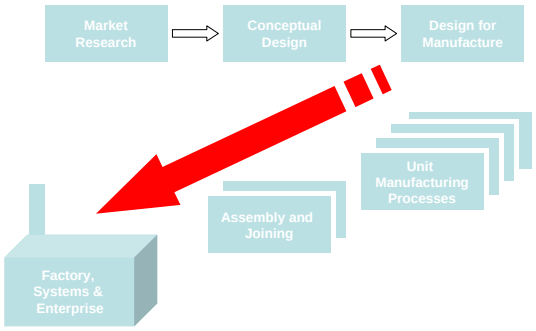
2.008

Manufacturing Systems

Outline

1. Manufacturing Systems
2. Types of Plant Layouts
3. Production Rates
4. Design and Operations

Manufacture

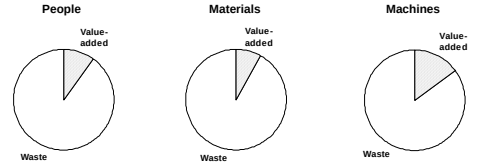


What is mfg systems?

Time spectrum of Typical Activities in a Manufacturing Organization

Seconds	Period	Activity
10^8	Decade	Plant design, Machine Selection, System Simulation
10^7	Year	
10^6	Month	Process design: CAD Catalogs Select manufacturing methods
	Week	
10^5	Day	Factory Operation Ship – Receive Transport Inventory
10^4		
	Hour	
10^3		
10^2		Part handling Load/Unload Assembly
	Minute	
10^1		
1	Second	
.1		Machine control CNC – DNC Adaptive control Intelligent machines Process control
.01		
.001	Millisecond	

How Man, Machine, and Material Spend Time in the Factory



"Waste": waiting for materials, watching machine running, producing defects, looking for tools, fixing machine breakdowns, producing unnecessary items, etc.

"Waste": transportation, storage, inspection and rework

"Waste": unnecessary movement of machine, setup time, machine breakdown, unproductive maintenance, producing defective products, producing products when not needed, etc.

Disruptions/Variation (Random Events)

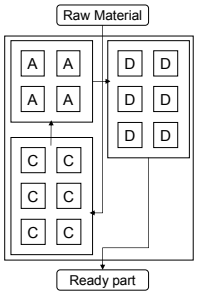
- Machine failure
- Set-up change
- Operator absence
- Starvation/Blockage
- Demand change

Types of Plant Layout

- Job Shop
- Project Shop
- Flow Line
- Transfer Line
- Cellular System

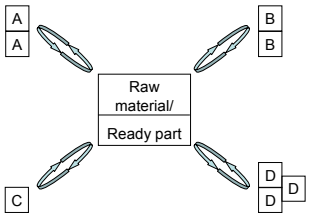
Job Shop

Machines/Resources are grouped according to the process they perform



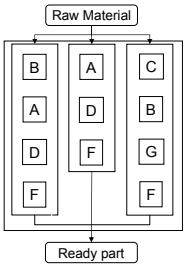
Project Shop

Machines/Resoues are brought to and removed from stationary part as required



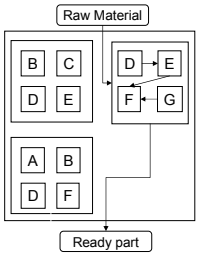
Flow Line and Transfer Line

Machines/Resources are grouped in lines according to the processes sequence of part(s)

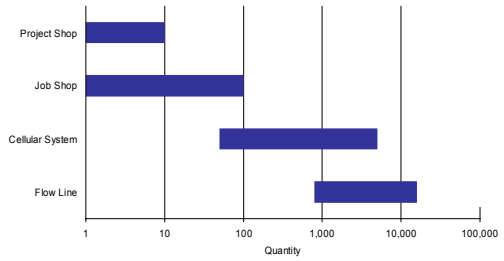


Cellular System

Machines/Resources are grouped according to the processes required for part families

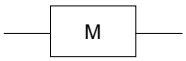


Production Quantity and Plant Layout



Production Rates

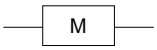
- Case I:
  - One machine
  - Everything works



$$\text{Production rate} = \frac{1}{\text{Operation time}}$$

Production Rates (cont'd)

- Case II:
  - One machine
  - Machine breaks down (disruption)
  - Everything else works

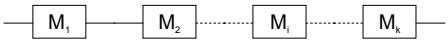


$$\underset{\text{(utilization)}}{\text{Efficiency}} = \frac{\text{MTTF}}{\text{MTTF}+\text{MTTR}} = \frac{\text{MTTF}}{\text{MTTR}}$$

$$\text{Production rate} = \frac{\text{Efficiency}}{\text{Operation time}}$$

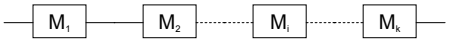
Production Rates (cont'd)

- Case III:
  - Many machines
  - No machine breaks down
  - No buffers



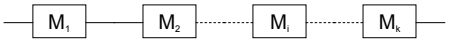
Production Rates (cont'd)

- Case IV:
  - Many machines (same operation time)
  - No machine breaks down
  - No buffers



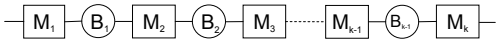
Production Rates (cont'd)

- Case V:
  - Many machines (same operation time)
  - Machine breaks down
  - No buffers



Production Rates (cont'd)

- Case VI:
  - Many machines and buffers in between
  - Machine breaks down



Production Rates (cont'd)

- Production rate increases if:
  - Increase the rate of the slowest machine
  - Reduce the disruptions
  - Introduce "buffers"
  - Introduce in-process control

Disruptions (Random Events)

- Machine failure
- Set-up change
- Operator absence
- Starvation/Blockage

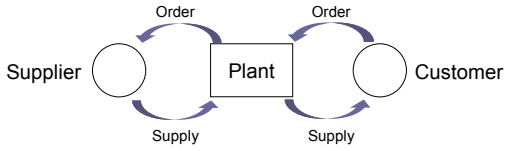
Waiting

- Underutilization
- Idleness
- Inventory

Inventory/Work-in-Process (WIP)

- It costs money
- It gets damaged
- It becomes obsolete
- It shrinks
- It increases lead time

Cycle Time and Lead Time



$$\text{Takt time} = \frac{\text{Daily available time}}{\text{Daily average demand}}$$

Cycle Time

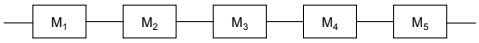
"Cycle Time"
- The time a part spends in the system

Little's Law: L = λw

L: average inventory
λ: average production rate
w: average cycle time

Cycle Time (cont'd)

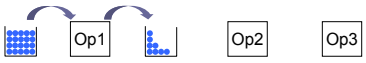
- Example:
  Operation time = 1, One-piece operation



Production rate = 1
Cycle time = 5
Inventory = 5

Cycle Time
Batch Production

1.



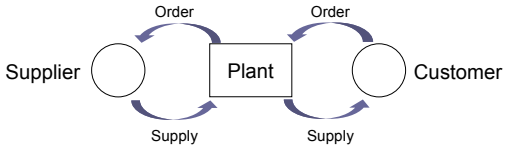
Operation time: 3 minutes
Batch (Lot) size: 1000
Cycle time = 1,000*3 + 1,000*3 + 1,000*3 = 9,000min

Cycle Time
One-Piece Production

2.

Operation time = 3 minutes
Cycle time = 1,000*3 + 2*3 = 3,006 minutes

Cycle Time and Lead Time

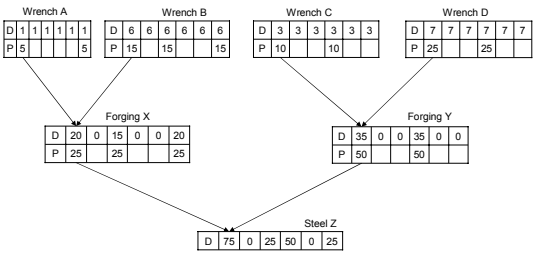


$$\text{Takt time} = \frac{\text{Daily available time}}{\text{Daily average demand}}$$

Systems Design and Operation

- Cycle time < Lead time
- Lumpiness
- Information contents

Lumpy Demand



Typical Design Guidelines

- Leveling
- Balancing
- Single-piece flow
- Low materials handling
- Low setup time
- Smaller lot size
- Low WIP
- Faster feedback

Plant Operations

- Push (MRP, ERP, etc.) vs. Pull (JIT)
- Batch vs. One-piece