assembly by actual musicians
IBM’s Charlotte, NC Plant

- Assembly line produces 27 significantly different products
- Products include hand-held bar-code scanners, portable medical computers, fiber-optic connectors and satellite communications devices
- “Kits” of parts delivered to workers
- Computer screen displays assembly instructions.
Rickard Associates

- Produces magazines and marketing materials
- Only two of editorial production company’s employees work at headquarters in NJ
- Art director works in AZ
- Editors are located in FL, GA, MI, and D.C.
- Freelancers even more scattered
- Internet and AOL used to coordinate work
Martin Marietta Aerospace Plant

- Originally with numerous functional departments
  - high WIP levels
  - long lead times
  - long travel distances
  - departmental barriers inhibited communication

- Plant subsequently arranged into three focused factories
Each focused factory completed entire electronic assembly for particular application
Each focused factory treated as separate business enterprise
Factory manager assigned to each focused factory
“NFL draft” used to select worker teams
Within focused factories part families identified based on technology and processes

Standard routings identified for each part family

Improvements

◦ seven months of consecutive production with no scrap
◦ 50% reduction in WIP
◦ 21% reduction in lead times
◦ 90% reduction in overtime
Variety of Transformation Systems

• Fender Custom Shop is job shop
• Rickard Associates is job shop and is also a virtual organization
• Martin Marietta converted from a job shop to focused factories
• IBM uses a flow shop
Forms of Transformation Systems

- Transformation system design considers alternative transformation forms and selects the best one, given the characteristics of desired outputs.
- Layout analysis seeks to maximize the efficiency or effectiveness of operations.
Forms of Transformation

Systems

Continuous Process
Continuous Process

- Highly standardized products in large volumes
- Often these products have become commodities
- Typically these processes operate 24 hours/day seven days/week
- Objective is to spread fixed cost over as large a volume as possible
Continuous Process \textit{continue} \\

- Starting and stopping a continuous process can be prohibitively expensive \\
- Highly automated and specialized equipment used \\
- Layout follows the processing stages \\
- Output rate controlled through equipment capacity and flow mixture rates
Continuous Process continue

- Low labor requirements
- Often one primary input
- Initial setup of equipment and procedures very complex
Forms of Transformation Systems

Flow Shop
Flow Shop

- Similar to continuous process except discrete product is produced
- Heavily automated special purpose equipment
- High volume - low variety
- Both services and products can use flow shop form of processing
A Generalized Flow Shop Operation
Advantages of the Flow Shop

- Low unit cost
  - specialized high volume equipment
  - bulk purchasing
  - lower labor rates
  - low in-process inventories
  - simplified managerial control
Disadvantages of Flow Shop

- Variety of output difficult to obtain
- Difficult to change rate of output
- Minor design changes may require substantial changes to the equipment
- Worker boredom and absenteeism
- Work not very challenging
- Vulnerable to equipment breakdowns
Disadvantages of Flow Shop continue

- Line balanced to slowest element
- Large support staff required
- Planning, design and installation is a very complex task
- Difficult to dispose of or modify special purpose equipment
Flow Shop Layout

- Objective is to assign tasks to groups
- The work assigned to each group should take about the same amount of time to complete
- Final assembly operations with more labor input often subdivided easier
- Paced versus unpaced lines
Line Balancing

Cycle time = \frac{\text{available work time}}{\text{demand}}

number of theoretical workstations, \( N_T = \sum \text{task times} / \text{cycle time} \)

efficiency = \frac{\text{output}}{\text{input}} = \frac{\text{total task time}}{(N_T \text{ stations}) \times \text{cycle time}}
### Line Balancing Example

<table>
<thead>
<tr>
<th>Task</th>
<th>Time Required (min)</th>
<th>Precedes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.2</td>
<td>B, C, D</td>
</tr>
<tr>
<td>B</td>
<td>3.4</td>
<td>E</td>
</tr>
<tr>
<td>C</td>
<td>1.7</td>
<td>E</td>
</tr>
<tr>
<td>D</td>
<td>4.1</td>
<td>F</td>
</tr>
<tr>
<td>E</td>
<td>2.7</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>3.3</td>
<td>G</td>
</tr>
<tr>
<td>G</td>
<td>2.6</td>
<td>--</td>
</tr>
</tbody>
</table>

Total Time: 20 mins
Line Balancing Example

continue

- Company operates one shift per day
- Available time per shift is 450 minutes
- Demand is 75 units/day
Calculations

\[ \text{cycle time} = \frac{450}{75} = 6 \text{ minutes/part} \]

\[ N_T = \frac{20}{6} = 3.33 = 4 \text{ stations} \]
## Task Assignment

<table>
<thead>
<tr>
<th>Station</th>
<th>Time Avail.</th>
<th>Elig. Tasks</th>
<th>Will Fit?</th>
<th>Task Assign.</th>
<th>Idle Time</th>
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<td>A</td>
<td>B,C</td>
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<tr>
<td></td>
<td></td>
<td>B,C,D</td>
<td>B,C</td>
<td>B</td>
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<td>6.0</td>
<td>C,D</td>
<td>C,D</td>
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<td>C</td>
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<tr>
<td></td>
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<td>E</td>
<td>--</td>
<td>--</td>
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<tr>
<td>Station</td>
<td>Time Avail.</td>
<td>Elig. Tasks</td>
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<td>Task Assign.</td>
<td>Idle Time</td>
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<td>6.0</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>3.4</td>
</tr>
</tbody>
</table>
Line Balancing Solution

Station 1

Station 2

Station 3

Station 4
Efficiency

efficiency = \frac{20}{(4 \times 6)} = 83.3\%
Forms of Transformation
Systems

Job Shop
Job Shop

- High variety - low volume
- Equipment and staff grouped based on function
- Each output processed differently
A Generalized Job Shop Operation
Advantages of the Job Shop

- Flexibility to respond to individual demands
- Less expensive general purpose equipment used
- Maintenance and installation of general purpose equipment easier
- General purpose equipment easier to modify and therefore less susceptible to becoming obsolete
Advantages of the Job Shop

- Dangerous activities can be segregated from other operations
- Higher skilled work leading to pride of workmanship
- Experience and expertise concentrated
- Pace of work not dictated by moving line
- Less vulnerable to equipment breakdowns
Disadvantages of the Job Shop

- General purpose equipment is slower
- Higher direct labor cost
- High WIP inventories
- High material handling costs
- Management control very difficult
Forms of Transformation

Systems

Cellular Production
The Cell Form

- Combines flexibility of job shop with low costs and short response times of flow shop
- Based on group technology
- First identify part families
- Then form machine cells to produce part families
Conversion of a Job Shop Layout to a Cellular Layout
Organization of Miscellaneous Parts into Families

![Diagram showing the organization of miscellaneous parts into families.](image-url)

- Unorganized parts
- Turned parts
- Geometric parts
- Formed parts

Parts organized by families
Advantages of Cellular Production

- Reduced machine setup times
  - increased capacity
  - economical to produce in smaller batch sizes
  - smaller batch sizes result in less WIP
  - less WIP leads to shorter lead times
  - shorter lead times increase forecast accuracy and provide a competitive advantage
Advantages of Cellular Production

- Parts produced in one cell
- Capitalize on benefits of using worker teams
- Minimal cost to move from job shop to cellular production
- Can move from cellular production to “mini-plants”
Disadvantages of Cellular Production

- Volumes too low to justify highly efficient high volume equipment
- Vulnerable to equipment breakdowns
- Balancing work across cells
- Does not offer the same high degree of customization as the job shop
Cellular Layout

- Teams of workers and equipment to produce families of outputs
- Workers cross-trained
- Nominal cells versus physical cells.
- Remainder cell
- Cell formation methods
  - production flow analysis
Forms of Transformation
Systems

Project Operations
Project Operations

- Large scale
- Finite duration
- Nonrepetitive
- Multiple interdependent activities
- Offers extremely short reaction times
Selection of the Process
Volume/Variety Considerations

- High volume indicate automated mass production
- High variety implies use of skilled labor and general purpose equipment
- Make-to-stock versus make-to-order
Effect of Output Characteristics on Transformation Systems
Service Processes

- Often implemented with little development or pretesting
- Need to consider amount of customer contact
- Customers may not arrive at smooth and even increments
- Including customer in service process provides opportunities to improve service
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