ME3302 - AUTOMATION IN MANUFACTURING

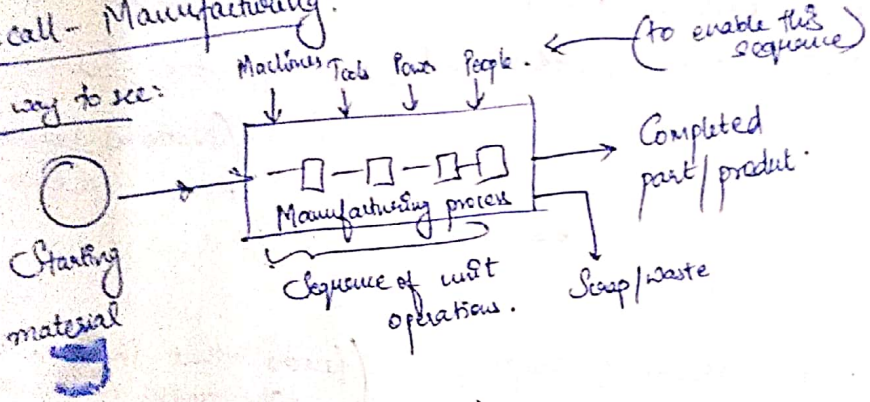
Evaluation:
- → Notes - 10%
- → Online self-assessment quizzes - 10%
- → Assignments / Tutorials - 15%
- → Project (team) - 25%
- → End-sem exam - 40%

Textbook:
Mikell P. Groover, Automation, Production Systems and Computer-Integrated Manufacturing

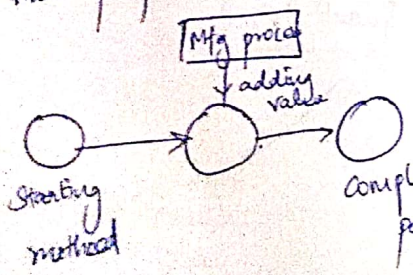
7/2/2021

1-1) Recall - Manufacturing:

(i) One way to see:



(ii) One more perspective. (economic view)



adding value typically means:
- → "shaping" the raw material.
- → changing properties
- → combining with other materials
- :
- etc.

Mfg. Process:

- Making a single part
  - Shaping process
    - → casting
    - → forming
    - → machining
    - → powder process
  - Property enhancing process
    - → heat treatment
    - → Surface process
- Assembly process operation.
  - → permanent
  - → semipermanent (eg. welding, brazing, soldering, fasteners, rivets.)
  - → rigidly
  - → join with motion permitted.

1-2) Manufacturing Industries

Industries ← Based on International standard (ISIC)

- Primary
- Secondary (focus in this course)
- Tertiary (Service)

International:

Basic Codes according to ISIC:

31 — Food, beverages, tobacco
32 — Textiles, clothing, leather goods.
⋮

There is an Indian Standard for Code for Industries.
(National Industrial Classification code)

1-3a) Product Quantity, Variety & complexity (factors that influence the way we mass manufacture products)

Classification based on Quantity (Q)

- Low-volume: 1-100 parts/yr. eg. ship.
- Med-volume: 100-10000 units/year. eg. luxury cars
- High volume: 10000 - million. eg. cars, cans etc.

Classification based on Variety (P)

- Soft (similar parts)
- Hard (very different parts)

total quantity of all products → $Q_t = \sum_{j=1}^{P} Q_j$

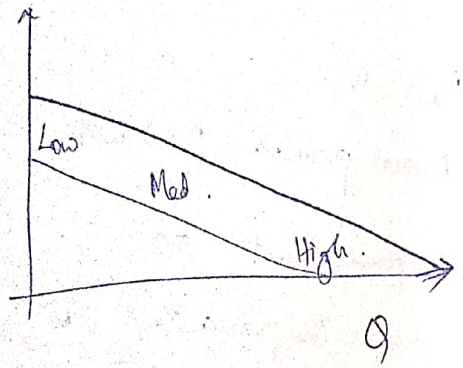
Q_j → Quantity of variety j

$j = 1, 2, 3, \ldots, P_1$

(P) — hard P_1 — # of distinct parts
— soft P_2 — # of models within a product

$1, 2, 3, \ldots, P_2$ | $1, 2, 3, \ldots, P_2$

Q v/s P plot.



1-3b) Complexity ... cost manufacturability

depends on

- # of parts the product is made of (n_p)
- # of manufacturing operations involved (n_o) ⇒ For examples, check book tables 2.4 & 2.5

~~Ways of achieving~~

$$n_{pf} = \sum_{j=1}^{p} Q_j n_{pj}$$

n_{pf}: total # of parts made in a factory per year.

$$n_{of} = \sum_{j=1}^{p} Q_j \sum_{k=1}^{n_{pj}} n_{ojk}$$

n_{of}: total # of manufacturing operations in a factory per year

n_{ojk}: # of processing options for each part k.

Using averages to quantify:

$$\bar{Q} = \frac{\sum_{j=1}^{p} Q_j}{P}$$

($\bar{Q}$: avg.)

$$n_{pf} = P\bar{Q}n_p$$

$$n_p = \frac{\sum_{j=1}^{p} Q_j n_{pj}}{P\bar{Q}}$$

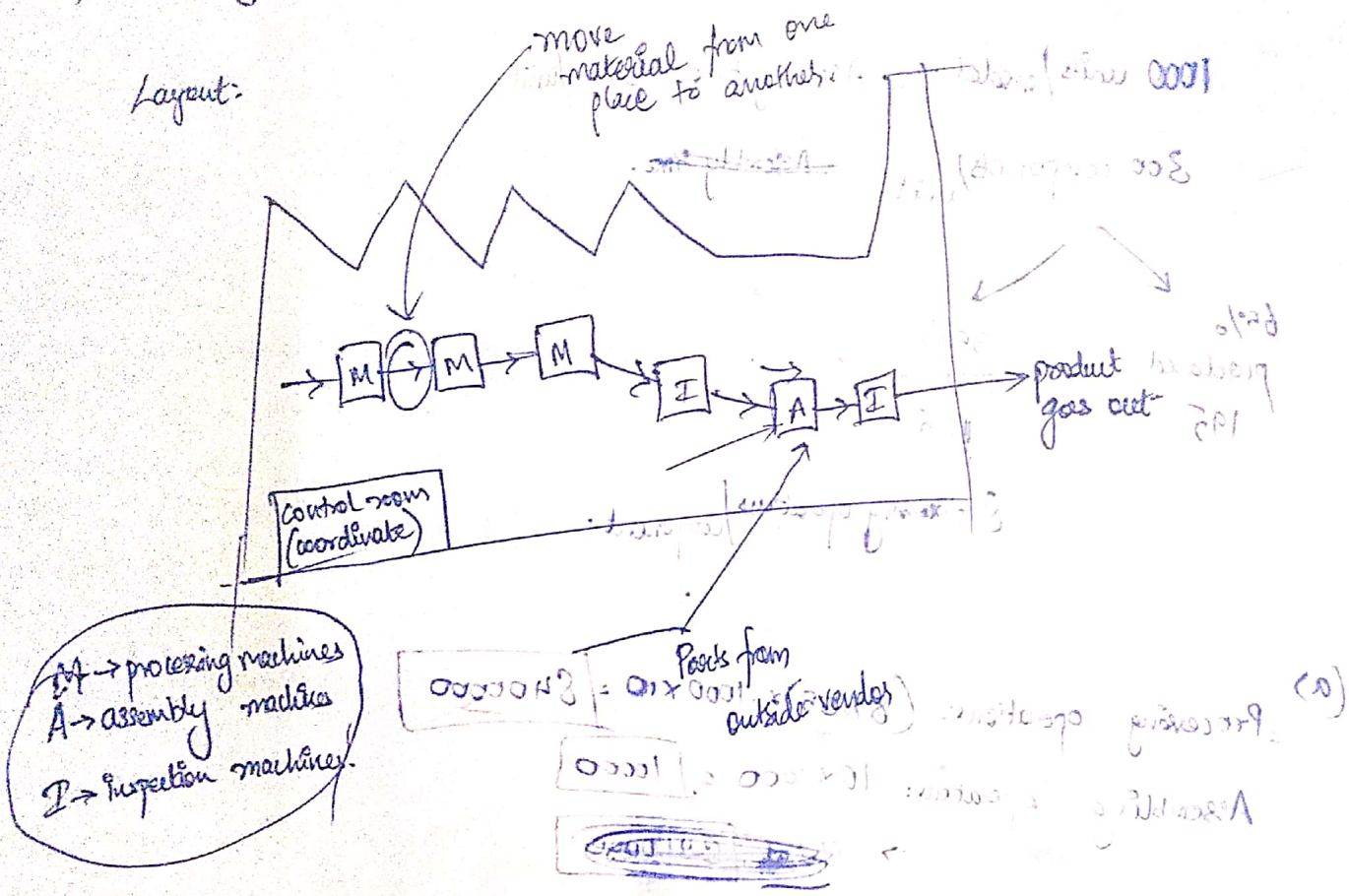
(n_p: avg. # of parts)

$$n_{of} = P\bar{Q}n_p n_o$$

$$n_o = \frac{\sum_{j=1}^{p} Q_j \sum_{k=1}^{n_{pj}} n_{ojk}}{P\bar{Q}n_{pf}}$$

1-4) Factory:

Layout:



Summarizing:

Factory

① Machines — Shaping
— Property enhancing

② Assembly machine

③ Material handling and storage

④ Inspection and quality check

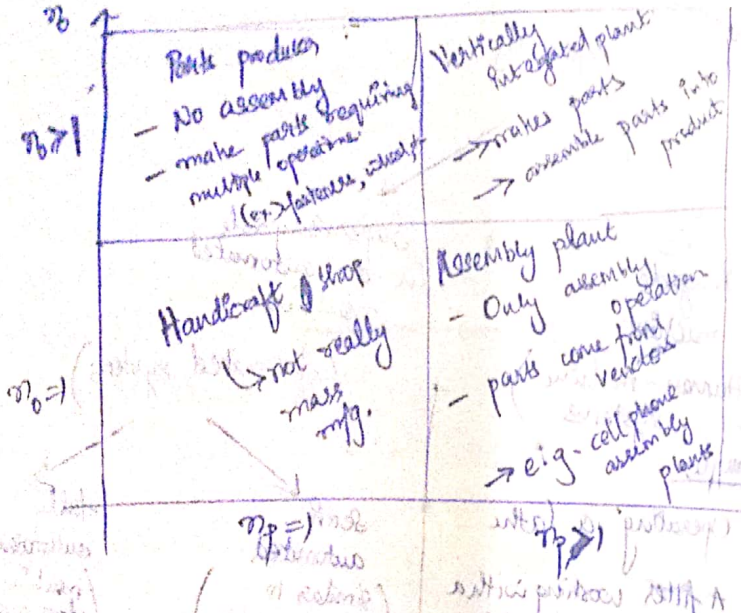
⑤ Coordination and control.

⑥ People

Historical dev. of factory → 4 revolutions that happened in the mfg. industry.

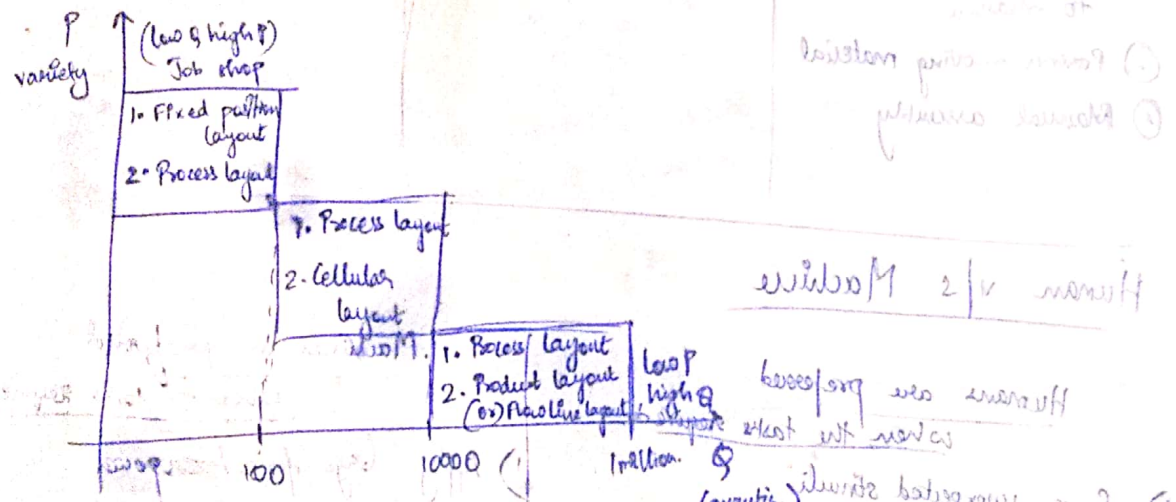
- Steam power (Industry 1.0) → belts run by a common shaft
- electricity (Industry 2.0)
- computer (Industry 3.0) → Automation
- network (Industry 4.0) — Autonomous

1-5a) Factory type (based on n_b, n_p)



Real world factories are a combination of these 3 types

1-5b) Factory type (based on Q & P)

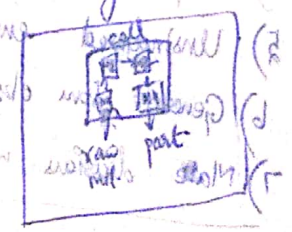


Case 1: Low Q, High P.

- Fixed pos. layout → large parts that cannot be moved easily. (ex.) ship.
- Process layout. → Machines will be grouped together based on processes → has high flexibility → lot of movement

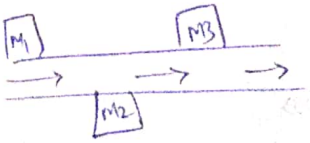
Case 2: Med Q & Med Var

- Process layout
- Cellular layout

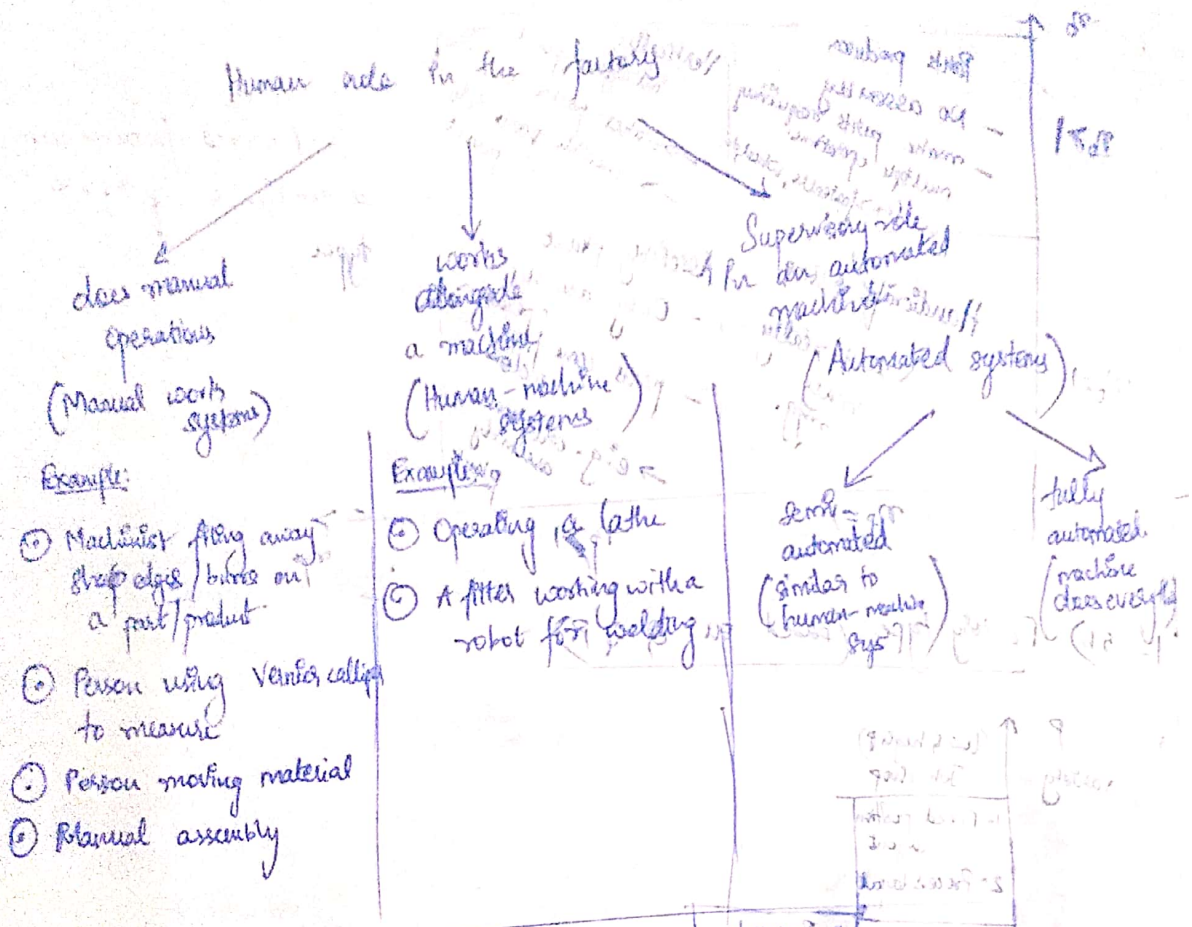


Case: High Q, Low P.

- Process layout
- Product layout (flowline products.



1-B) People in factory



Human v/s Machine

Humans are preferred when the tasks require to

1) Sense unexpected stimuli
2) Develop new solutions to problems
3) Cope with abstract problem
4) Adapt to changes
5) Unstructured environment
6) Generate from observation / learn from experience
7) Make decisions with incomplete data

Machines are preferred when the tasks require to

1) Apply large force / power
2) Repetitive tasks constantly
3) Perform tasks simultaneously
4) Structured environment
5) Store large amount of data
6) Retrieve data easily
7) Perform routine decisions quickly

Advantages:

1) Task is technology challenging
2) Short life cycle
3) Customized products
4) Fluctuating demand
5) Reduce risk of product failures
6) Lack of capital

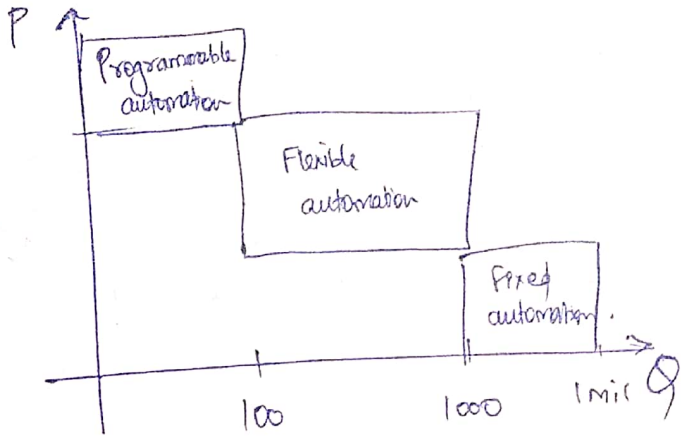
1-7a) Machines in a factory

Why automation

1. High labour cost,
2. Improve productivity
3. Eliminate manual routine tasks
4. Improve safety & quality
5. Reduced mfg. lead time
6. Some tasks are infeasible manually

1-28

Types of automation



→ Fixed automation / hard automation:

The sequence of operations is fixed by equipment configuration.
Each operation would be a very simple task. Suitable for high Q & Low P.
(ex) drill a hole on a part.

→ Programmable automation (low Q, high P)

Variety is high → equipment/machine should be capable to change the sequence of operations. Should be feasible by setup change.

Investments are high.
Batch production only is feasible.

→ Flexible automation: (Med Q & Med P)

Almost like programmable but very minimal setup change.
Works ONLY for soft variety.
Majority of changes will be software changes. Very less hardware changes

Cost is high.
Can do continuous production.
Batch sizes can be very small

1-7c) Automation strategies

USA Principle

U S A
↑ ↑ ↑
Understand Simplify automate

1. U → what are the inputs
what are the outputs
what are the various unit processing steps

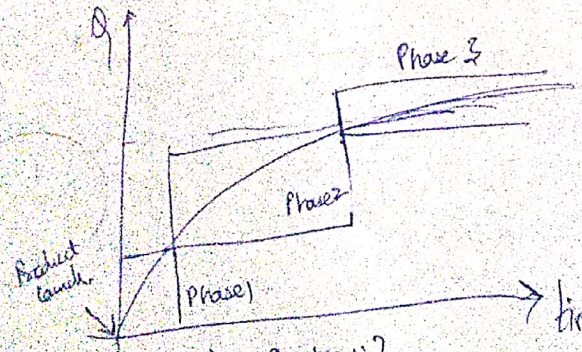
2. S → Simplify
what is the purpose of each step
Value addition
Necessity
Technology used
How to simplify
Combining steps

3. A → Automate: Consider the options to automate based on U & S

Strategies to automate :

1. Specialization of operation - fixed automation
2. Combine operation
3. Simultaneously perform operations
4. Integrate operations
5. Flexibility
6. Improve material handling and storage
7. Online/Online Inspection
8. Process control & optimization

Phased migration to automation



Degree of automation based on demand.

Phase 1: Low Q ⇒ predominantly manual

Phase 2: Med Q ⇒ manual + automated

Phase 3: High Q ⇒ Predominantly automated.

Why migration strategy?

1. Allows introduction of a new product quickly
2. Allows gradual investment based on demand
3. Reduces risk in committing to automation