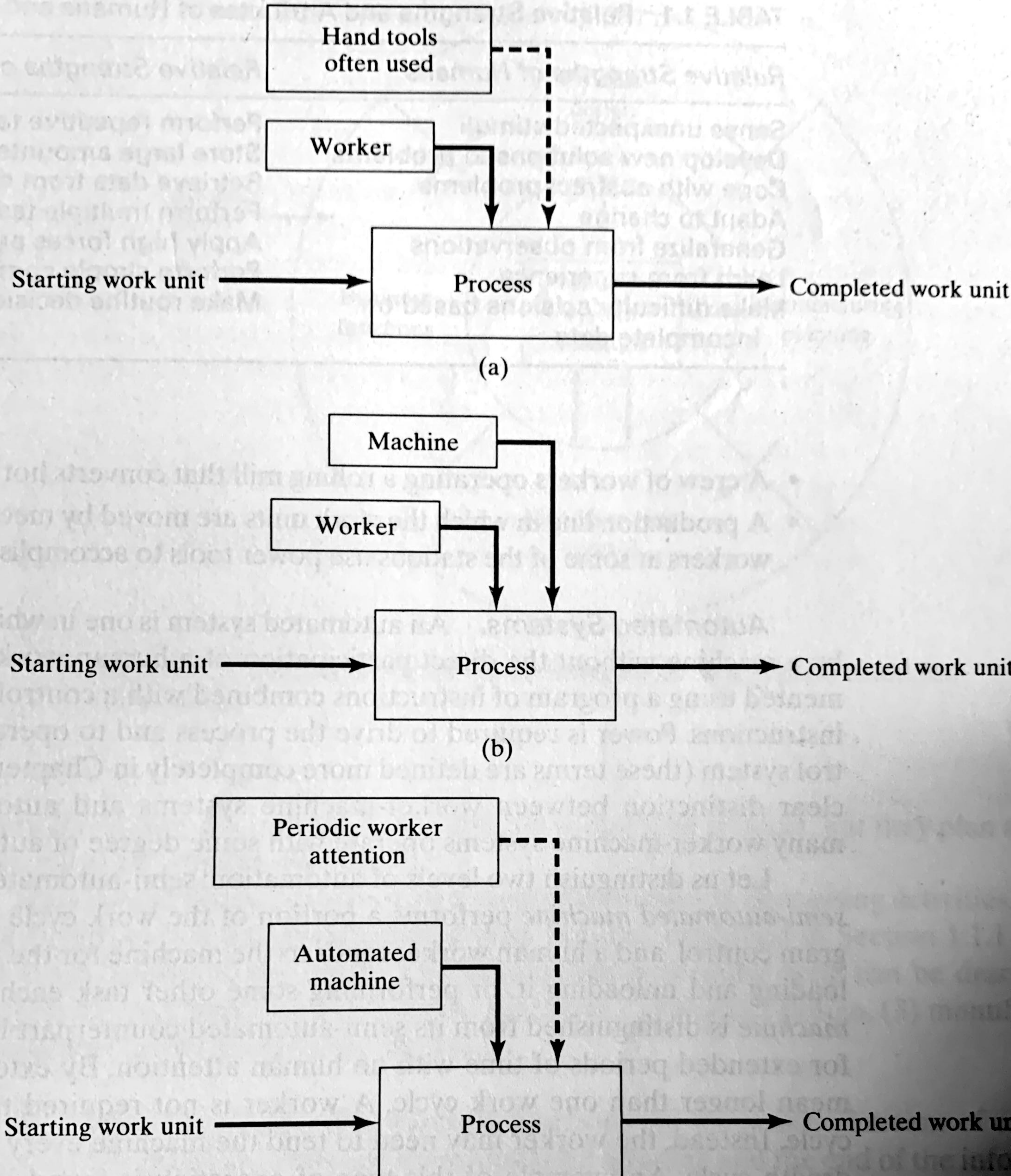


Figure 1.2 Three categories of manufacturing systems: (a) manual work system, (b) worker-machine system, and (c) automated system.

Worker-Machine Systems. In a worker-machine system, a human worker op-ates powered equipment, such as a machine tool or other production machine. This is one of the most widely used manufacturing systems. Worker-machine systems include combinations of one or more workers and one or more pieces of equipment. The work-ers and machines are combined to take advantage of their relative strengths and attrib-utes, which are listed in Table 1.1. Examples of worker-machine computer-integrated manufacturing is used to indicate this extensive use of computers in production systems. The two categories of automation are shown in Figure 1.4 as an overlay on Figure 1.1.

1.2.1 Automated Manufacturing Systems

Automated manufacturing systems operate in the factory on the physical product. They perform operations such as processing, assembly, inspection, and material handling, in some cases accomplishing more than one of these operations in the same system. They are called automated because they perform their operations with a reduced level of human participation compared with the corresponding manual process. In some highly automated systems, there is virtually no human participation. Examples of automated manufacturing systems include:

- Automated machine tools that process parts
- Transfer lines that perform a series of machining operations
- Automated assembly systems
- Manufacturing systems that use industrial robots to perform processing or assembly operations
- Automatic material handling and storage systems to integrate manufacturing operations
- Automatic inspection systems for quality control.

TYPES OF AUTOMATION

Automated manufacturing systems can be classified into three basic types: (1) fixed automation, (2) programmable automation, and (3) flexible automation. They generally operate as fully automated systems although semi-automated systems are common in

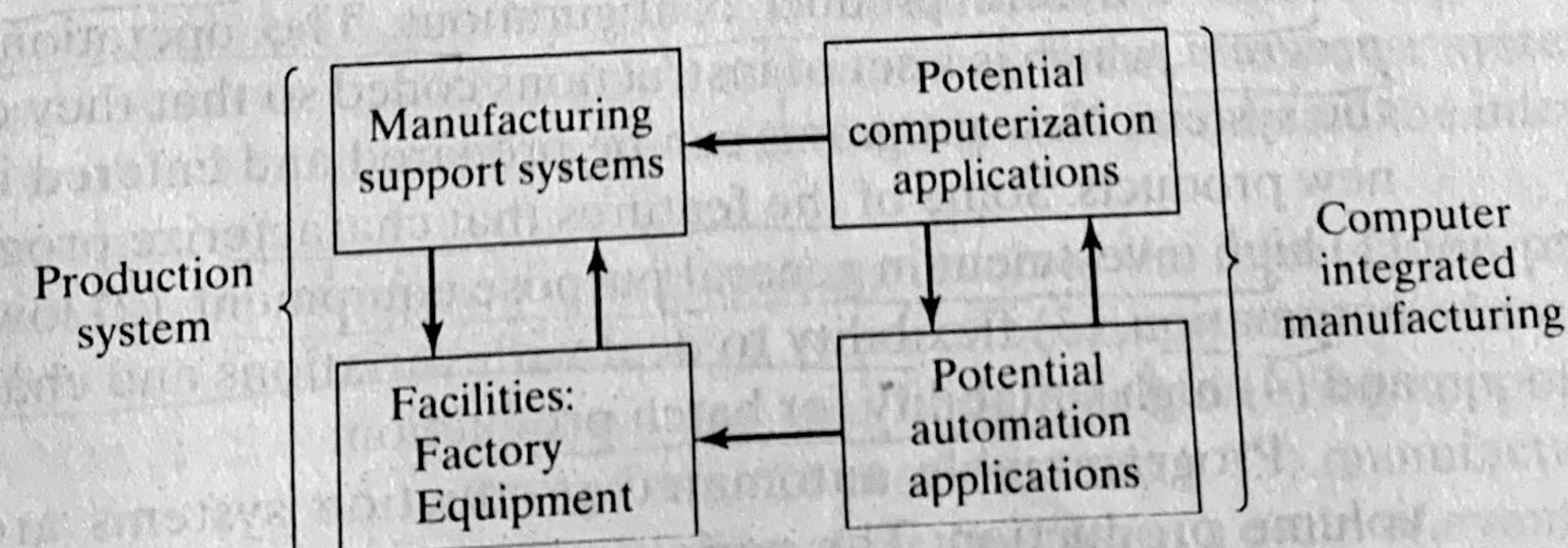


Figure 1.4 Opportunities for automation and computerization in a production system.

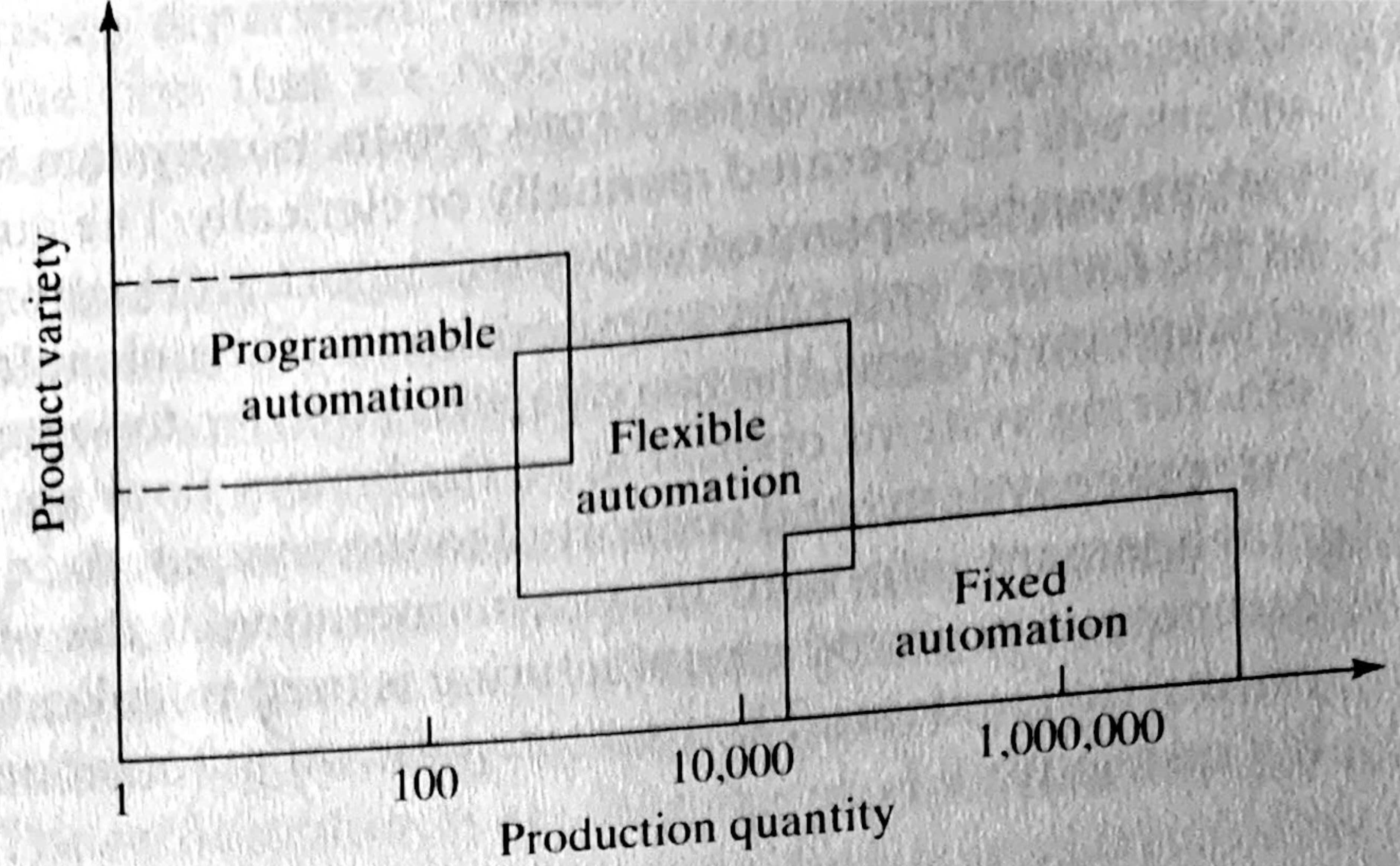


Figure 1.5 Three types of automation relative to production quantity and product variety.

programmable automation. The relative positions of the three types of automation for different production volumes and product varieties are depicted in Figure 1.5.

Fixed Automation. Fixed automation is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. Each operation in the sequence is usually simple, involving perhaps a plain linear or rotational motion or an uncomplicated combination of the two, such as the feeding of a rotating spindle. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex. Typical features of fixed automation are (1) high initial investment for custom-engineered equipment, (2) high production rates, and (3) relative inflexibility of the equipment to accommodate product variety.

The economic justification for fixed automation is found in products that are produced in very large quantities and at high production rates. The high initial cost of the equipment can be spread over a very large number of units, thus making the unit cost attractive compared with alternative methods of production. Examples of fixed automation include machining transfer lines and automated assembly machines.

Programmable Automation. In programmable automation, the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is controlled by a *program,* which is a set of instructions coded so that they can be read and interpreted by the system. New programs can be prepared and entered into the equipment to produce new products. Some of the features that characterize programmable automation include (1) high investment in general purpose equipment, (2) lower production rates than fixed automation, (3) flexibility to deal with variations and changes in product configuration, and (4) high suitability for batch production.

Programmable automated production systems are used in low- and medium-volume production. The parts or products are typically made in batches. To produce each new batch of a different product, the system must be reprogrammed with the set of machine instructions that correspond to the new product. The physical setup of the machine must also be changed: Tools must be loaded, fixtures must be attached to the machine table, and the required machine settings must be entered. This changeover procedure takes time. Consequently, the typical cycle for a given product includes a period during which the setup and reprogramming takes place, followed by a period in which the parts in the batch are produced. Examples of programmable automation include numerically controlled (NC) machine tools, industrial robots, and programmable logic controllers.

Flexible Automation. Flexible automation is an extension of programmable automation. A flexible automated system is capable of producing a variety of parts (or products) with virtually no time lost for changeovers from one part style to the next. There is no lost production time while reprogramming the system and altering the physical setup (tooling, fixtures, machine settings). Accordingly, the system can produce various mixes and schedules of parts or products instead of requiring that they be made in batches. What makes flexible automation possible is that the differences between parts processed by the system are not significant, so the amount of changeover required between styles is minimal. The features of flexible automation include (1) high investment for a custom-engineered system, (2) continuous production of variable mixtures of products, (3) medium production rates, and (4) flexibility to deal with product design variations. Examples of flexible automation are the flexible manufacturing systems for performing machining operations. The first of these systems was installed in the late 1960s.

Socio Economic Impacts of Automation

1.2.3 Reasons for Automating

Companies undertake projects in manufacturing automation and computer-integrated manufacturing for a variety of good reasons. Some of the reasons used to justify automation are the following:

1. *To increase labor productivity.* Automating a manufacturing operation usually increases production rate and labor productivity. This means greater output per hour of labor input.
2. *To reduce labor cost.* Ever-increasing labor cost has been and continues to be the trend in the world's industrialized societies. Consequently, higher investment in automation has become economically justifiable to replace manual operations. Machines are increasingly being substituted for human labor to reduce unit product cost.
3. *To mitigate the effects of labor shortages.* There is a general shortage of labor in many advanced nations, and this has stimulated the development of automated operations as a substitute for labor.
4. *To reduce or eliminate routine manual and clerical tasks.* An argument can be put forth that there is social value in automating operations that are routine, boring, fatiguing, and possibly irksome. Automating such tasks improves the general level of working conditions.
5. *To improve worker safety.* Automating a given operation and transferring the worker from active participation in the process to a monitoring role, or removing the worker from the operation altogether, makes the work safer. The safety and physical well-being of the worker has become a national objective with the enactment of the Occupational Safety and Health Act (OSHA) in 1970. This has provided an impetus for automation.
6. *To improve product quality.* Automation not only results in higher production rates than manual operation, it also performs the manufacturing process with greater uniformity and conformity to quality specifications.
7. *To reduce manufacturing lead time.* Automation helps reduce the elapsed time between customer order and product delivery, providing a competitive advantage to the manufacturer for future orders. By reducing manufacturing lead time, the manufacturer also reduces work-in-process inventory.
8. *To accomplish processes that cannot be done manually.* Certain operations cannot be accomplished without the aid of a machine. These processes require precision, miniaturization, or complexity of geometry that cannot be achieved manually. Examples include certain integrated circuit fabrication operations, rapid prototyping processes based on computer graphics (CAD) models, and the machining of complex, mathematically defined surfaces using computer numerical control. These processes can only be realized by computer controlled systems.
9. *To avoid the high cost of not automating.* There is a significant competitive advantage gained in automating a manufacturing plant. The advantage cannot easily be demonstrated on a company's project authorization form. The benefits of automation often show up in unexpected and intangible ways, such as in improved quality, higher sales, better labor relations, and better company image. Companies that do not automate are likely to find themselves at a competitive disadvantage with their customers, their employees, and the general public.

SC SIII OPPC

Ten strategies for Automation & PS

Specialization of Operations — Involve use of special purpose equipment design To perform 1 operaⁿ with greatest possible efficiency

Combined Operations — Involve reduc'g no. of distinct productⁿ m/c through part route. Accomplish by perform'g more than 1 operaⁿ at a given m/c.

Simultaneous operations — Simultaneously perform operaⁿ that combined at 1 w/stⁿ. Reduc'g total process'g time.

Integration of operations — To link several w/stⁿ together into single integrated mech. I'sly overall O/P of system.

Increased flexibility — To achive maxᵐ utilizaⁿ of equip for job shop. To reduce set up time & prog. time for productⁿ m/c.

Improved material Handl'g & storage — Include reduced work in process. shorter manuf. lead times

On-Line Inspection — Permits correcⁿ of process as product being made. Overall quality of product close to nominal specificaⁿ

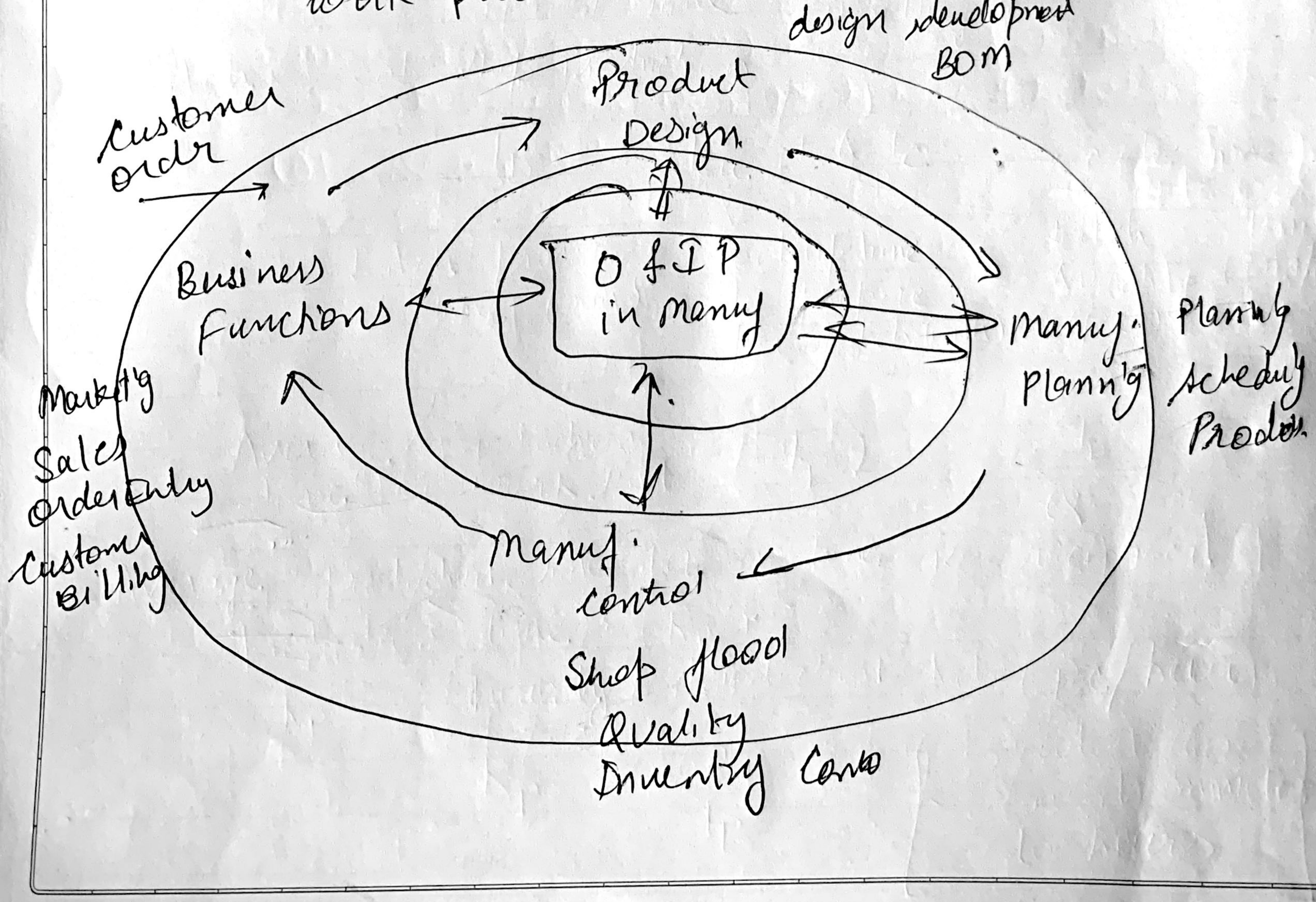
Process control & optimization — include wide range of control schemes intented to operate indiviual process & equip more efficiently

Plant operations control — Attempt to manag. & co-ordinate aggregate operaⁿˢ in plant. ~~Hig~~ Involve high level of computer Network'g within factory

Comp. Integrated Manuf. (CIM) — Extensive use of computer Appⁿ, computer database, computer network'g through enterprise.

Functions of Manufacturing

1. Design & Development
2. Planning
3. Production control
4. " Planning
5. Quality Control
6. Maintenance
7. Improve Performace
8. Inventory control
9. ~~mar~~ meet Quality Stds
10. Monitoring & support'g work processes

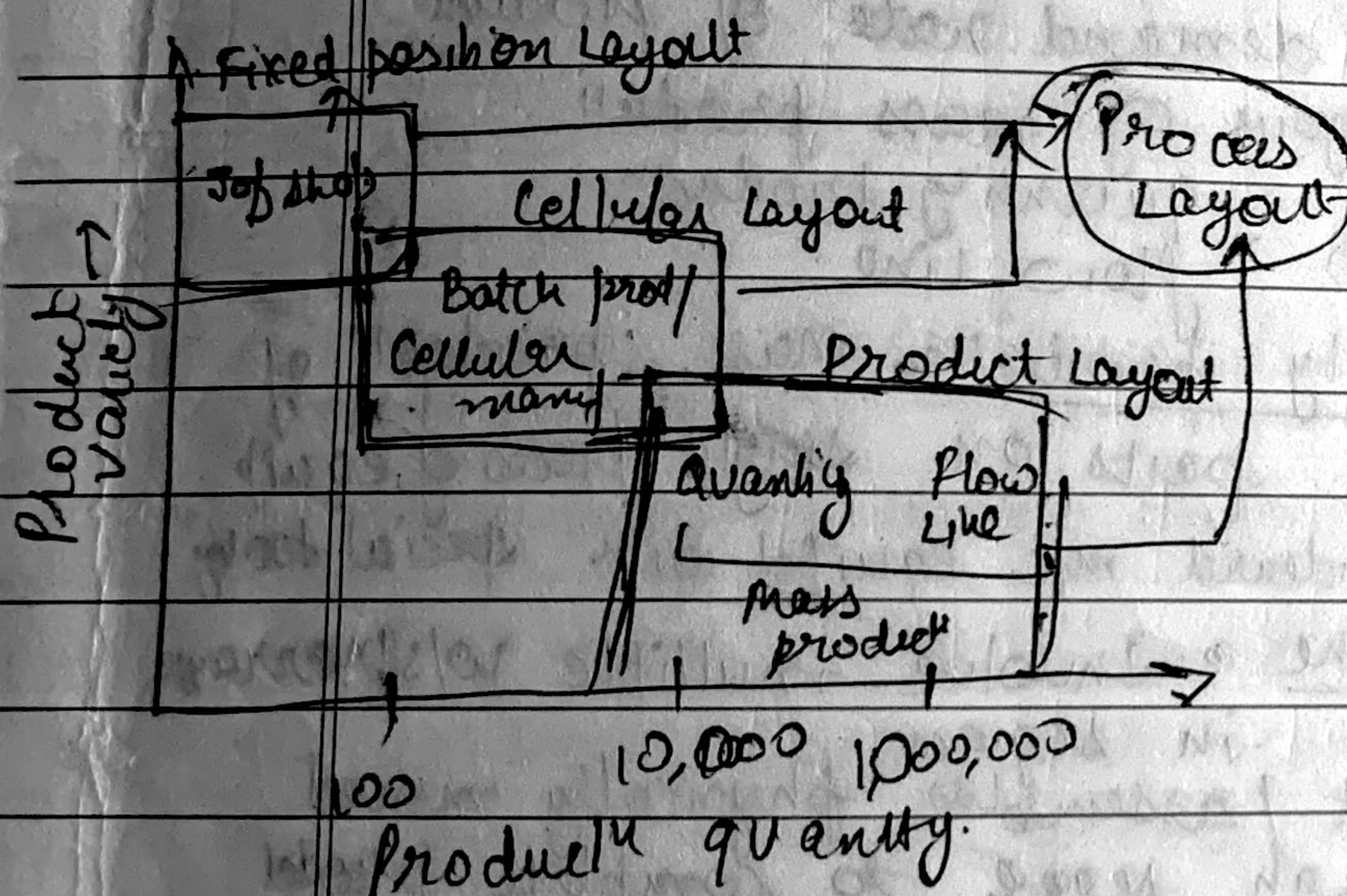


3) Production concept & Mathematical Models

2) Production

- **Continous or Repetitive PS**
  - **Mass/ Flow/ In-Line PS**
    - 1) Low Varity
    - 2) High Volume
    - Ex- Automobile, Food Process Plants
  - **Process PS**
    - 24x7 Prodn, High Vol., High Variety
    - Ex- Steel making, Paper making Plants
- **Non Continous or Intermittent PS**
  - **Batch**
    - Prodn in Lots or Groups
    - Medium → Variety, Volume, Quantity
    - Ex- Drugs, Chemicals
  - **Job-shop**
    - Variety of Products produced in Small amount
    - Ex:- M/c tool shop, Painting shop
  - **Project**
    - Large Var contract & Project Product
    - Ex- Construction of airport, ship building, drilling Oil wells

Characteristics	Low	Medium	High
quantity range.	1 to 100 units/yr.	100-10,000 units annually	10,000,000 ~~to~~ million of units/year
Production.	Job-shop.	Batch.	Mass
Product Variety (PV)	~~Soft~~/ Hard.	Hard / Soft	Both Soft / Hard depend on flow line
Productn Rate (PR)	~~Very~~ Low PR of equip. as ~~the~~ demand is less	PR of equipment > Demand Rate for single product	Demand rate is higher for product
Labour force	Highly skilled	Less skilled as Mechanized & semi Automatic	NO reqr as ~~fut~~ Fully Autumatic



Low Quantity production

1. Range of 1-100 units/year.
2. Job-shop prod. system.
3. Low quantities of specilized & customized products
4. Products typically complex such as capsules, Aircrafts & special mchry
5. Include fabricating component parts for product
6. Customer order for these kinds of items are special & repeat order never occur.
7. Labour force highly skilled.
8. Designed for maxm flexibility
9. To deal with wide part & product variations (Hard PV)
10. Difficult to move in factory, remain in single locn
11. Worker & processing equip. brought to product.
12. Exp. ships, aircrafts, railway locomotive, heavy mchry

13. Individual parts comprise Large product made have process layout
14. Exp Lathe in one department, milling m/c in another dep. & so-on.
15. Accomodate greater variety of alternative operatn sequence for diff. part conf.
16. Disadvg :- M/c & method to produce a part not designed for high eff. Material handlg reqr to move parts b/w department, so in process inventory be high.

Various types of plant layout

Medium Qlty Productn

1. Range 100 – 10,000 units annualy
2. when product variety hard → batch prodn
3. Batch of 1 product made after facility changed over produce batch for next product
4. PR of equip. > DR for single prodn
5. Change over / set time b/w productn run takes time
6. Set up time :- Time to change tooling & set up & reprogram m/cery
7. ~~Disadage~~ ~~lowest~~ Lost productn time
   item manuf. to replenish inventy that gradually depleted by demd
8. Cellular manuf. :- process or assembly of diff. parts or produd accomplish in cell consist of several w/stn or m/c
9. Each cell designed to produe limited variety of part config.
10. Cell specitize in productn of given set of similar parts or product acc. to principle of Group Tech.

High Production

1. Range (10,000 to millons of units/yr)
2. Reffered to mass productn
3. High demand rate of product
4. 2 category of mass productn
   a. quantity productn
   b. flow line
5. Quantity productn • mass productn of single parts on single pieces of equip
   • standard m/c equiped with special tooling
6. Flow Line • Involve multiple w/stn arrange in sequence
   • Part / assemblies physically moved through seque to complete prodt
   • Exp- cars & houshold appliances
7. Single model PL- No variatn in product made on line, every product is identical
8. ~~Mixed model PL: soft varity prodct made on line, such as differes in models as in cars~~

Manufact. suppo...
To design the ... qty ... Peo...
Customer orders
Product design
Business funcn
Productn sys. Facilities
Manuf. contro...
Product de...
- Product m...
- Design ...
- Manuf's ... not
- Product ...
- Manuf's ... no ... manu...
Manufa...