CIM&FMS

(MODULE-1)

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SYLLABUS

- MODULE – I (12 HOURS)

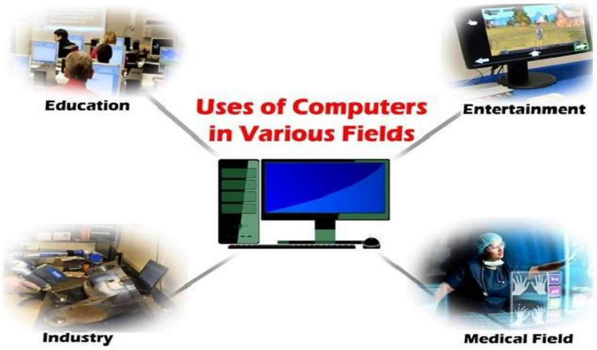
Fundamentals of Manufacturing and Automation: Production systems, automation principles and its strategies; Manufacturing industries; Types of production function in manufacturing; Automation principles and strategies, elements of automated system, automation functions and level of automation; product/production relationship, Production concept and mathematical models for production rate, capacity, utilization and availability; Cost-benefit analysis. Computer Integrated Manufacturing: Basics of product design, CAD/CAM, Concurrent engineering, CAPP and CIM.

LEARNING OUTCOMES:

- Students are able to Know about:
  1. Production systems, automation principles and its strategies
  2. Different Manufacturing Industries and their types
  3. Automation principles and its different levels
  4. Mathematical Models for different types of production and its associated costs.
  5. Basic product design using CAD/CAM and its applications in CIM.
  6. Concept of Concurrent Engineering and CAPP.

INTRODUCTION TO CIM

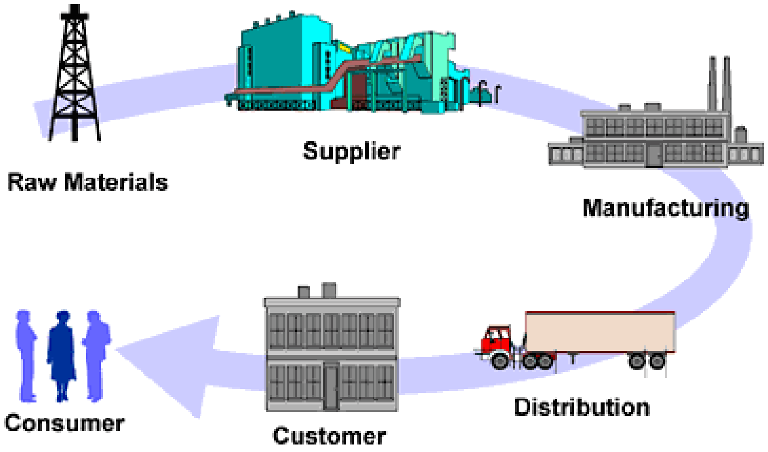
- The idea of "digital manufacturing" became prominent in the early 1970s, with the release of Dr. Joseph Harrington's book, Computer Integrated Manufacturing.
- However, it was not until 1984 when computer-integrated manufacturing (CIM) began to be developed and promoted by machine tool manufacturers and the Computer and Automated Systems Association and Society of Manufacturing Engineers
- A **computer** is a machine that can be instructed to carry out sequences of arithmetic or logical operations automatically via computer programming.
- Modern computers have the ability to follow generalized sets of operations, called programs.
- These programs enable computers to perform an extreme



INTRODUCTION TO CIM

Definitions: Manufacturing

- Manufacturing is the process of converting raw materials, components or parts into finished goods that meet a customer's expectations or specifications.
- Manufacturing is a value-adding process allowing businesses to sell finished products at a premium over the value of the raw materials used.

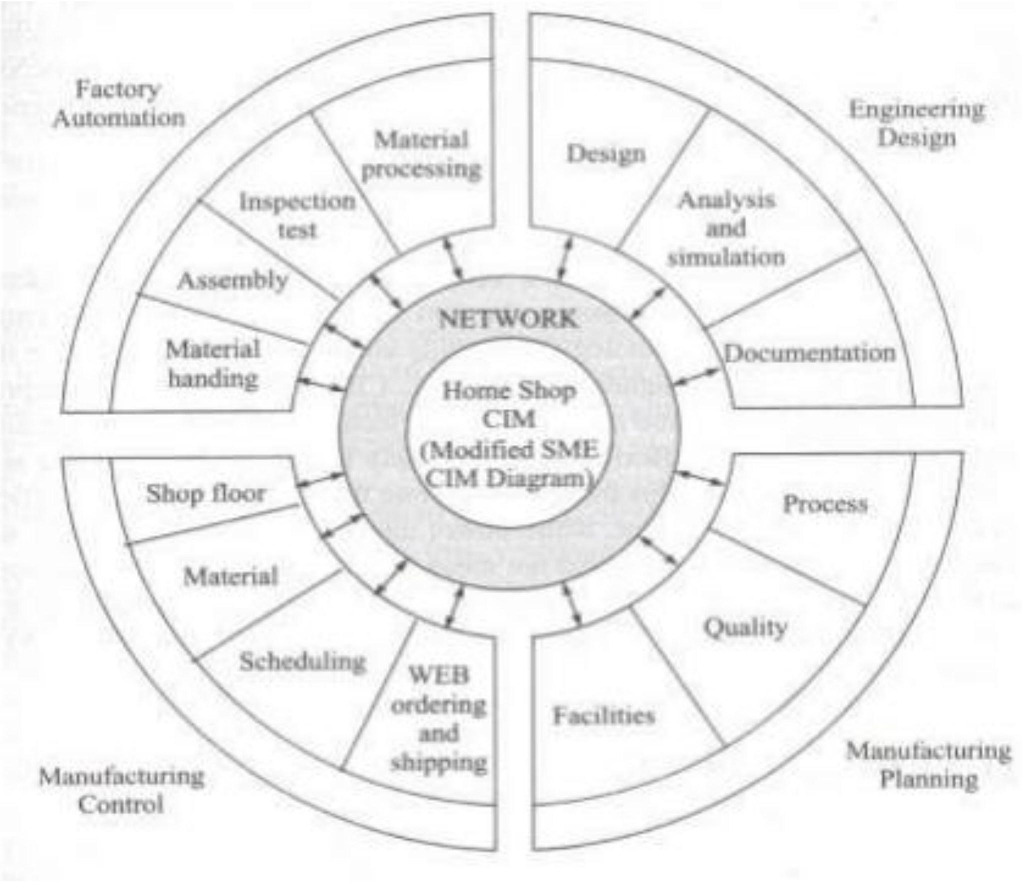


INTRODUCTION TO CIM

What is CIM ?

- Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control entire production process. This integration allows individual processes to exchange information with each other and initiate actions.
- Computer-integrated manufacturing (CIM) makes the use of computer-controlled machineries and automation systems in manufacturing products. CIM combines various technologies like CAD and CAM to provide an error-free manufacturing process that reduces manual labor and automates repetitive tasks.
- The term "computer-integrated manufacturing" is both a method of manufacturing and the name of a computer-automated system in which individual engineering, production, marketing, and support functions of a manufacturing enterprise are organized.
- In a CIM system functional areas such as design, analysis, planning, purchasing, cost accounting, inventory control, and distribution are linked through the computer with factory floor functions such as materials handling and management, providing direct control and monitoring of all the operations.

CIM WHEEL



Factory Automation
Material processing
Inspection test
Assembly
Material handing
Design
Analysis and simulation
Documentation
Engineering Design
NETWORK
Home Shop CIM (Modified SME CIM Diagram)
Shop floor
Material
Scheduling
WEB ordering and shipping
Manufacturing Control
Process
Quality
Facilities
Manufacturing Planning

ISLANDS OF AUTOMATION

The various ‘islands of automation which by integration forms computer integrated manufacturing, include:

1. Computer-aided design (CAD)
2. Computer-aided manufacture (CAM)
3. Computer numerically controlled (CNC) machines
4. Flexible manufacturing systems (FMS)
5. Robotics
6. Automated material handling systems (AMHS)
7. Group technology (GT)
8. Computer aided process planning (CAPP)
9. Manufacturing resource planning (MRP II)
10. Computer control systems.

WHY CIM?

- Error Reduction

Elimination of human error in many assignment and reporting functions on factory floor operations drastically reduces the error rate.

- Speed

CIM environments reduce the time it takes to perform manufacturing fabrication and assembly, allowing quicker flow of product to customers and increased capacity.

- Flexibility

With CIM companies quickly react to market conditions and then return to previous settings when market conditions change.

- Integration

CIM offers a degree of integration that enables the flexibility, speed and error reduction required to compete and lead markets. Integrating factory floor operations with enterprise software enables employees to do higher value functions for their companies.

USAGES OF CIM

- Industrial and Production Engineering
- Mechanical Engineering
- Electronic Design Automation
    1) Printed Circuit Board design
    2) Integrated Circuit design

CHALLENGES

- Integration of components from different suppliers

When different machines, such as CNC, conveyors and robots, are using different communications protocols (In the case of AGVs, even differing lengths of time for charging the batteries) may cause problems.

- Data Integrity

The higher the degree of automation, the more critical is the integrity of the data used to control the machines. While the CIM system saves on labor of operating the machines, it requires extra human labor in ensuring that there are proper safeguards for the data signals that are used to control the machines.

- Process Control

Computers may be used to assist the human operators of the manufacturing facility, but there must always be a competent engineer on hand to handle circumstances which could not be foreseen by the designers of the control software.

SUB-SYSTEMS IN CIM:

- Computer-aided techniques

  CAD, CAM, CAE,CAPP, FMS,ERP etc.

- Devices and equipments required

  CNC, Computer numerical controlled machine tools

  DNC, Direct numerical control machine tools

  PLCs, Programmable logic controllers,

  Robotics,

  Computers, Software, Controllers, Networks, Interfacing, Monitoring equipment

- Technologies

  FMS, (flexible manufacturing system) ASRS, automated storage and retrieval system, AGV, automated guided vehicle, Robotics, Automated conveyance systems

PRESENT SCENARIO

- Smart manufacturing
- Digital manufacturing
- Internet Of Things (IoT)
- Artificial Intelligence (AI)

SMART MANUFACTURING:

- Smart manufacturing is a broad category of manufacturing that employs computer-integrated manufacturing, high levels of adaptability and rapid design changes, digital information technology, and more flexible technical workforce training. Other goals sometimes include fast changes in production levels based on demand, optimization of the supply chain, efficient production and recyclability.

DIGITAL MANUFACTURING:

- Digital manufacturing is the use of an integrated, computer-based system comprised of simulation, 3D visualization, analytics and collaboration tools to create product and manufacturing process definitions simultaneously.
- Digital manufacturing evolved from manufacturing initiatives such as design for manufacturability (DFM), computer-integrated manufacturing (CIM), flexible manufacturing and lean manufacturing that highlight the need for collaborative product and process design.

INTERNET OF THINGS (IOT):

- There are essentially two different roles that the IOT can play in manufacturing. It can connect the "things" that make your product—machines and equipment—to potentially make your manufacturing processes run more smoothly.
- Or you can tap into data collected or generated by your products, making them "smart" products.
- IOT has multitudes of applications in manufacturing plants. It can facilitate the production flow in a manufacturing plant, as IOT devices automatically monitor development cycles, and manage warehouses as well as inventories.

ARTIFICIAL INTELLIGENCE (AI) :

- Artificial intelligence technology is now making its way into manufacturing.
- "AI will perform manufacturing, quality control, shorten design time, and reduce materials waste, improve production reuse, perform predictive maintenance, and more," says Andrew Ng, the creator of the deep-learning Google Brain project and an adjunct professor of computer science at Stanford University.

CLOUD BASED MANUFACTURING :

- Cloud models come as infrastructure, platform, and services. Manufacturers can opt for the solution of choice and strategize migration in stages. This makes cloud a flexible and convenient choice.
- Cloud allows the synchronization of data from multiple sources into a single dashboard. Hence it relieves executives from the burden of manually transferring data from one system to another.

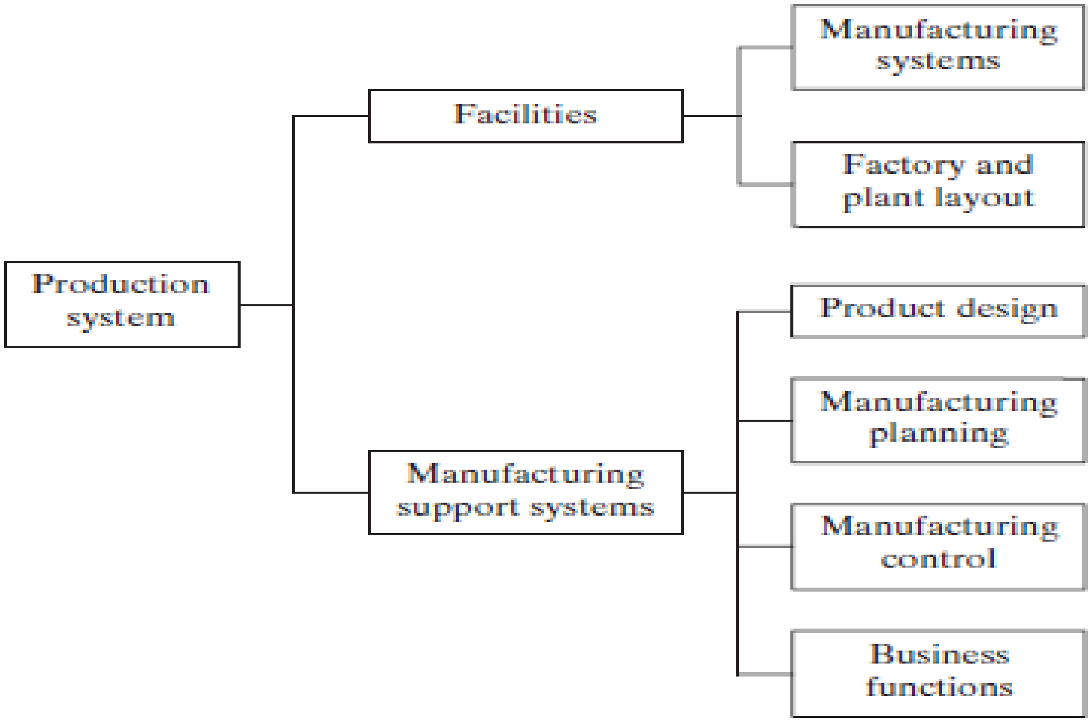
PRODUCTION SYSTEMS

- The word manufacturing derives from two Latin words, manus (hand) and factus (make), so that the combination means made by hand.
- A production system is a collection of people, equipment, and procedures organized to perform the manufacturing operations of a company. It consists of two major components

  1. *Facilities.* 2. *Manufacturing support systems*.

- ***Facilities :*** The physical facilities of the production system include the equipment, the way the equipment is laid out, and the factory in which the equipment is located.
- ***Manufacturing support systems :*** These are the procedures used by the company to manage production and to solve the technical and logistics problems encountered in ordering materials, moving the work through the factory, and ensuring that products meet quality standards. Product design and certain business functions are included in the manufacturing support systems.

PRODUCTION SYSTEMS (CONTD..)



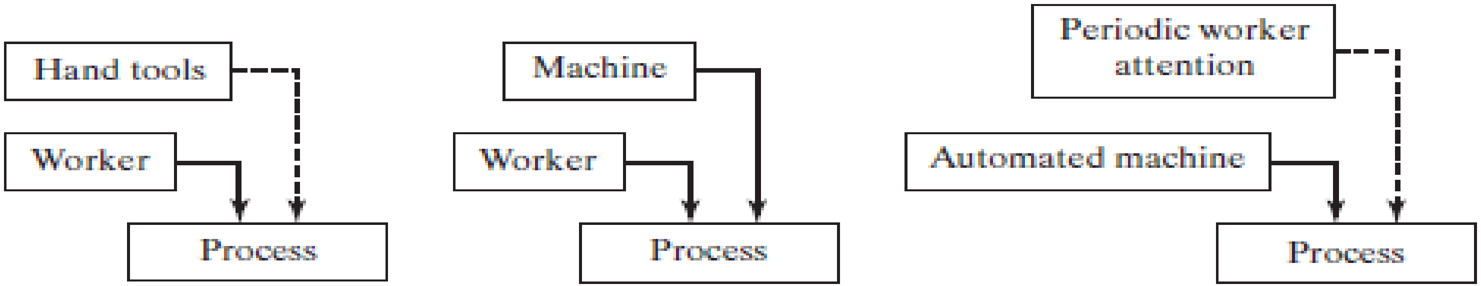
PRODUCTION SYSTEMS (CONTD.)

- In modern manufacturing operations, portions of the production system are automated and/or computerized.
- In addition, production systems include people.
- People make these systems work.
- In general, direct labor people (blue-collar workers) are responsible for operating the facilities, and professional staff people (white-collar workers) are responsible for the manufacturing support systems.

FACILITIES

- Facilities include the plant layout, which is the way the equipment is physically arranged in the factory.
- The equipment is usually organized into manufacturing systems, which are the logical groupings of equipment and workers that accomplish the processing and assembly operations on parts and products made by the factory.
- Manufacturing systems, three basic categories can be distinguished

(a) manual work systems,
(b) worker-machine systems, and
(c) automated systems.

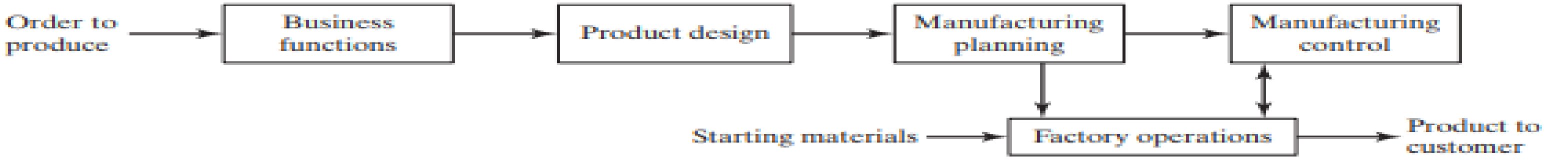


(a) (b) (c)

RELATIVE STRENGTHS AND ATTRIBUTES OF HUMANS AND MACHINES

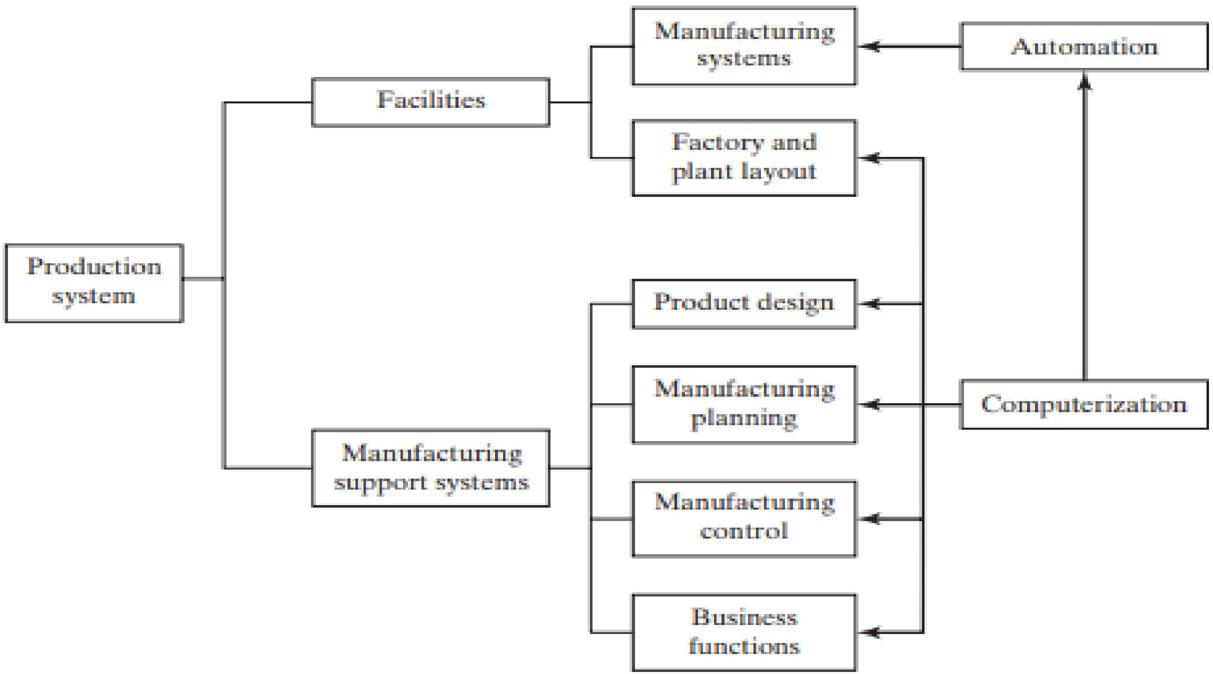
Humans	Machines
Sense unexpected stimuli	Perform repetitive tasks consistently
Develop new solutions to problems	Store large amounts of data
Cope with abstract problems	Retrieve data from memory reliably
Adapt to change	Perform multiple tasks simultaneously
Generalize from observations	Apply high forces and power
Learn from experience	Perform simple computations quickly
Make decisions based on incomplete data	Make routine decisions quickly

MANUFACTURING SUPPORT SYSTEMS



- ***Business Functions:*** The business functions are the principal means by which the company communicates with the customer. Included in this category are sales and marketing, sales forecasting, order entry, and customer billing etc.
- ***Product Design :*** Product design include research and development, design engineering, and perhaps a prototype shop.
- ***Manufacturing Planning:*** The information-processing activities in manufacturing planning include process planning, master scheduling, material requirements planning, and capacity planning.
- ***Manufacturing Control:***Manufacturing control is concerned with managing and controlling the physical operations in the factory to implement the manufacturing plans. Included in this function are shop floor control, inventory control, and quality control.

AUTOMATION IN PRODUCTION SYSTEM



AUTOMATED MANUFACTURING SYSTEMS

- 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.

AUTOMATED MANUFACTURING SYSTEMS

- Automated manufacturing systems can be classified into three basic types:

  (1) fixed automation,

  (2) programmable automation

  (3) flexible automation

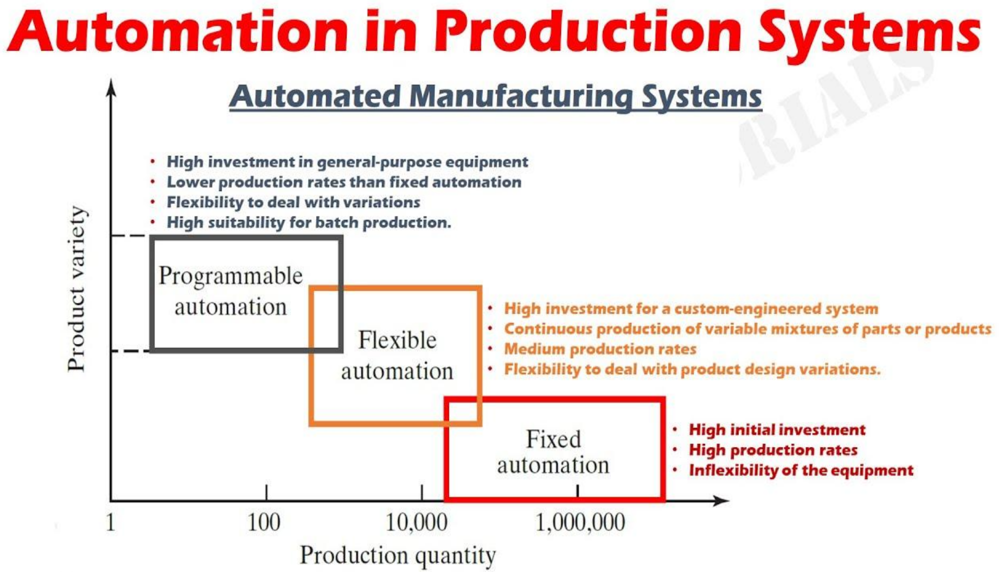


Fig: Three types of automation relative to production quantity and product variety.

FIXED AUTOMATION

A manufacturing system in which the sequence of processing(or assembly) operations is fixed by the equipment configuration.

Typical features:

- Suited to high production quantities
- High initial investment for custom-engineered equipment
- High production rates
- Relatively inflexible in accommodating product variety

PROGRAMMABLE AUTOMATION

A manufacturing system designed with the capability to change the sequence of operations to accommodate different product configurations.

Typical features:

- High investment in general purpose equipment
- Lower production rates than fixed automation
- Flexibility to deal with variations and changes in product configuration
- Most suitable for batch production
- Physical setup and part program must be changed between jobs (batches)

FLEXIBLE AUTOMATION

An extension of programmable automation in which the system is capable of changing over from one job to the next with no lost time between jobs.

Typical features:

- High investment for custom-engineered system
- Continuous production of variable mixes of products
- Medium production rates
- Flexibility to deal with soft product variety

COMPUTERIZED MANUFACTURING SUPPORT SYSTEMS

Objectives of automating the manufacturing support systems:

- To reduce the manual and clerical effort in product design, manufacturing planning and control, and the business functions
- Integrates computer-aided design (CAD) and computer-aided manufacturing (CAM) in CAD/CAM
- CIM includes CAD/CAM and the business functions of the firm.

REASONS FOR AUTOMATING

- Increase labor productivity
- Reduce labor cost
- Mitigate the effects of labor shortages
- Reduce or eliminate routine manual and clerical tasks
- Improve worker safety
- Improve product quality
- Reduce manufacturing lead time
- Accomplish processes that cannot be done manually
- Avoid the high cost of not automating

MANUAL LABOR IN FACTORY OPERATIONS

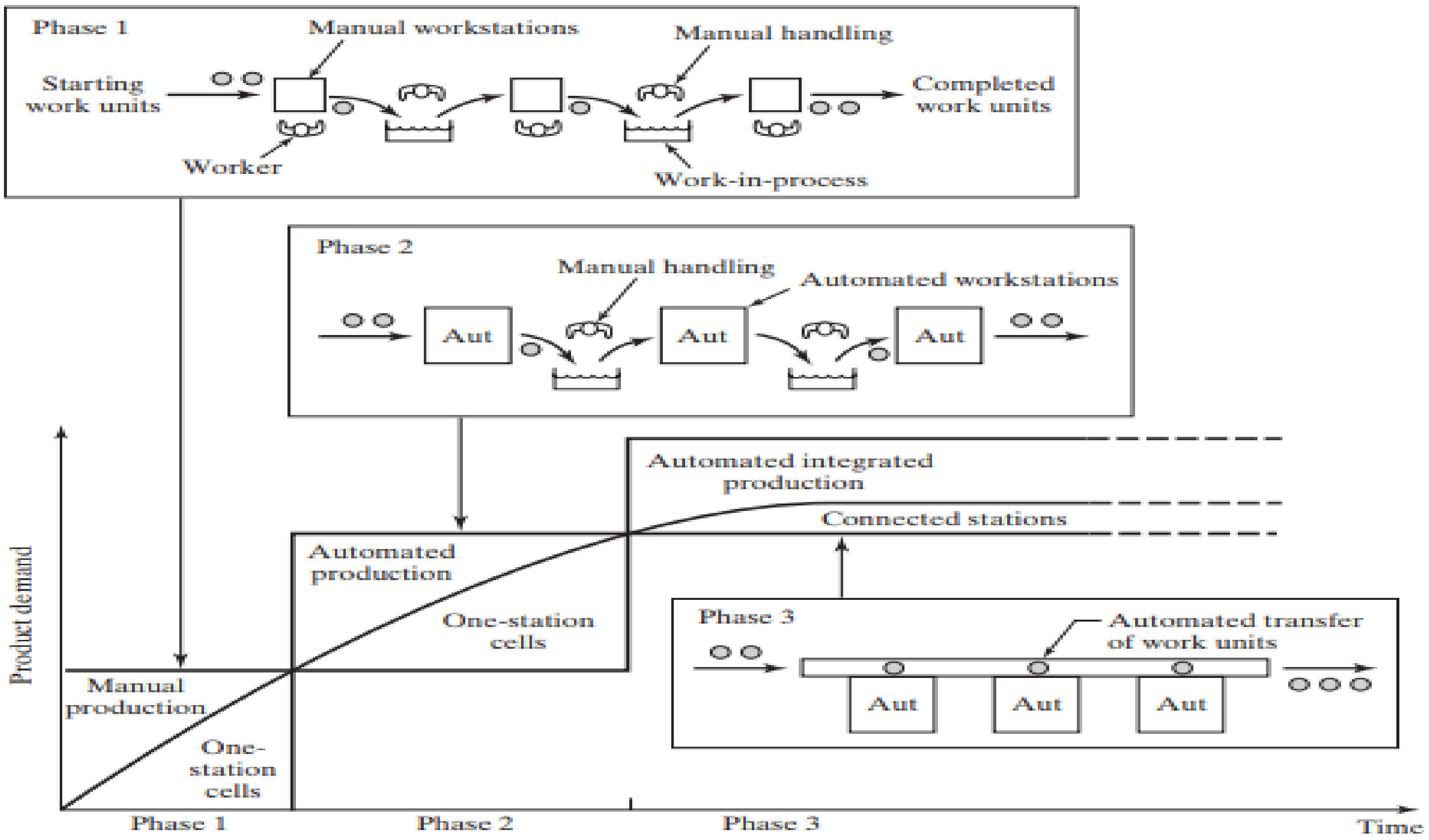
- Task is technologically too difficult to automate.
- Short product life cycle
- Customized product
- Ups and downs in demand
- Need to reduce risk of product failure
- Lack of capital

AUTOMATION PRINCIPLES AND STRATERGIES

- The USA Principle: USA stands for
  - (1) understand the existing process,
  - (2) simplify the process,
  - (3) automate the process

- Ten Strategies for Automation and Process Improvement:
  1. Specialization of operations.
  2. Combined operations
  3. Simultaneous operations
  4. Integration of operations
  5. Increased flexibility
  6. Improved material handling and storage
  7. On-line inspection
  8. Process control and optimization
  9. Plant operations control
  10. Computer-integrated manufacturing (CIM)

AUTOMATION MIGRATION STRATEGY



MANUFACTURING METRICS AND ECONOMICS

- Successful manufacturing companies use metrics to manage their operations.
- Quantitative metrics allow a company to estimate part and product costs, track performance in successive periods (e.g., months and years), identify problems with performance, and compare alternative methods.
- Manufacturing metrics can be divided into two basic categories:

  (1) production performance measures

  (2) manufacturing costs.
- Metrics are production performance that include production rate, plant capacity, Manufacturing Metrics and Economics, equipment availability (a reliability measure), and manufacturing lead time.
- Manufacturing costs that are important to a company include labor and material costs, overhead costs, the cost of operating a given piece of equipment, and unit part and product costs.

PRODUCTION PERFORMANCE METRICS

- Cycle Time:

T_c = Cycle Time.

Time that one work unit spends being processed or assembled. It is the time interval between when one work unit begins processing (or assembly) and when the next unit begins.

T_c is the time an individual part spends at the machine, but not all of this is processing time. In a typical processing operation, such as machining, Tc consists of

(1) actual processing time,

(2) work part handling time,

(3) tool handling time per workpiece.

$$T_c = T_o + T_h + T_t$$

T_c = cycle time (min/pc)

T_o = time of the actual processing or assembly operation, min/pc

T_h = handling time, min/pc

T_t = average tool handling time, min/pc

PRODUCTION RATE

- work units completed per hour (pc/hr)
- **Job shop production**, quantities are low (1 … Q … 100).
- At the extreme low end of the range, when quantity Q = 1,
- the production time per work unit is the sum of setup and cycle times: $T_p = T_{su} + T_c$

T_p = average production time, min/pc;

T_{su} = setup time to prepare the machine to produce the part, min/pc;

T_c = cycle time from Equation

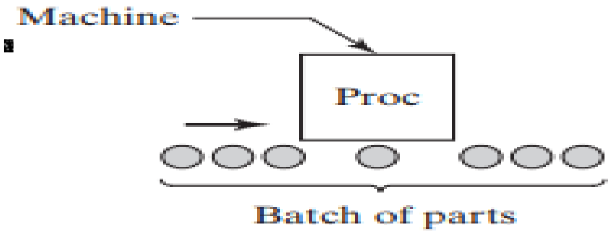
- The production rate for the unit operation is the reciprocal of production time,

$$R_p = 60/T_p$$

R_p = hourly production rate, pc/hr

T_p = production time

PRODUCTION RATE (CONTD..)



- **Batch production**

$$T_b = T_{su} + QT_c$$

T_b = batch processing time, min/batch

T_{su} = setup time to prepare the machine for the batch, min/batch

Q = batch quantity, pc/batch

T_c = cycle time per work unit, min/cycle.

Production time per work unit T_p for the unit operation

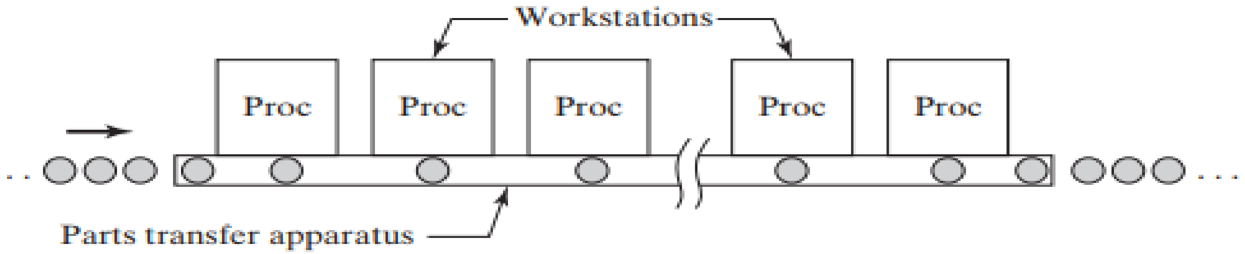
$$T_p = T_b/Q$$

The production rate for the unit operation is the reciprocal of production time

$$R_p = 60/T_p$$

PRODUCTION RATE (CONTD.)

- **Flow-line Mass production**



$$T_c = \text{Max } T_o + T_r$$

T_c = cycle time of the production line, min/cycle
Max T_o = the operation time at at the bottleneck station, min/cycle
T_r = time to transfer work units between stations each cycle, min/cycle

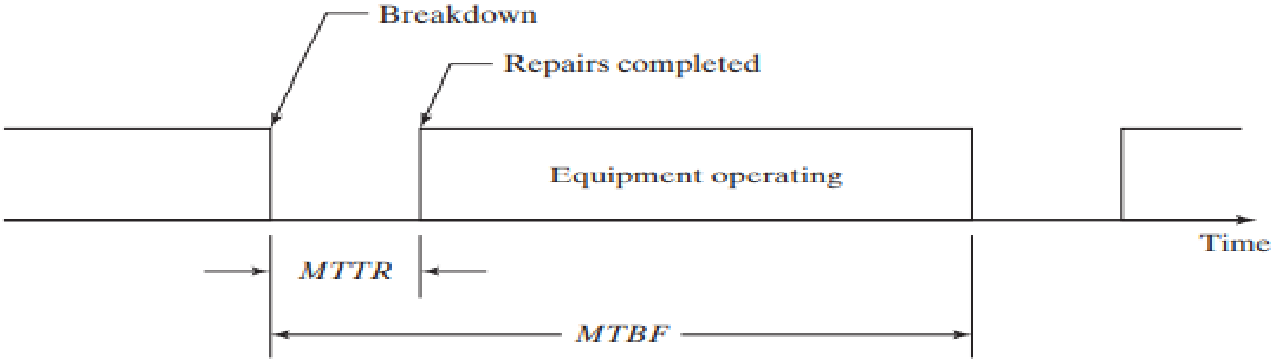
Production rate can be determined by taking the reciprocal of T_c

$$R_c = 60 / T_c$$

AVAILABILITY

- Uptime proportion of the equipment.
- The proportion of time that the equipment is capable of operating (not broken down) relative to the scheduled hours of production.
- Availability can also be defined using two other reliability terms,

    1. Mean time between failures (MTBF)
    2. Mean time to repair (MTTR)



$$A = \frac{MTBF - MTTR}{MTBF}$$

Average production rate = AR_p

PRODUCTION CAPACITY

- It is defined as the maximum rate of output that a production facility (or production line, or group of machines) is able to produce under a given set of assumed operating conditions.
- PC = Production capacity of a given facility, where the measure of capacity is the number of units produced per time period (e.g., week, month, year).

$$PC = nH_{pc}R_p$$

PC = production capacity, pc/period;

n = number of machines;

H_{pc}= the number of hours in the period being used to measure production capacity (or plant capacity)

R_p= Production Rate

PROBLEM

The automatic lathe department has five machines, all devoted to the production of the same product. The machines operate two 8-hr shifts, 5 days/week, 50 weeks/year. Production rate of each machine is 15 unit/hr. Determine the weekly production capacity of the automatic lathe department.

UTILIZATION

- Utilization is the proportion of time that a productive resource (e.g., a production machine) is used relative to the time available under the definition of plant capacity.

$$U_i = \sum_j f_{ij}$$

U_i = utilization of machine i,
f_{ij} = the fraction of time during the available hours that machine i is processing part style j.

An overall utilization for the plant is determined by averaging the U_i values over the numbe

$$U = \frac{\sum_{i=1}^{n} \sum_j f_{ij}}{n} = \frac{\sum_j U_i}{n}$$

MANUFACTURING LEAD TIME

- MLT is defined as the total time required to process a given part or product through the plant, including any time due to delays, parts being moved between operations, time spent in queues, and so on.

$$MLT_j = \sum_{i=1}^{n_{oj}} (T_{suij} + Q_j T_{cij} + T_{noij})$$

MLT_j = manufactur product j, min

T_{suij} = setup time for operation i on part or product j, min

Q_j = quantity of part or product j in the batch being processed, pc

T_{cij} = cycle time for operation i on part or product j, min/pc

T_{noij} = nonoperation time associated with operation i, min

i indicates the operation sequence in the processing, i = 1, 2……. n_{oj} .

$$MLT = n_o(T_{su} + QT_c + T_{no})$$

LET'S THINK…….

- A certain part is produced in batch sizes of 100 units. The batches must be routed through five operations to complete the processing of the parts. Average setup time is 3.0 hr/batch, and average operation time is 6.0 min/pc. Average nonoperation time is 7.5 hr for each operation. Determine the manufacturing lead time to complete one batch, assuming the plant runs 8 hr/ day, 5 days/wk.

MANUFACTURING COSTS:

- Manufacturing costs can be classified

  (1) fixed costs

  (2) variable costs.

- A fixed cost is one that remains constant for any level of production output. e.g cost of the factory building and production equipment, insurance, and property taxes.
- A variable cost is one that varies in proportion to production output.

  As output increases, variable cost increases.

  Examples are : direct labor, raw materials, and electric power to operate the production equipment.

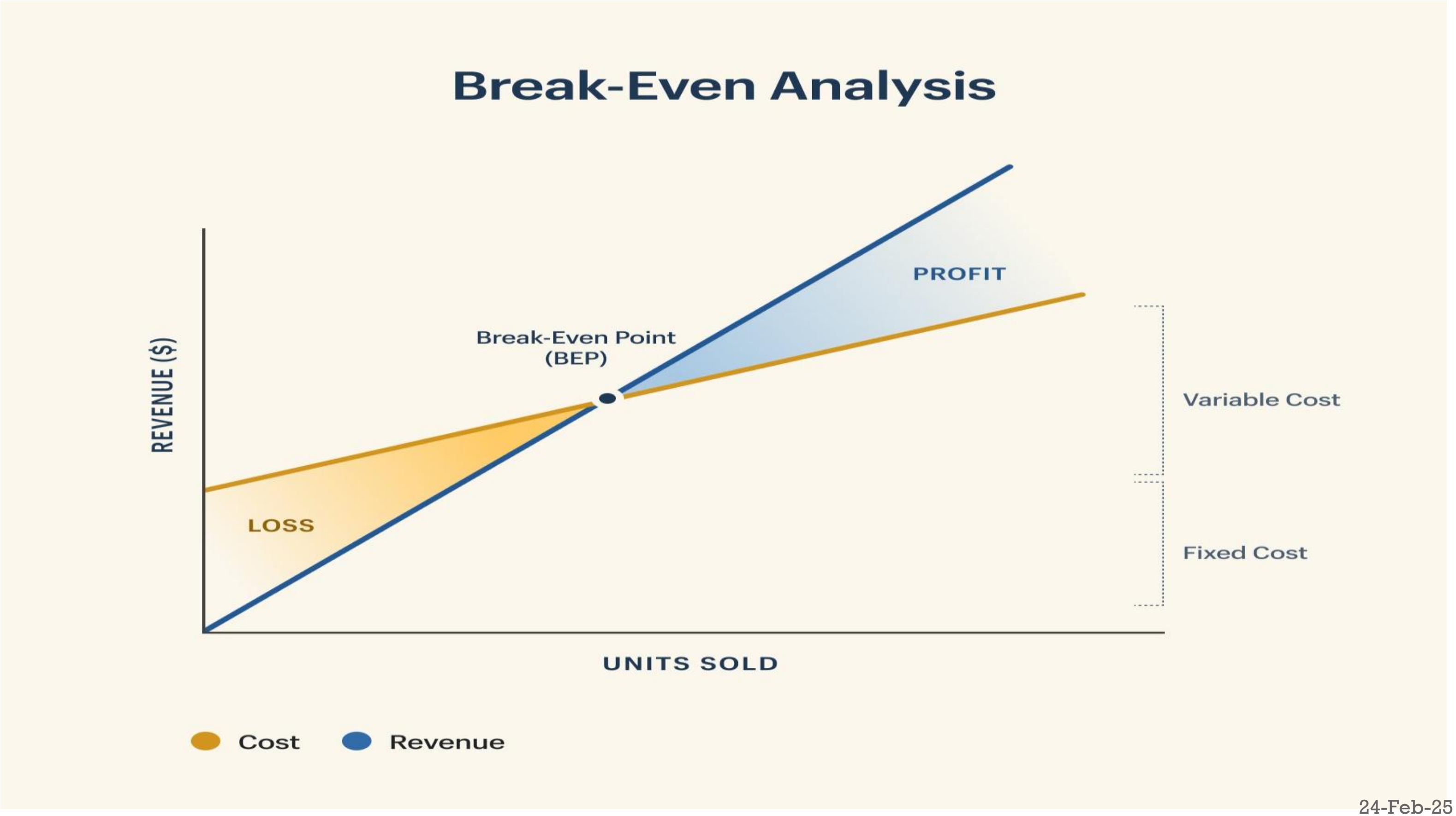
$$TC = C_f + C_v Q$$

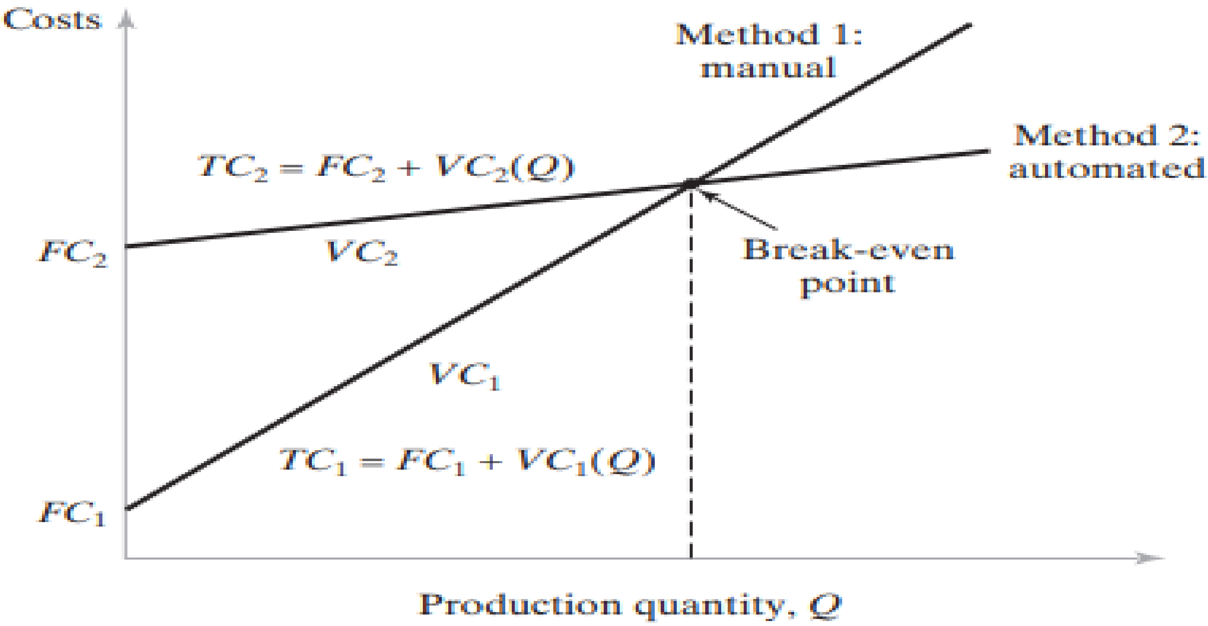
TC = total annual cost, Rs./yr

C_f = fixed annual cost, Rs./yr

C_v = variable cost, Rs/pc

Q = annual quantity produced, pc/yr


Break-Even Analysis
PROFIT
Break-Even Point
(BEP)
REVENUE ($)
Variable Cost
LOSS
Fixed Cost
UNITS SOLD
Cost
Revenue


Costs
Method 1: manual
Method 2: automated
$TC_2 = FC_2 + VC_2(Q)$
FC_2
VC_2
Break-even point
VC_1
$TC_1 = FC_1 + VC_1(Q)$
FC_1
Production quantity, Q

LET'S THINK…….

- Two production methods are being compared, one manual and the other automated. The manual method produces 10 pc/hr and requires one worker at Rs15.00/hr. Fixed cost of the manual method is Rs5,000/yr. The automated method produces 25 pc/hr, has a fixed cost of Rs55,000/yr, and a variable cost of Rs4.50/hr. Determine the break-even point for the two methods; that is, determine the annual production quantity at which the two methods have the same annual cost. Ignore the costs of materials used in the two methods.

DIRECT LABOR, MATERIAL, AND OVERHEAD

- Direct labor cost is the sum of the wages and benefits paid to the workers who operate the production equipment and perform the processing and assembly tasks.
- Material cost is the cost of all raw materials used to make the product.
- Overhead costs are all of the other expenses associated with running the manufacturing firm.

(1) factory overhead

(2) corporate overhead.

- Factory overhead consists of the costs of operating the factory other than direct labor and materials, such as the factory expenses.

Plant supervision	Applicable taxes	Factory depreciation
Line foreman	Insurance	Equipment depreciation
Maintenance crew	Heat and air conditioning	Fringe benefits
Custodial services	Light	Material handling
Security personnel	Power for machinery	Shipping and receiving
Tool crib attendant	Payroll services	Clerical support

factory overhead

Corporate executives	Engineering	Applicable taxes
Sales and marketing	Research and development	Office space
Accounting department	Other support personnel	Security personnel
Finance department	Insurance	Heat and air conditioning
Legal counsel	Fringe benefits	Lighting

Corporate overhead

OVERHEAD RATE

$$FOHR = \frac{FOHC}{DLC}$$

FOHR = factory overhead rate
FOHC = annual factory overhead costs, Rs/yr
DLC = annual direct labor costs, Rs/yr.

$$COHR = \frac{COHC}{DLC}$$

COHR = corporate overhead rate
COHC = annual corporate overhead costs, Rs/yr
DLC = annual direct labor costs, Rs/yr.

INTRODUCTION TO AUTOMATION

- ***Automation*** can be defined as the technology by which a process or procedure is accomplished without human assistance.
- It is implemented using a program of instructions combined with a control system that executes the instructions.
- To automate a process, power is required, both to drive the process itself and to operate the program and control system.
- ***Mechanization*** refers to the use of machinery (usually powered) to assist or replace human workers in performing physical tasks, but human workers are still required to accomplish the cognitive and sensory elements of the tasks.
- ***Automation*** refers to the use of mechanized equipment that performs the physical tasks without the need for oversight by a human worker.

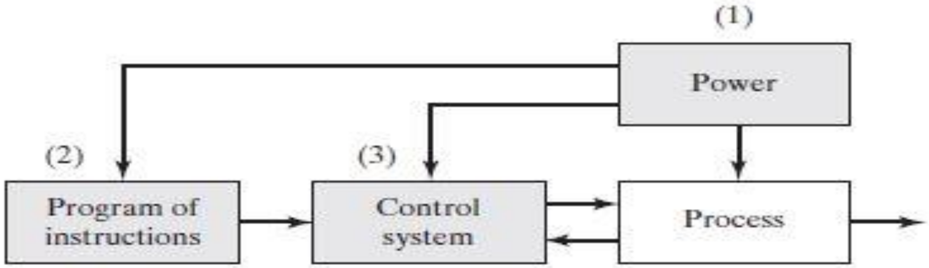
BASIC ELEMENTS OF AN AUTOMATED SYSTEM

- An automated system consists of three basic elements:

  (1) power to accomplish the process and operate the system,

  (2) a program of instructions to direct the process, and

  (3) a control system to actuate the instructions



POWER TO ACCOMPLISH THE AUTOMATED PROCESS

- An automated system is used to operate some process, and power is required to drive the process as well as the controls. The principal source of power in automated systems is electricity.
- Electric power has many advantages in automated as well as non automated processes:

• Electric power is widely available at moderate cost. It is an important part of the industrial infrastructure.

- Electric power can be readily converted to alternative energy forms: mechanical,thermal, light, acoustic, hydraulic, and pneumatic.
- Electric power at low levels can be used to accomplish functions such as signal transmission, information processing, and data storage and communication.
- Electric energy can be stored in long-life batteries for use in locations where an external source of electrical power is not conveniently available.

In addition to driving the manufacturing process itself, power is also required for the following material handling functions:

- Loading and unloading the work unit.
- Material transport between operations

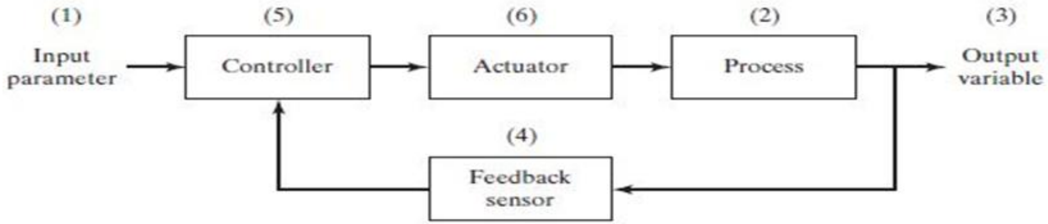
Power for Automation

- Controller unit
- Power to actuate the control signals
- Data acquisition and information processing

PROGRAM OF INSTRUCTIONS

- Process parameters
- Number of steps in work cycle
- Manual participation in the work cycle
- Operator interaction.
- Variations in part or product styles
- Variations in starting work units

CONTROL SYSTEM



LEVELS OF AUTOMATION