COURSE MATERIAL

IV Year B. Tech II- Semester

MECHANICAL ENGINEERING

AUTOMATION IN MANUFACTURING

R15A0344

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

(Autonomous Institution-UGC, Govt. of India)
Secunderabad-500100,Telangana State, India.
www.mrcet.ac.in

CONTENTS

MRCET CAMPUS

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

VISION

- To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become technology leaders of Indian vision of modern society.

MISSION

- To become a model institution in the fields of Engineering, Technology and Management.
- To impart holistic education to the students to render them as industry ready engineers.
- To ensure synchronization of MRCET ideologies with challenging demands of International Pioneering Organizations.

QUALITY POLICY

- To implement best practices in Teaching and Learning process for both UG and PG courses meticulously.
- To provide state of art infrastructure and expertise to impart quality education.
- To groom the students to become intellectually creative and professionally competitive.
- To channelize the activities and tune them in heights of commitment and sincerity, the requisites to claim the never - ending ladder of **SUCCESS** year after year.

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Department of Mechanical Engineering

VISION

To become an innovative knowledge center in mechanical engineering through state-of-the-art teaching-learning and research practices, promoting creative thinking professionals.

MISSION

The Department of Mechanical Engineering is dedicated for transforming the students into highly competent Mechanical engineers to meet the needs of the industry, in a changing and challenging technical environment, by strongly focusing in the fundamentals of engineering sciences for achieving excellent results in their professional pursuits.

Quality Policy

- ✓ To pursuit global Standards of excellence in all our endeavors namely teaching, research and continuing education and to remain accountable in our core and support functions, through processes of self-evaluation and continuous improvement.
- ✓ To create a midst of excellence for imparting state of art education, industry-oriented training research in the field of technical education.

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Department of Mechanical Engineering

PROGRAM OUTCOMES

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	Ability to analyze, design and develop Mechanical systems to solve the Engineering problems by integrating thermal, design and manufacturing Domains.
PSO2	Ability to succeed in competitive examinations or to pursue higher studies or research.
PSO3	Ability to apply the learned Mechanical Engineering knowledge for the Development of society and self.

Program Educational Objectives (PEOs)

The Program Educational Objectives of the program offered by the department are broadly listed below:

PEO1: PREPARATION

To provide sound foundation in mathematical, scientific and engineering fundamentals necessary to analyze, formulate and solve engineering problems.

PEO2: CORE COMPETANCE

To provide thorough knowledge in Mechanical Engineering subjects including theoretical knowledge and practical training for preparing physical models pertaining to Thermodynamics, Hydraulics, Heat and Mass Transfer, Dynamics of Machinery, Jet Propulsion, Automobile Engineering, Element Analysis, Production Technology, Mechatronics etc.

PEO3: INVENTION, INNOVATION AND CREATIVITY

To make the students to design, experiment, analyze, interpret in the core field with the help of other inter disciplinary concepts wherever applicable.

PEO4: CAREER DEVELOPMENT

To inculcate the habit of lifelong learning for career development through successful completion of advanced degrees, professional development courses, industrial training etc.

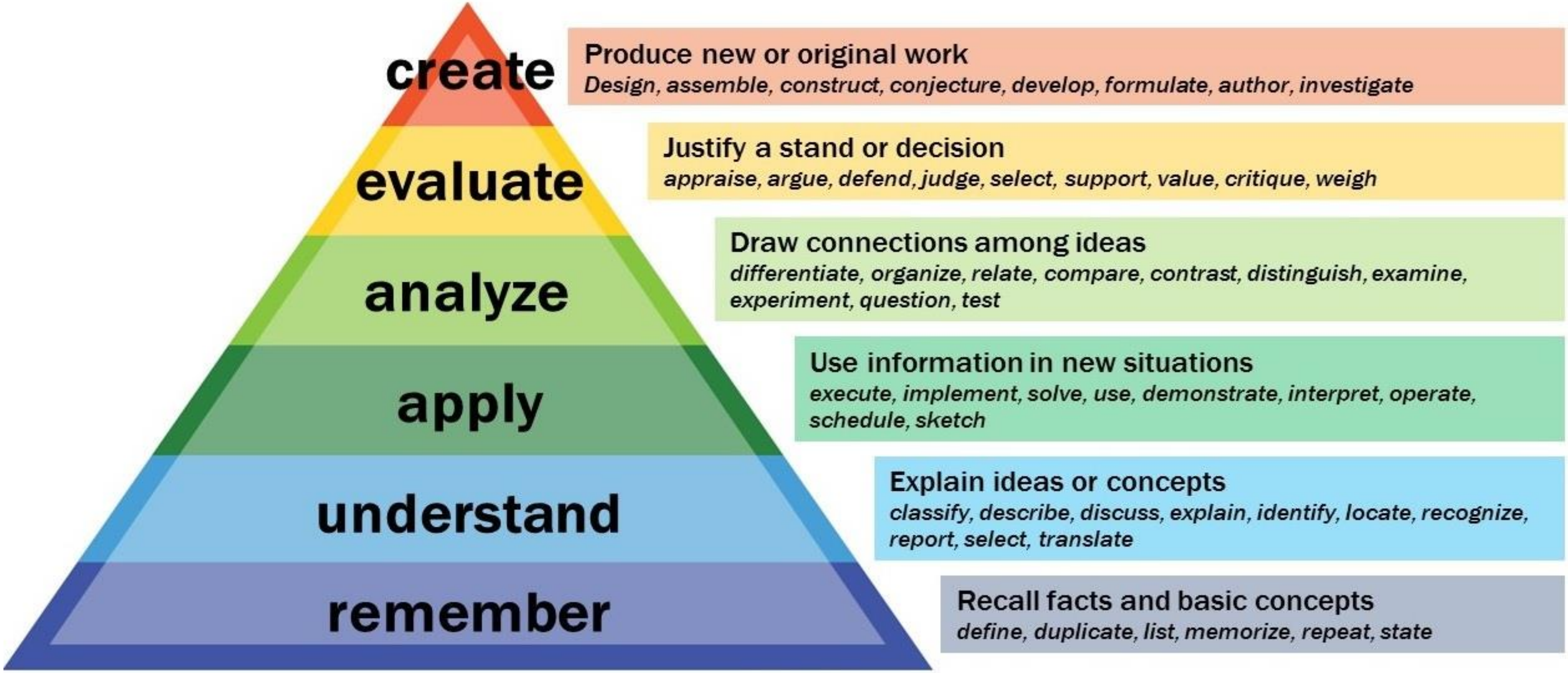
PEO5: PROFESSIONALISM

To impart technical knowledge, ethical values for professional development of the student to solve complex problems and to work in multi-disciplinary ambience, whose solutions lead to significant societal benefits.

Blooms Taxonomy

Bloom's Taxonomy is a classification of the different objectives and skills that educators set for their students (learning objectives). The terminology has been updated to include the following six levels of learning. These 6 levels can be used to structure the learning objectives, lessons, and assessments of a course.

1. **Remembering**: Retrieving, recognizing, and recalling relevant knowledge from long- term memory.
2. **Understanding**: Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. **Applying**: Carrying out or using a procedure for executing or implementing.
4. **Analyzing**: Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
5. **Evaluating**: Making judgments based on criteria and standard through checking and critiquing.
6. **Creating**: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.



create
Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate
evaluate
Justify a stand or decision
appraise, argue, defend, judge, select, support, value, critique, weigh
analyze
Draw connections among ideas
differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test
apply
Use information in new situations
execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch
understand
Explain ideas or concepts
classify, describe, discuss, explain, identify, locate, recognize, report, select, translate
remember
Recall facts and basic concepts
define, duplicate, list, memorize, repeat, state

COURSE SYLLABUS

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

IV Year B. Tech, ME-II Sem	L	T/P/D	C
	5	1	4

(R15A0344) AUTOMATION IN MANUFACTURING
(CORE ELECTIVE–VI)

Objectives:

- Too know about the Automation and types of Automations in the industries.
- To understand the different Automated flow lines in the Industries.
- To perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts.
- To perform a sequence of automated or mechanized assembly operations Flexible manufacturing system (FMS)—a highly automated machine cell that produces part
- To know product families often consists of workstations comprising CNC machine tools.

UNIT –I

Introduction: Types and strategies of automation, pneumatic and hydraulic components circuits, Automation in machine tools, Mechanical Feeding and to changing and machine tool control transfer the automation.

UNIT –II

Automated flow lines: Methods or work part transport transfer Mechanical buffer storage control function, design and fabrication consideration.

Analysis of Automated flow lines: General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines .

UNIT –III

Assembly system and line balancing: Assembly process and systems assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

UNIT –IV

Automated material handling: Types of equipment, functions, analysis and design of material handling systems conveyor systems, automated guided vehicle systems.

Automated storage systems: Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

UNIT –V

Fundamentals of Industrial controls: Review of control theory, logic controls, sensors and actuators, Data communication and LAN in manufacturing.

Business process Re-engineering: Introduction to BPE logistics, ERP, Software configuration of BPE.

Outcomes:

- Students will understand the process of automation and types
- Students will get exposure to workstation, which refers to the location in the factory where some well-defined task or operation is accomplished by an automated machine.
- Worker-and-machine combination or a worker using hand tools
- Understand the Automated Material handling equipments and types
- Student gets exposure on portable power tools.

TEXT BOOKS:

1. M.P.Groover 3e - Automation, Production Systems and Computer Integrated Manufacturing, PHI,2009.
2. Frank Lamb - Industrial Automation , Mc Graw Hill,2013
3. W. Buekinsham – Automation.

REFERENCE BOOKS:

1. Nick Dawkins - Automation and Controls
2. Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang - Computer Aided Manufacturing, Pearson 2009
3. Peter G. Martin and Gregory Hale - Automation Made Easy

UNIT I
INTRODUCTION TO AUTOMATION

Objective:

- Too know about the Automation and types of Automations in the industries.

Outcome:

- Students will understand the process of automation and types

Introduction: Types and strategies of automation, pneumatic and hydraulic components circuits, Automation in machine tools, Mechanical Feeding and to changing and machine tool control transfer the automation

UNIT –I

1. Types of Automation System with examples

Automated production systems can be classified into three basic types:

1. Fixed automation,
2. Programmable automation, and
3. Flexible automation.

2. Fixed Automation examples

FIXEDAUTOMATION

It is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. The operations in the sequence are usually simple. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex. The typical features of fixed automation are:

a. High initial investment for custom–Engineered equipment;
b. High production rates; and
c. Relatively inflexible in accommodating product changes.

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

PROGRAMMABLEAUTOMATION

In this 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 the system can read and interpret them. New programs can be prepared and entered into the equipment to produce new products. Some of the features that characterize programmable automation are:

a. High investment in general-purpose equipment;
b. Low production rates relative to fixed automation;
c. Flexibility to deal with changes in product configuration; and
d. Most suitable for batch production.

Automated production systems that are programmable 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 over: Tools must be loaded, fixtures must be attached to the machine table also be changed machine settings must be entered. This changeover procedure takes time. Consequently, the typical cycle for given product includes a period during which the setup and reprogramming takes place, followed by a period in which the batch is produced. Examples of programmed automation include numerically controlled machine tools and industrial robots

FLEXIBLEAUTOMATION

It is an extension of programmable automation. A flexible automated system is one that is capable of producing a variety of products (or parts) with virtually no time lost for changeovers from one product to the next. There is no production time lost while reprogramming the system and altering the physical setup (tooling, fixtures, and machine setting). Consequently, the system can produce various combinations and schedules of products instead of requiring that they be made in separate batches. The features of flexible automation can be summarized as follows:

1. High investment for a custom-engineered system.
2. Continuous production of variable mixtures of products.
3. Medium production rates.
4. Flexibility to deal with product design variations.

The essential features that distinguish flexible automation from programmable automation are:

1. the capacity to change part programs with no lost production time; and
2. the capability to changeover the physical setup, again with no lost production time.

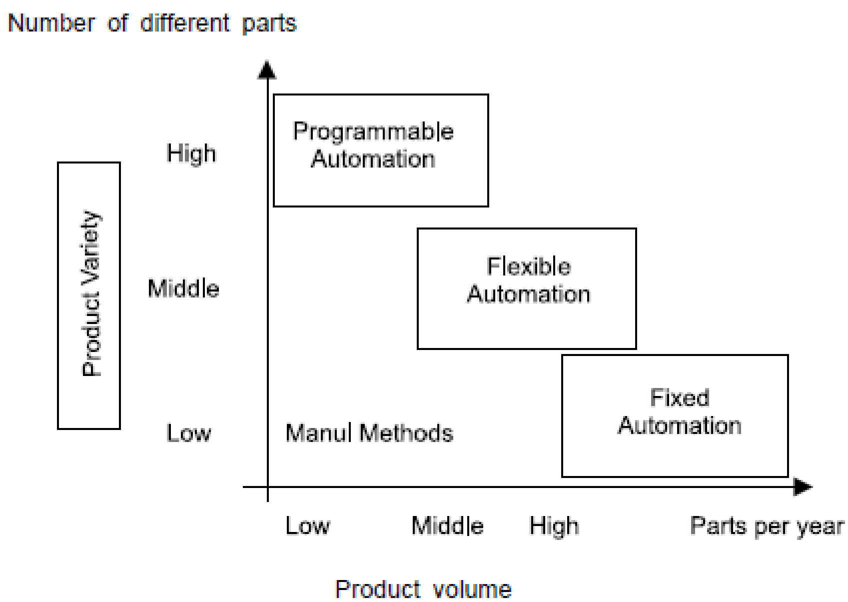
These features allow the automated production system to continue production without the downtime between batches that is characteristic of programmable automation. Changing the part programs is generally accomplished by preparing the programs off-line on a computer system and electronically transmitting the programs to the automated production system. Therefore, the time required to do the programming for the next job does not interrupt production on the current job. Advances in computer systems technology are largely responsible for this programming capability in flexible automation. Changing the physical setup between parts is accomplished by making the changeover off-line and then moving it into place simultaneously as the next part comes into position for processing.

The use of pallet fixtures that hold the parts and transfer into position at the workplace is one way of implementing this approach. For these approaches to be successful; the variety of parts that can be made on a flexible automated production system is usually more limited than a system controlled by programmable automation.

The relative positions of the three types of automation for different production volumes and product varieties are depicted in the following figure.

3. Automation in Production system

Types of production automation



Understand, simplify and automate the process
Following the USA Principle is a good first step in any automation project.
The USA Principle is a common sense approach to automation projects. Similar procedures have been suggested in
the manufacturing and automation trade literature, but none has a more captivating title than this one.
USA stands for:

1. Understand the existing process
2. Simplify the process
3. Automate the process.

It may turn out that automation of the process is unnecessary or cannot be cost justified after it has been simplified.

If automation seems a feasible solution to improving productivity, quality, or other measure of performance, then
the following ten strategies provide a road map to search for these improvements.
These ten strategies seem as relevant and appropriate today as they did in 1980. We refer to them as strategies for
automation and production systems because some of them are applicable whether the process is a candidate for
automation or just for simplification.

1. Specialization of operations

The first strategy involves the use of special-purpose equipment designed to perform one operation with the
greatest possible efficiency.
This is analogous to the concept of labor specialization, which is employed to improve labor
productivity.

2. Combined operations

Production occurs as a sequence of operations.
Complex parts may require dozens, or even hundreds, of processing steps. The strategy of combined operations
involves reducing the number of distinct production machines or workstations through which the part must be routed.
This is accomplished by performing more than one operation at a given machine , thereby reducing the number of
separate machines needed.
Since each machine typically involves a setup, setup time can usually be saved as a consequence of this
strategy. Material handling effort and non-operation time are also reduced.
Manufacturing lead time is reduced for better customer service.

3. Simultaneous operations

A logical extension of the combined operations strategy is to simultaneously perform the operations that are
combined at one workstation. In effect, two or more processing (or assembly) operations are being performed
simultaneously on the same workpart, thus reducing total processing time.

4. Integration of operations

Another strategy is to link several workstations together into a single integrated mechanism, using automated
work handling devices to transfer parts between stations. In effect, this reduces the number of separate machines
through which the product must be scheduled.

With more than one workstation, several parts can be processed simultaneously, thereby increasing
the overall output of the system.

5. Increased flexibility
This strategy attempts to achieve maximum utilization of equipment for job shop and medium volume situations
by using the same equipment for a variety of parts or products. It involves the use of the flexible automation concepts.
Prime objectives are to reduce setup time and programming time for the production machine. This normally
translates into lower manufacturing lead time and less work-in-process.
6. Improved material handling and storage
A great opportunity for reducing nonproductive time exists in the use of automated material handling and storage
systems.
Typical benefits include reduced work-in-process and shorter manufacturing lead times.
7. On-line inspection
Inspection for quality of work is traditionally performed after the process is completed. This means that any poor
quality product has already been produced by the time it is inspected. Incorporating inspection into the manufacturing
process permits corrections to the process as the product is being made.
This reduces scrap and brings the overall quality of product closer to the nominal specifications
intended by the designer.
8. Process control and optimization
This includes a wide range of control schemes intended to operate the individual processes and associated
equipment more efficiently. By this strategy, the individual process times can be reduced and product quality
improved.
9. Plant operations control
Whereas the previous strategy was concerned with the control of the individual manufacturing process, this strategy
is concerned with control at the plant level. It attempts to manage and coordinate the aggregate operations in the
plant more efficiently.
Its implementation usually involves a high level of computer networking within the factory.
10. Computer-integrated manufacturing (CIM)
Taking the previous strategy one level higher, we have the integration of factory operations with engineering
design and the business functions of the firm.

• It is a hardware which converts a controller command signal into a change in a physical parameter

- It requires amplifier to strengthen the controller command
- Types

– Electrical
– Hydraulic
– Pneumatic

Basic Components of a Hydraulic System

Hydraulic systems are power-transmitting assemblies employing pressurized liquid as a fluid for transmitting energy from an energy-generating source to an energy-using point to accomplish useful work. Figure 1.1 shows a simple circuit of a hydraulic system with basic components.

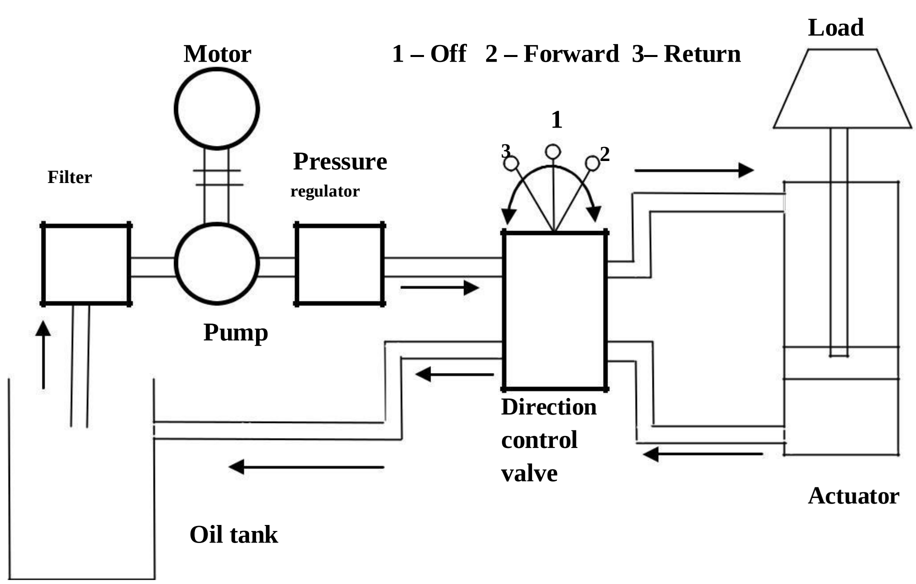


Figure 1.1 Components of a hydraulic system

Functions of the components shown in Fig. 1.1 are as follows:

1. The hydraulic actuator is a device used to convert the fluid power into mechanical power to do useful work. The actuator may be of the linear type (e.g., hydraulic cylinder) or rotary type(e.g., hydraulic motor) to provide linear or rotary motion, respectively.

2. The hydraulic pump is used to force the fluid from the reservoir to rest of the hydraulic circuit by converting mechanical energy into hydraulic energy.

3. Valves are used to control the direction, pressure and flow rate of a fluid flowing through the circuit.

4. Piping system carries the hydraulic oil from one place to another.

5. Filters are used to remove any foreign particles so as keep the fluid system clean and efficient, as well as avoid damage to the actuator and valves.

6. Pressure regulator regulates (i.e., maintains) the required level of pressure in the hydraulic fluid.

The piping shown in Fig. 1.1 is of closed-loop type with fluid transferred from the storage tank to one side of the piston and returned back from the other side of the piston to the tank. Fluid is drawn from the tank by a pump that produces fluid flow at the required level of pressure. If the fluid pressure exceeds the required level, then the excess fluid returns back to the reservoir and remains there until the pressure acquires the required level.

Cylinder movement is controlled by a three-position change over a control valve.

1. When the piston of the valve is changed to upper position, the pipe pressure line is connected to port A and thus the load is raised.

2. When the position of the valve is changed to lower position, the pipe pressure line is connected to port B and thus the load is lowered.

3. When the valve is at center position, it locks the fluid into the cylinder(thereby holding it in position) and dead-ends the fluid line (causing all the pump output fluid to return to tank via the pressure relief).

In industry, a machine designer conveys the design of hydraulic systems using a circuit diagram. Figure 1.2 shows the components of the hydraulic system using symbols. The working fluid, which is the hydraulic oil, is stored in a reservoir. When the electric motor is switched ON, it runs a positive displacement pump that draws hydraulic oil through a filter and delivers at high pressure. The pressurized oil passes through the regulating valve and does work on actuator. Oil from the other end of the actuator goes back to the tank via return line. To and fro motion of the cylinder is controlled using directional control valve.

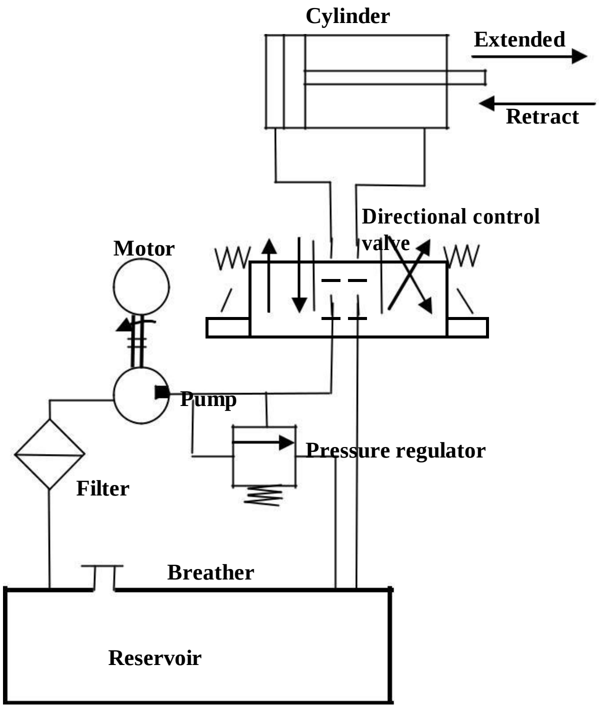


Figure 1.2 Components of a hydraulic system (shown using symbols).

The hydraulic system discussed above can be broken down into four main divisions that are analogous to the four main divisions in an electrical system.

4. The power device parallels the electrical generating station.

5. The control valves parallel the switches, resistors, timers, pressure switches, relays, etc.

6. The lines in which the fluid power flows parallel the electrical lines.

7. The fluid power motor (whether it is a rotating or a non rotating cylinder or a fluid power motor) parallels the solenoids and electrical motors.

Basic Components of a Pneumatic System

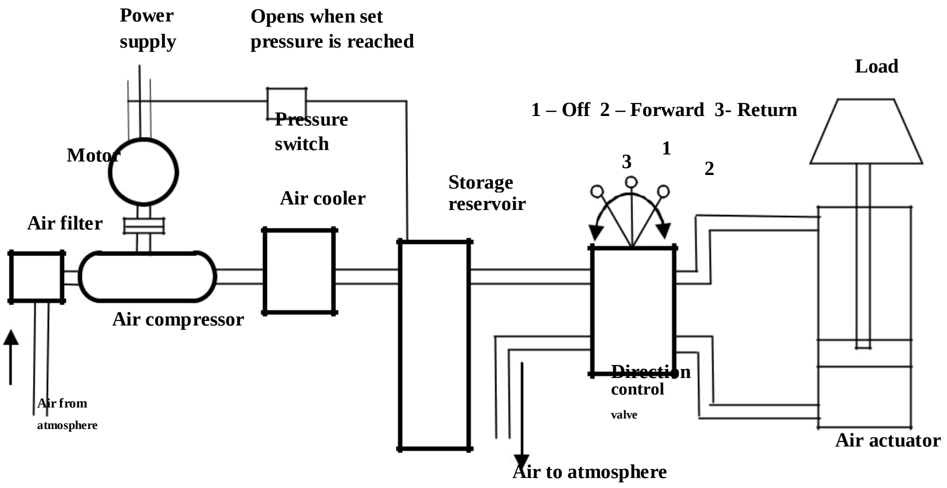


Figure 1.3 Components of a pneumatic system.

The functions of various components shown in Fig. 1.3 are as follows:

1. The pneumatic actuator converts the fluid power into mechanical power to perform useful work.

2. The compressor is used to compress the fresh air drawn from the atmosphere.

3. The storage reservoir is used to store a given volume of compressed air.

4. The valves are used to control the direction, flow rate and pressure of compressed air.

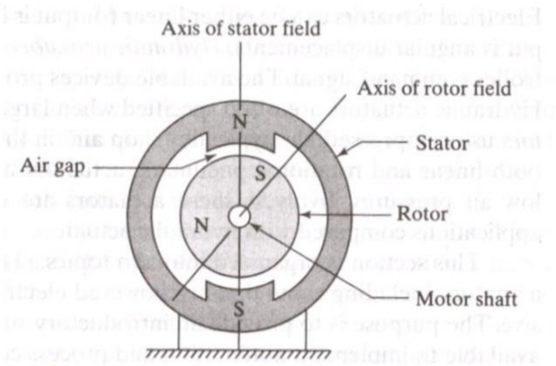
5. External power supply (motor) is used to drive the compressor.

6. The piping system carries the pressurized air from one location to another.

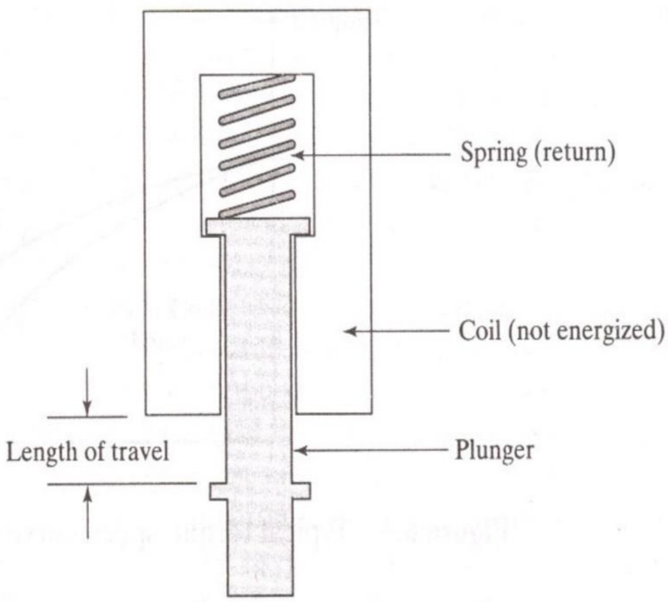
Air is drawn from the atmosphere through an air filter and raised to required pressure by an air compressor. As the pressure rises, the temperature also rises; hence, an air cooler is provided to cool the air with some preliminary treatment to remove the moisture. The treated pressurized air then needs to get stored to maintain the pressure. With the storage reservoir, a pressure switch is fitted to start and stop the electric motor when pressure falls and reaches the required level, respectively.

The three-position change over the valve delivering air to the cylinder operates in a way similar to its hydraulic circuit.

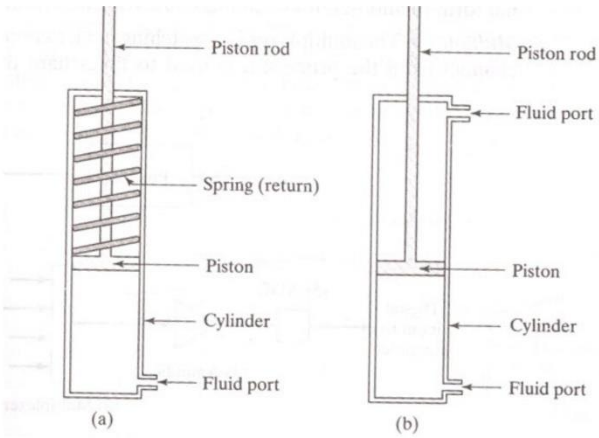
Rotating electric motor



Solenoid



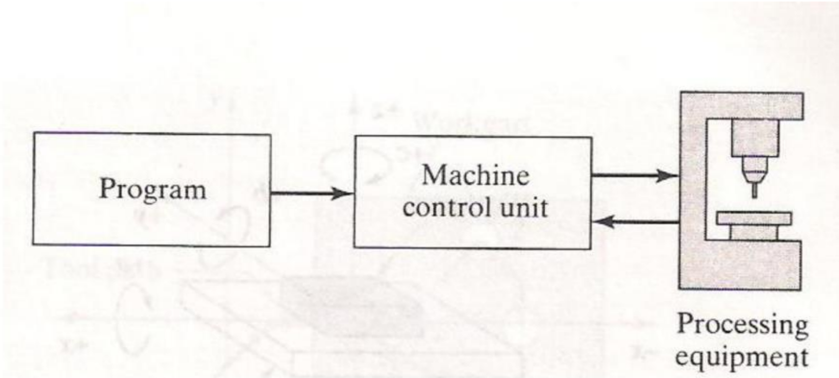
Cylinder and Piston



(a) (b)

NC:
NC is a form of programmable automation in which the mechanical actions of machine tools are controlled by a program containing coded alphanumeric data.

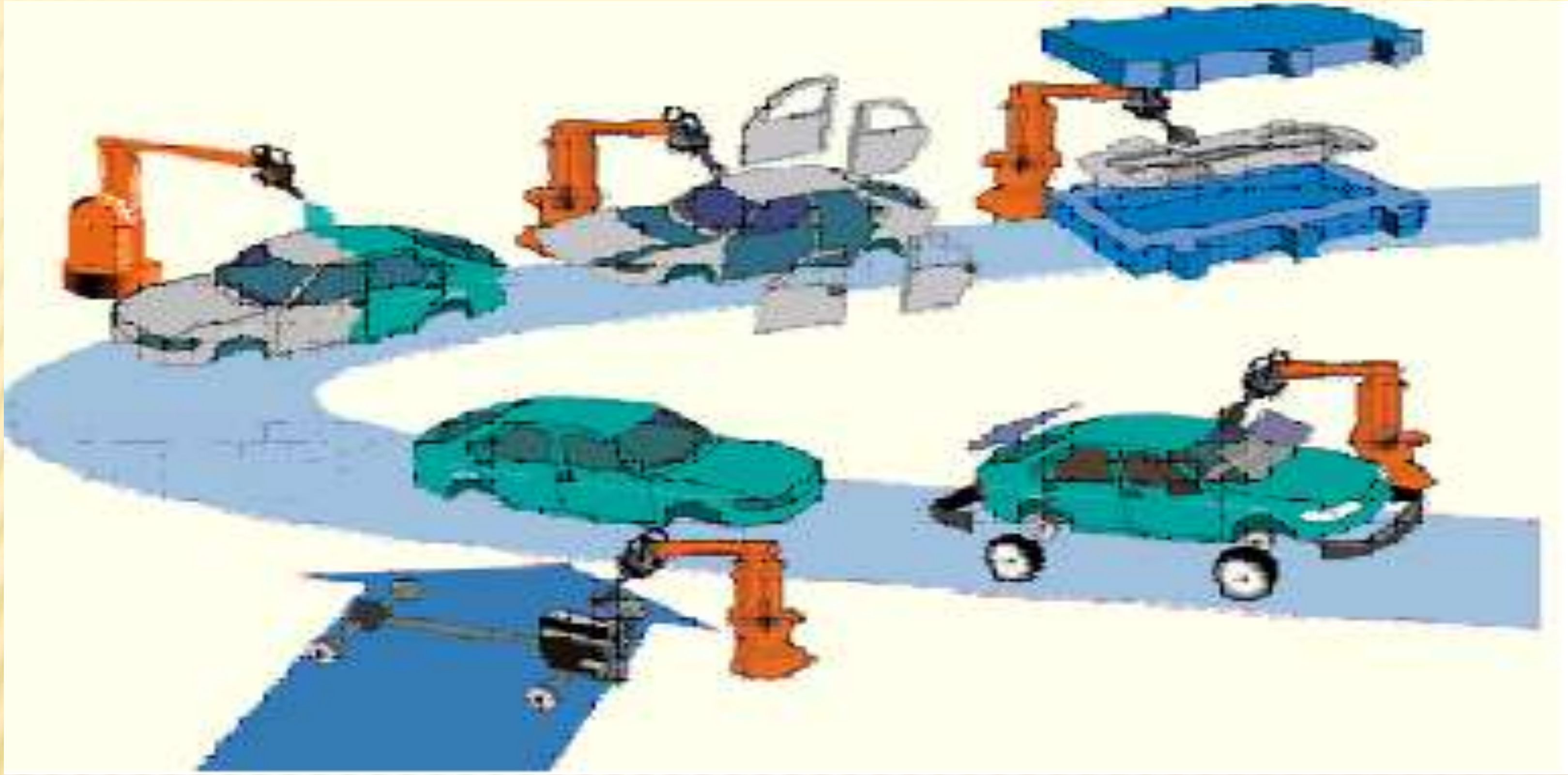
Basic components of NC



- Part program: set of instructions or step by step commands
- Punched tape was the medium used whereas flexowriter was used to write/punch program on it.
- Now magnetic tapes, disks, CDs are commonly used mediums

UNIT I
POWER POINT PRESENTATION SLIDES

PRINCIPLES AND AN OVER VIEW OF AUTOMATION IN MANUFACTURING



Dr. T. Lokeswara Rao

Dr. G. Thrisekhar Reddy

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Manufacturing Systems

Facilities:		Manufacturing systems:
Factory. Production machines. Tooling. Material Handling Equipment. Inspection equipment. Computer control system.	→ Plant Layout	Integration of facilities and people (operators, designers, managers, etc)

The organisation of facilities and people into manufacturing system is critical to the efficiency of a manufacturing operation → Automation issue.

People and Manufacturing Systems

People are an important part of manufacturing system.

- Not all equipment and processes are automated.
- Direct labour (blue collar) workers are generally responsible for operating the facilities.
- Professional staff (white collar) workers are generally responsible for the manufacturing support systems – design, delivery, material order, layout, etc.

Variables affecting Production

The quantity and variety of products are dominant factors to decide the type of production and degree of automation, etc.

Production quantity:

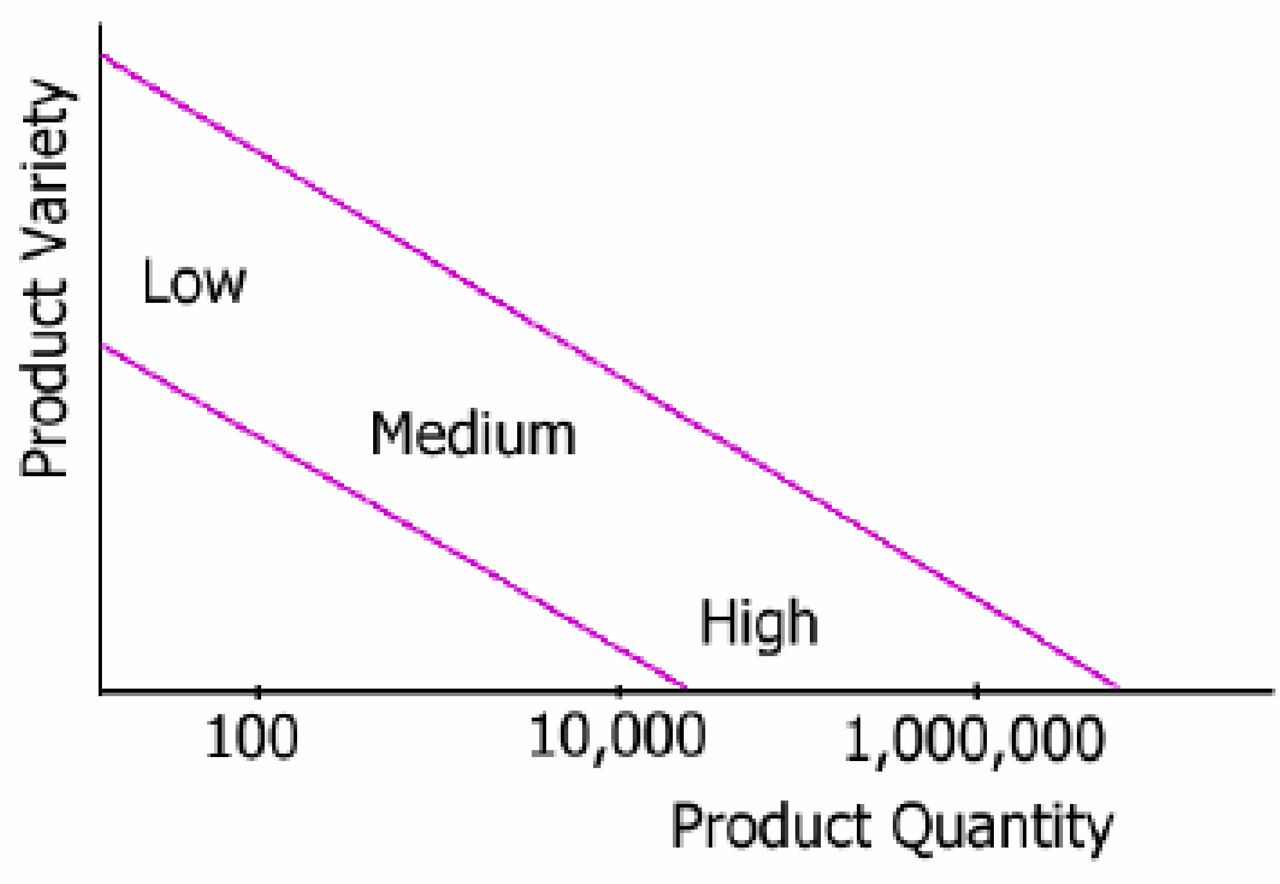
Low production: 1 to 100 units/year.

Medium quantity: 100-10,000units/year.

High production: 10,000 to millions of units/year.

Product variety refers to the different product designs or types that are produced in a factory.

Relationship



Type of Production

- Three type of production
  - ✓ Mass production
  - ✓ Batch production
  - ✓ Job shop production

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Mass production

- **Continuous flow production:** continuous dedicated production of large amount of bulk product – continuous chemical plant or oil refinery.
- **Mass production of discrete products:** dedicated production of large quantities of one product (with limited model variations) – automobiles.

✓ Very high production and demand rate.
✓ Dedicated and specialized machines and tools.
✓ Very high installation cost.
✓ Skill level of labour tends to be lower.

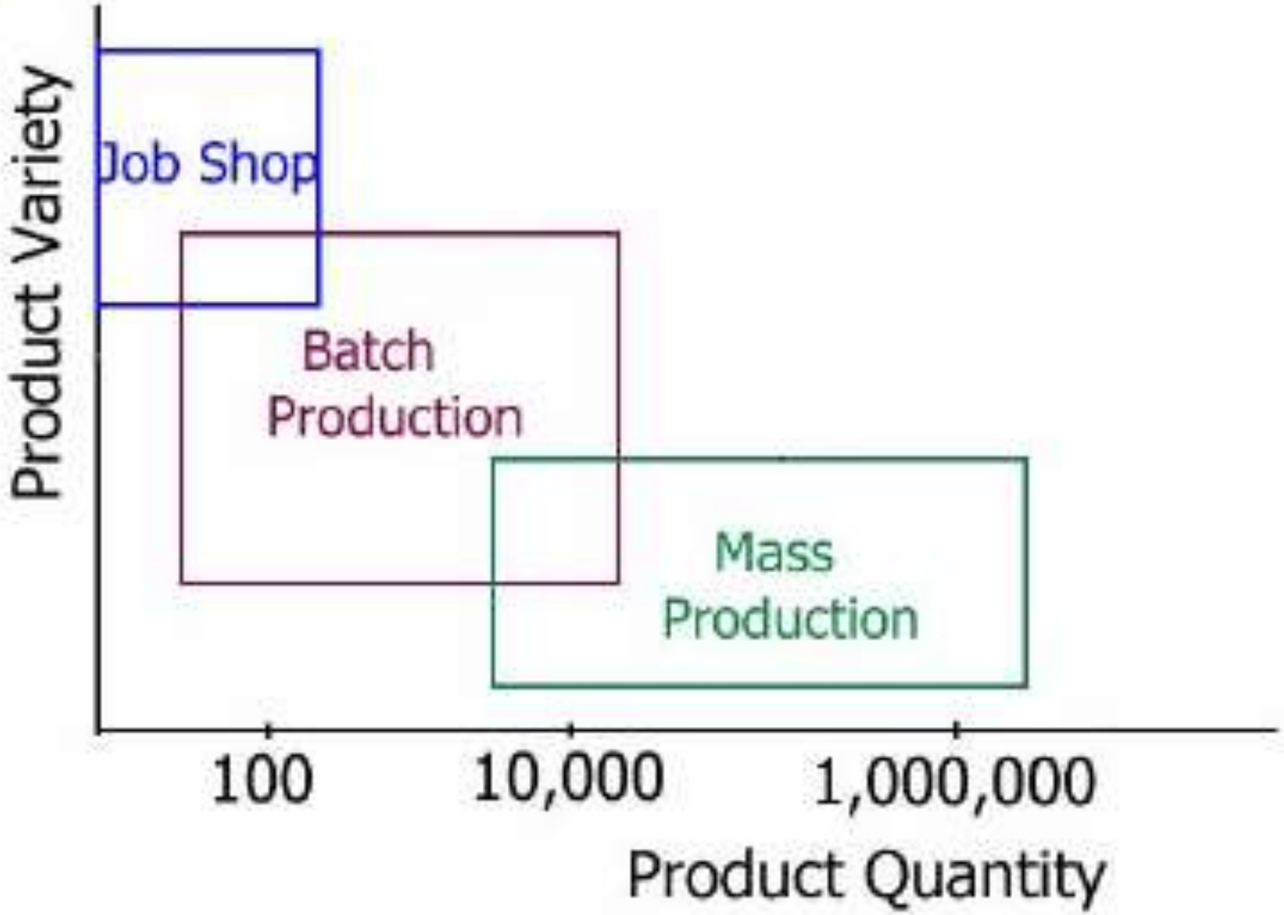
Batch Production

- production of medium sizes of same products or parts – books, clothing, furniture, some industrial machinery.
  - ✓ Produce with regular interval or only once.
  - ✓ Production rate is usually higher than the demand rate.
  - ✓ General purpose equipment but with high usage rate.
  - ✓ Specially designed jigs and fixtures.

Job Shop Production

- Production of low quantities of specialized product – prototypes, aircraft and machine tools.
  - ✓ Low production volume
  - ✓ Lot size is small
  - ✓ Customer order usually trigger the production – customized design and greater variety
  - ✓ Relatively high skilled labour required
  - ✓ Flexible and general purpose equipment used.

Type of Production

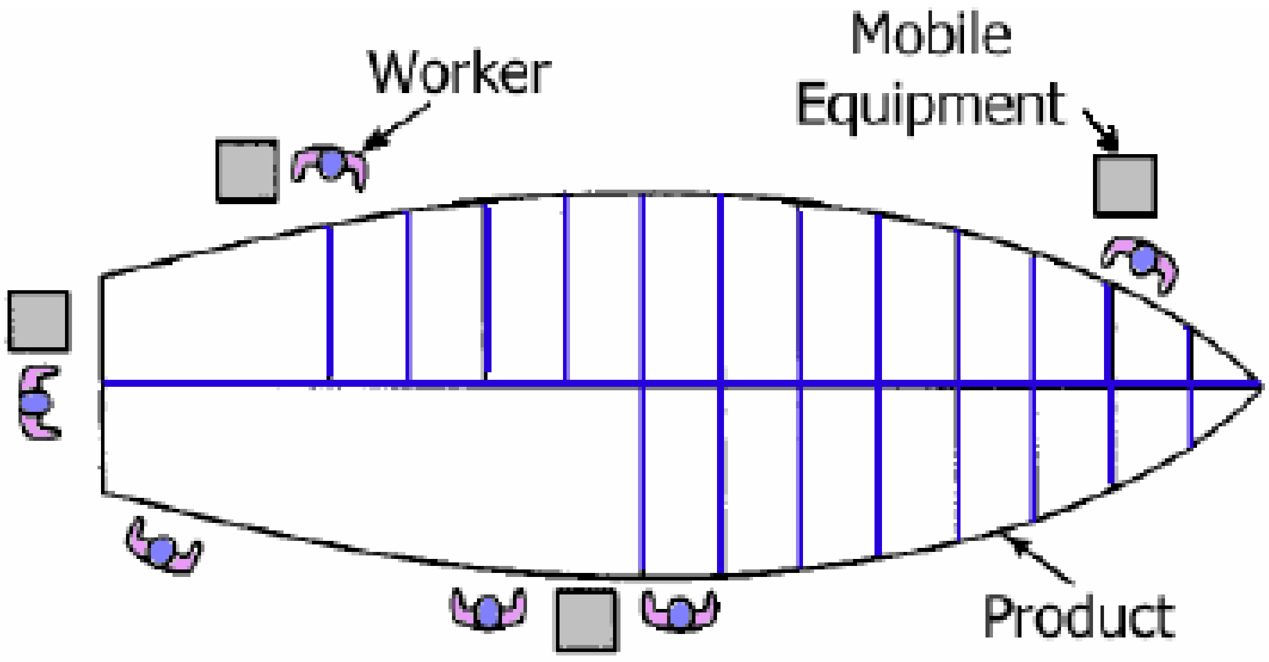


Plant layouts

The physical size, quantity, and variety of products being manufactured often determine the plant layouts.

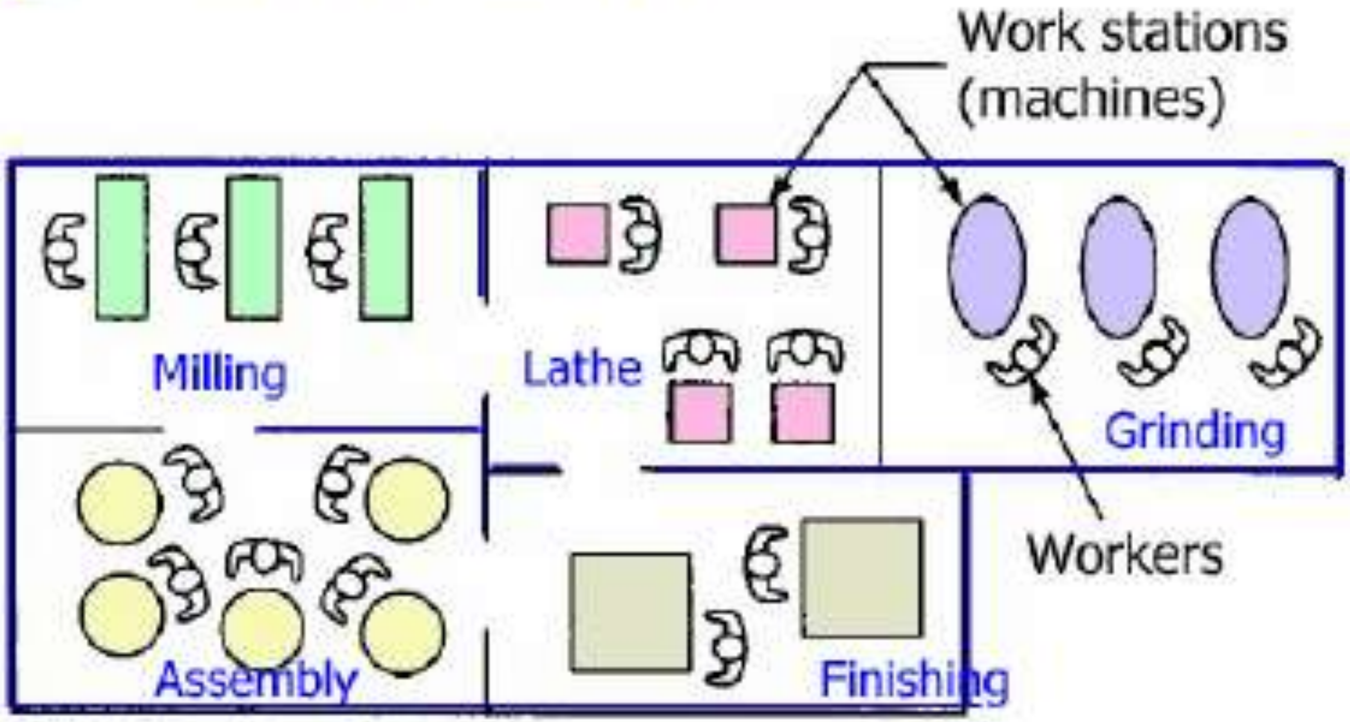
- Fixed-position Layout.
- Process Layout.
- Cellular Layout.
- Product Layout.

Fixed-position Layout



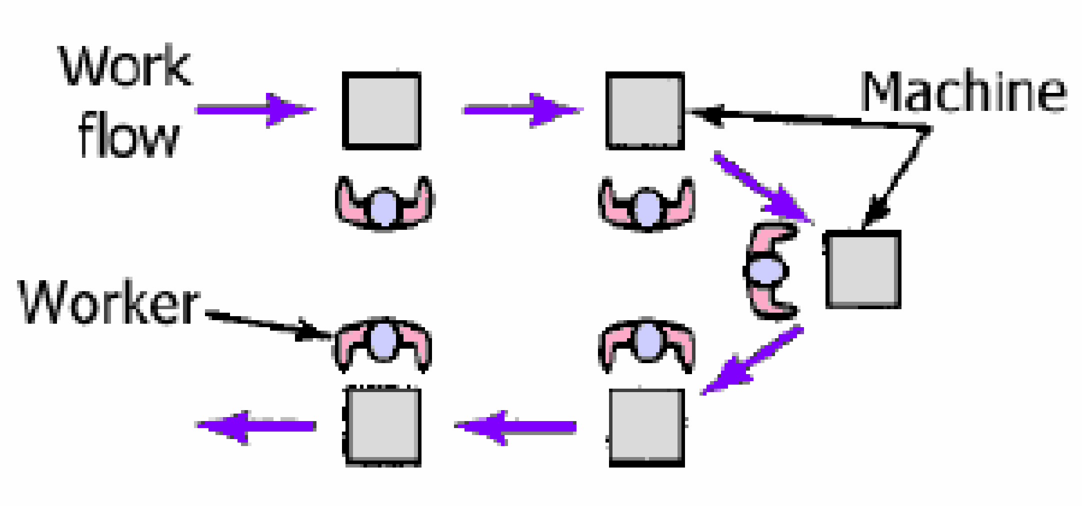
- Product remains in one location. Workers and equipment move around the product – ship or aircraft production.
- Usually associated with Job shop production type

Process Layout



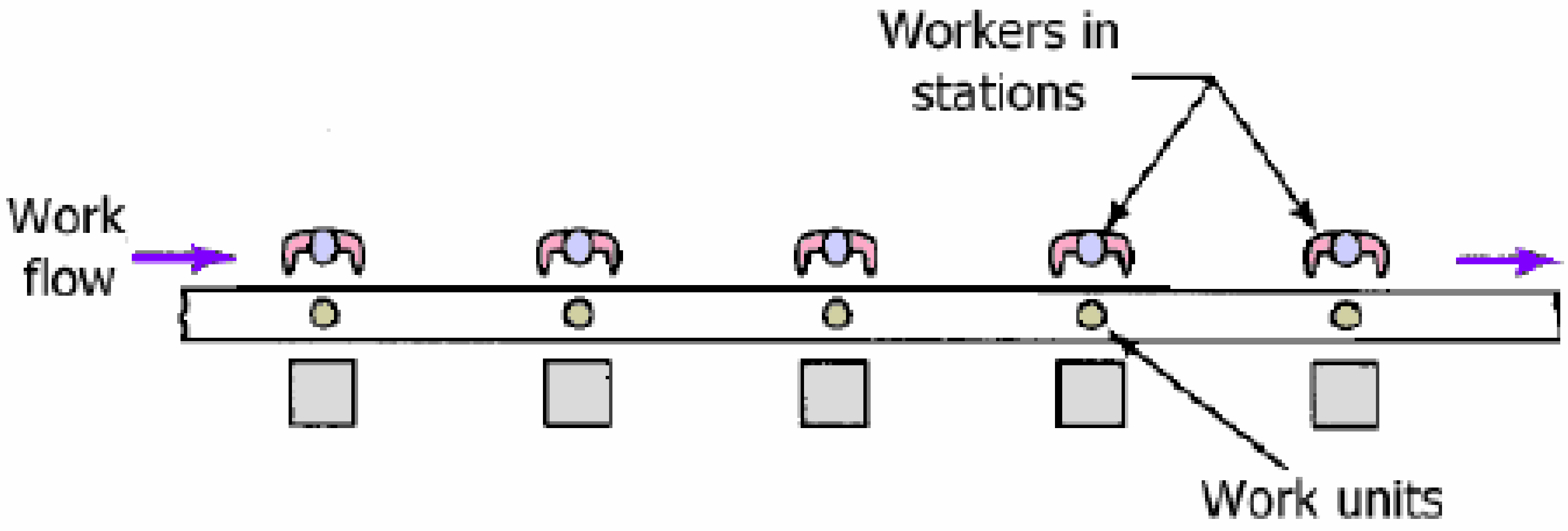
- Common operations or processes are grouped together.
- In production of one product or one class of products in large volumes

Cellular Layout



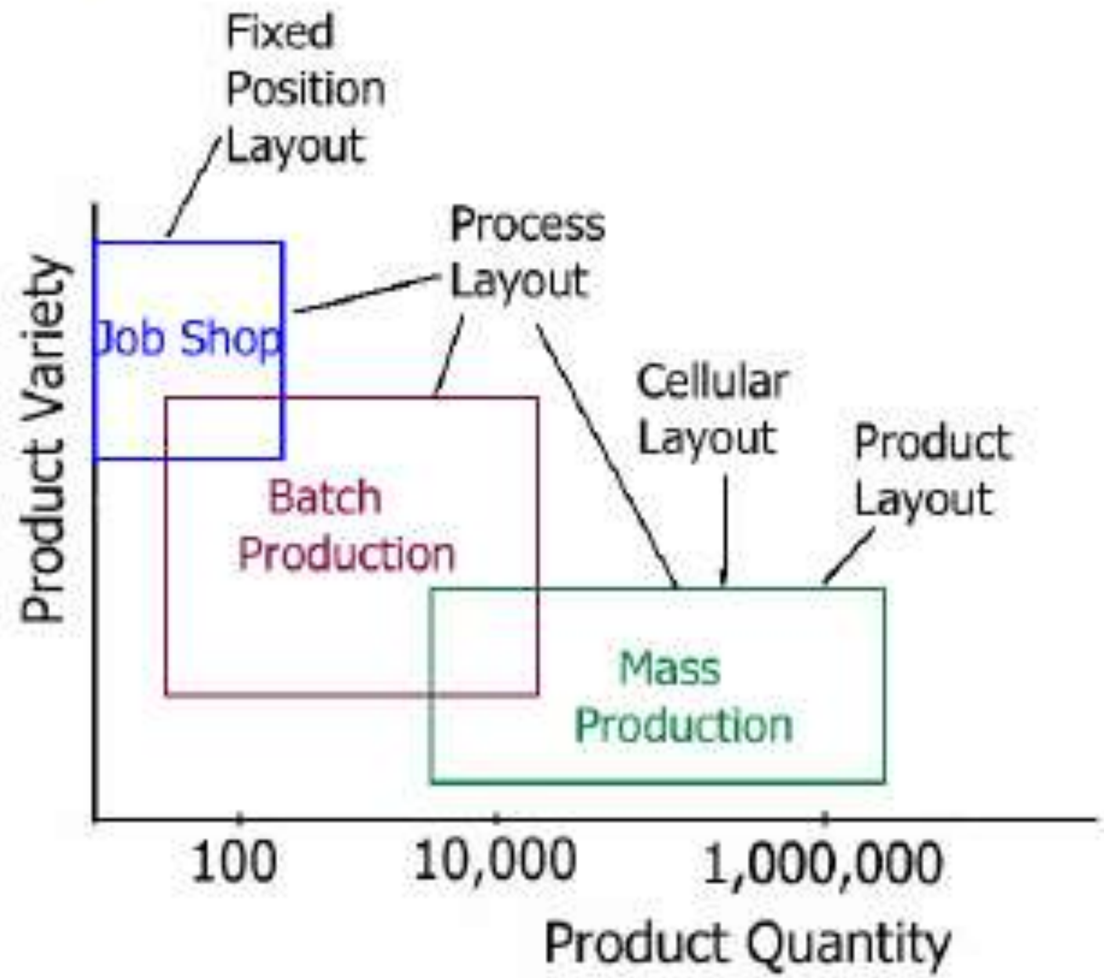
- Each manufacturing cell specialised in the production of a given set of similar products.
- Reduced work piece handling, lower setup times, less in progress inventory, shorter lead time.

Product Layout



- Collection of workers and stations are designed specifically for the production of certain product(s).
- Typical for job shops or batch productions

Composite view



INTRODUCTION TO AUTOMATION

- Automation is 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.
- Although automation can be applied in a wide variety of areas, it is most closely associated with the manufacturing industries.

HISTORY OF AUTOMATION

The history of automation can .be traced to the development of basic mechanical devices, such as

- The wheel (circa 3200 B.C.),
- Lever, winch (circa 600 B.C.),
- Cam (circa A,D. 1000),
- Screw(A.D. 1405),
- Windmills (circa A.D. 650),
- Steam engines (A.D.1765).
- Flour mills (circa 85 B.C.),
- Weaving machines (flying shuttle, 1733),
- Machine tools (boring mill, 1775),
- Steamboats (1787),
- Railroad locomotives (1803).
- Electrification (starting in 1881)

HISTORY OF AUTOMATION CONT…

- The moving assembly line (1913), Mechanized transfer lines for mass production, whose programs were fixed by their hardware configuration (1924),
- A mathematical theory of control systems (1938 and 1948); and
- The MARK I electromechanical computer at Harvard University (1944).
- The first electronic digital computer was developed at University of Pennsylvania in 1946.
- The first numerical control machine tool was developed and demonstrated in 1952 at Massachusetts Institute of Technology based on a concept proposed by John Pamons and Frank Stulen
- By the late 1968 and early 1970s, digital computers were being connected to machine tools.
- In 1954, the first industrial robot was designed and patented (issued 1961) by George Devol
- The first commercial robot was installed to unload parts in a die casting operation in 1961.

HISTORY OF AUTOMATION CONT…

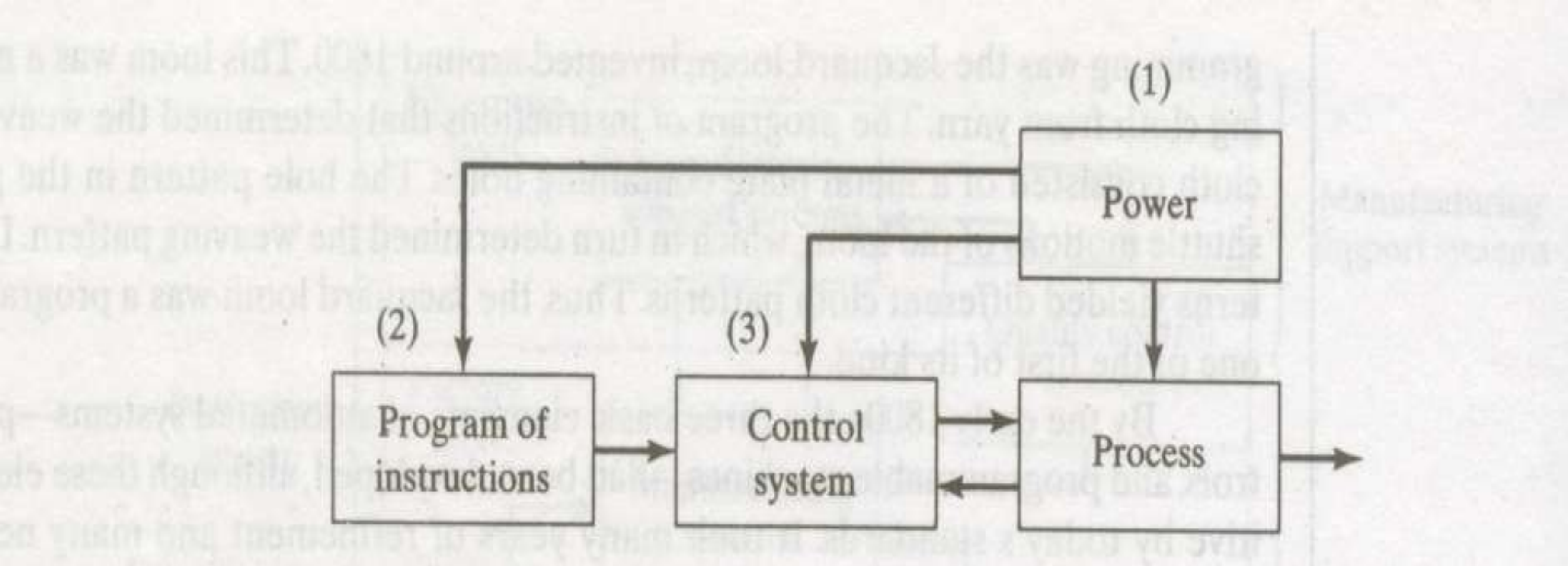
- In the late 1968, the first flexible manufacturing system in the United States was installed at Ingersoll Rand Company to perform machining operations on a variety of parts .
- Around 1969, the first programmable logic controller was introduced.
- In 1978, the first commercial personal computer (PC) had been introduced by Apple Computer, although a similar product had been introduced in kit form as early as 1975.
- Developments in computer technology were made possible by advances in electronics, including the transistor (1948),
- hard disk for computer memory (1956),
- Integrated circuits (1960),
- The microprocessor (1971)

HISTORY OF AUTOMATION CONT…

- Random accesss memory (1984),
- Megabyte capacity memory chips (circa 1990),
- The Pentium microprocessors (1993).
- Software developments related to automation have been equally important, including the FO RTRAN computer programming language (1955),
- The APT programming language for numerical control (NC) machine tools (1961),
- The UNIX operating system (1969),
- The VAL language for robot programming (1979),
- Microsoft Windows (1985),and the JAVA programming language (1995).
- Advances and enhancements in these technologies continue

BASIC ELEMENTS OF AN AUTOMATED SYSTEM

(1)Power,
(2)Program of instructions, and
(3)Control systems.



1. POWER TO ACCOMPLISH THE AUTOMATED PROCESS

Process	Power Form	Action Accomplished
Casting	Thermal	Melting the metal before pouring into a mold cavity where solidification occurs.
Electric discharge machining (EDM)	Electrical	Metal removal is accomplished by a series of discrete electrical discharges between electrode (tool) and workpiece. The electric discharges cause very high localized temperatures that melt the metal.
Forging	Mechanical	Metal workpart is deformed by opposing dies. Workparts are often heated in advance of deformation, thus thermal power is also required.
Heat treating	Thermal	Metallic work unit is heated to temperature below melting point to effect microstructural changes.
Injection molding	Thermal and mechanical	Heat is used to raise temperature of polymer to highly plastic consistency, and mechanical force is used to inject the polymer melt into a mold cavity.
Laser beam cutting	Light and thermal	A highly coherent light beam is used to cut material by vaporization and melting.
Machining	Mechanical	Cutting of metal is accomplished by relative motion between tool and workpiece.
Sheet metal punching and blanking	Mechanical	Mechanical power is used to shear metal sheets and plates.
Welding	Thermal (maybe mechanical)	Most welding processes use heat to cause fusion and coalescence of two (or more) metal parts at their contacting surfaces. Some welding processes also apply mechanical pressure to the surfaces.

Common manufacturing process and their power requirements

2. PROGRAM OF INSTRUCTIONS

- The actions performed by an automated process are defined a program of instructions.
- Whether the manufacturing operation involves low, medium, or high production each part or product style made in the operation requires one or more processing steps that are unique to that style.
- These processing steps are performed during a work cycle.
- A new part is completed during each work cycle.
- The particular processing steps for the work cycle are specified in a work cycle program

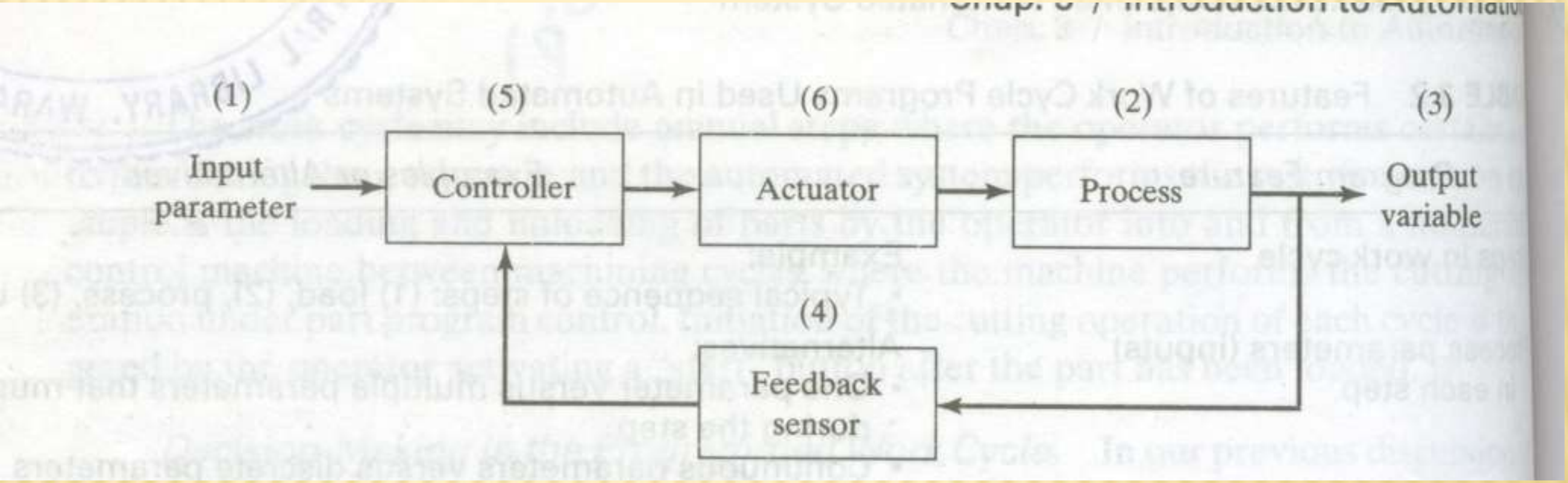
FEATURES OF WORK CYCLE PROGRAMS USED IN AUTOMATED SYSTEMS

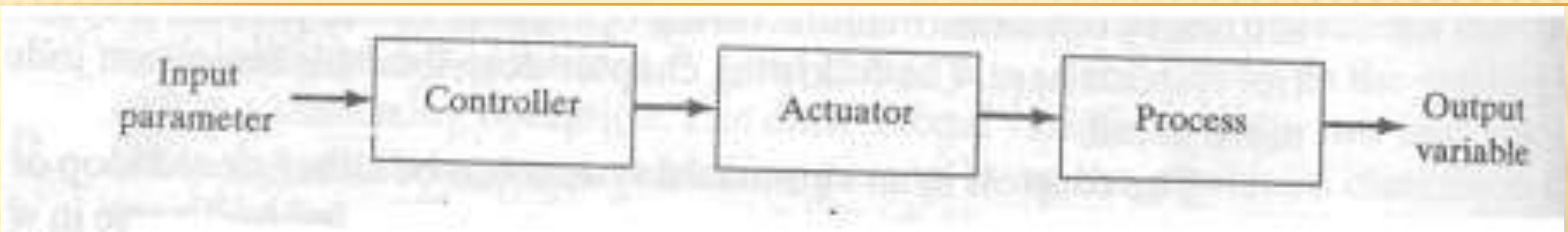
Program Feature	Examples or Alternatives
Steps in work cycle	Example: • Typical sequence of steps: (1) load, (2), process, (3) unload
Process parameters (inputs) in each step	Alternatives: • One parameter versus multiple parameters that must be changed during the step • Continuous parameters versus discrete parameters • Parameters that change during the step; for example, a positioning system whose axes values change during the processing step
Manual steps in work cycle	Alternatives: • Manual steps versus no manual steps (completely automated work cycle) Example: • Operator loading and unloading parts to and from machine
Operator interaction	Alternatives: • Operator interaction versus completely automated work cycle Example: • Operator entering processing information for current workpart
Different part or product styles	Alternatives: • Identical part or product style each cycle (mass or batch production) versus different part or product styles each cycle (flexible automation)
Variations in starting work units	Example: • Variations in starting dimensions or part features

3. CONTROL SYSTEM

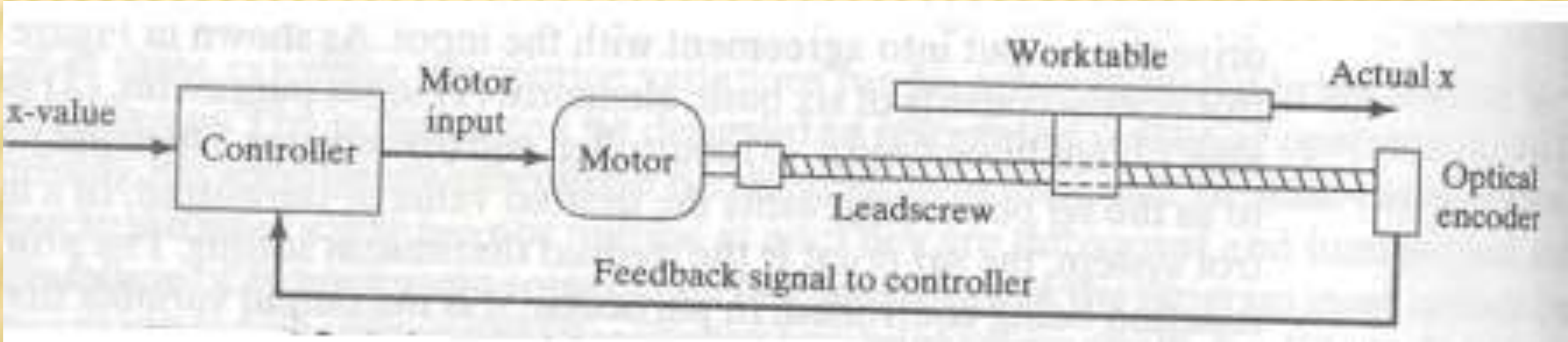
- The control element of the automated system executes the program of instructions.
- The control system causes the process to accomplish its defined function, which for our purpose is to carry out some manufacturing operation.
- Let us provide a brief introduction to control systems here.
- The controls in an automated system can be either closed loop or open loop

A FEEDBACK CONTROL SYSTEM
OR CLOSED LOOP CONTROL SYSTEM





Open loop control system



A positioning system consist of a lead screw driven by a DC Motor

Types of Automation

- Fixed Automation
- Programmable Automation
- Flexible Automation

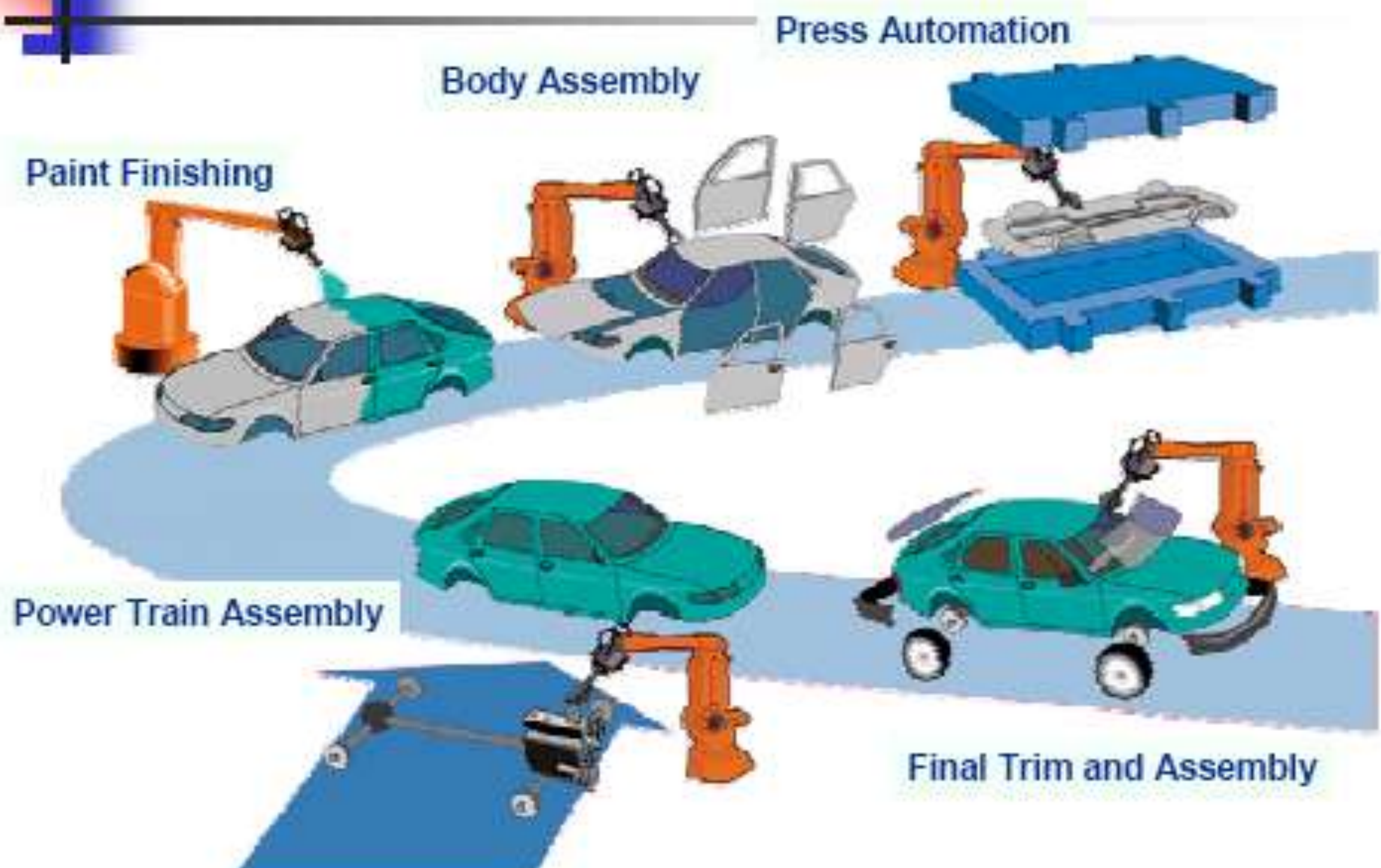
Fixed Automation

- A system in which the sequence of the (usually simple) processing or assembly operation is fixed by the equipment configuration. The integration and coordination among the operation make the system very complex.
- Consists of workstations connected by conveyers or machine transfer lines.

Fixed Automation

- High initial investment for customised equipment (Jig, Die, etc.)
- High production rate.
- Relatively flexible in accommodating product changes only.
- Only product with high demands and volumes – automobile.

Fixed Automation



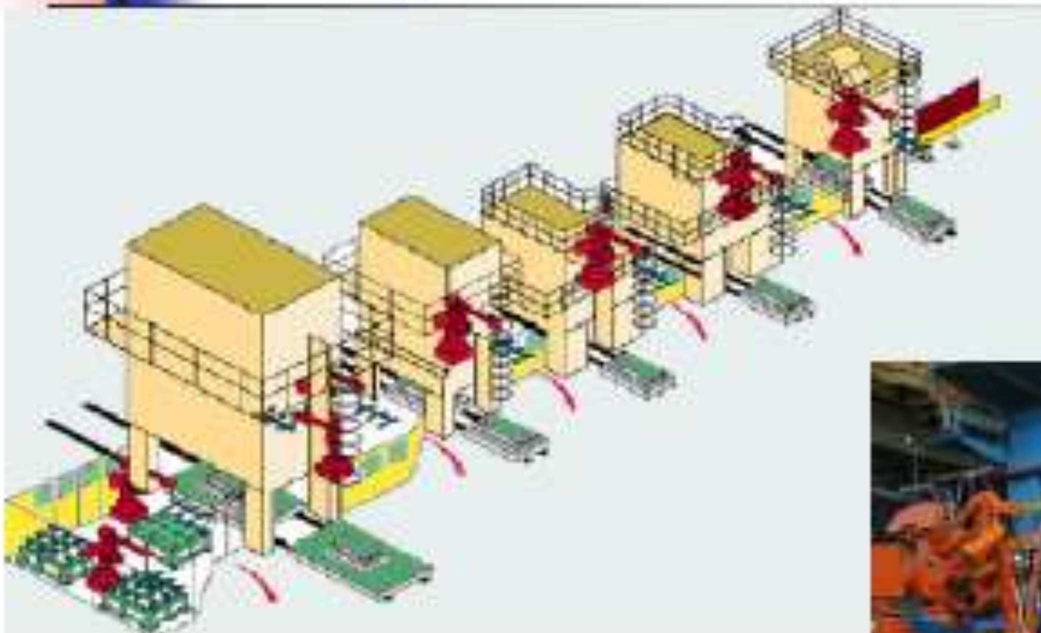
Programmable Automation

- The production equipment is designed with the capability to change the sequence of operations to accommodate different product configuration.
- Operation sequence controlled by program. Usually new program required for new product.
- Consists of NC machining centres, industrial robots etc

Programmable Automation

- High investment in general-purpose equipment.
- Low production rates relative to fixed automation-Usually low and medium-volume production.
- Flexibility to deal with changes in product configuration.
- Most suitable for batch production-change over time required.

Programmable Automation



Flexible Automation

- Capable of producing a variety of products (or parts) with virtually no time lost for changeovers.
- Can produce various combinations and schedules of products (instead of batch production).
- No down time for changeovers or program changes – physical setup needs to be placed simultaneously.

Flexible Automation

- High investment for customised equipment.
- Continuous production of variable mixtures of products.
- Medium production rate.
- Flexibility to deal with product design variations.

ADVANCED AUTOMATION FUNCTIONS

Advanced automation functions include the following:

(1) safety monitoring,

(2) Maintenance and repair diagnostics and

(3) error detection and recovery.

1. SAFETY MONITORING

The following list suggests some of the possible sensors and their applications for safety monitoring:

- Limit switches to detect proper positioning of a part in a work holding device
- Photoelectric sensors triggered by the interruption of a light beam
- Temperature sensors to indicate that a metal workpart is hot enough to proceed with a hot forging operation.
- Heat or smoke detectors to sense fire hazards.
- Pressure-sensitive floor pads to detect human intruders into the work cell.
- Machine vision systems to supervise the automated system and its surroundings

2. MAINTENANCE AND REPAIR DIAGNOSTICS

1. **Status monitoring:** In the status monitoring mode, the diagnostic subsystem monitors and records the status of key sensors and parameters of the system during normal operation

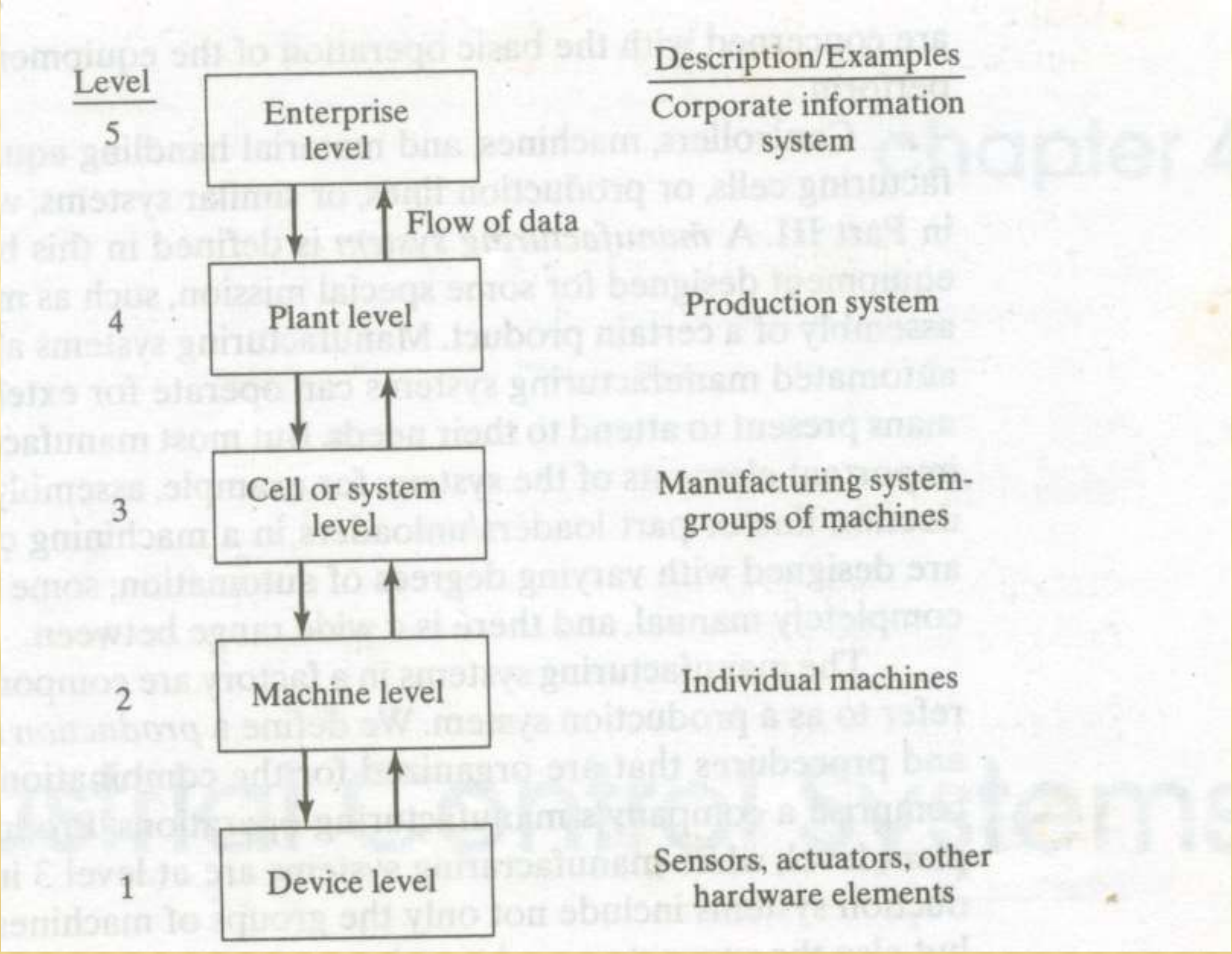
2. **Failure diagnostics:** The failure diagnostics mode is invoked when a malfunction or failure occurs.

3. **Recommendation of repair procedure:** In the third mode of operation, the subsystem provides a recommended procedure to the repair crew as to the steps that should be taken to effect repairs.

ERROR DETECTION AND RECOVERY

- In the operation of any automated system, there are hardware malfunctions and unexpected events that occur during operation. These events can result in costly delays and loss of production until the problem has been corrected and regular operation is restored.
- Traditionally, equipment malfunctions are corrected by human workers, perhaps with the aid of a maintenance and repair diagnostics subroutine.
- With the increased use of computer control for manufacturing processes, there is a trend toward using the control computer not only to diagnose the malfunctions but also to automatically take the necessary corrective action to restore the system to normal operation.
- The term error detection and recovery is used when the computer performs these functions

LEVELS OF AUTOMATION

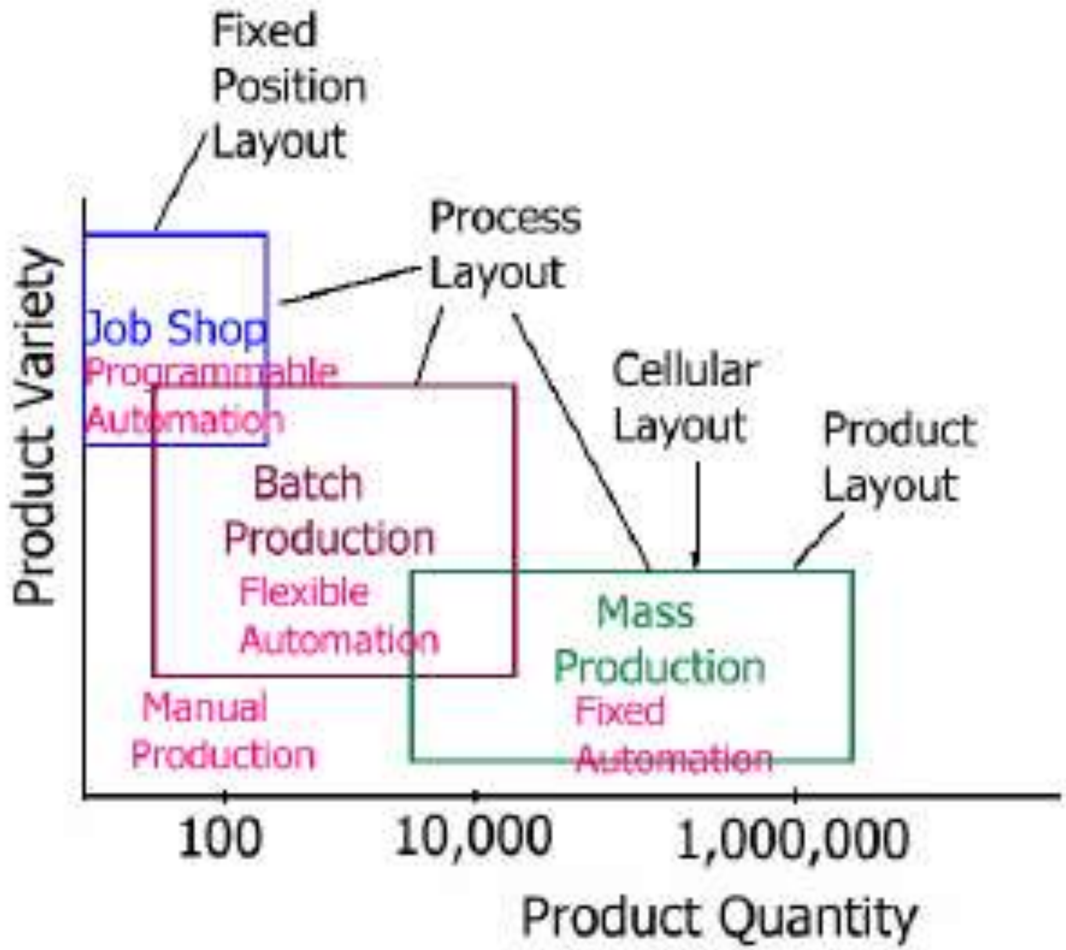


1. **Device level:** This is the lowest level in our automation hierarchy. It includes the actuators, sensors, and other hardware components that comprise the machine level. The devices are combined into the individual control loops of the machine; for example, the feedback control loop for one axis of a CNC machine or one joint of an industrial robot
2. **Machine level:** Hardware at the device level is assembled into individual machines. Examples include CNC machine tools and similar production equipment, industrial robots, powered conveyors, and automated guided vehicles. Control functions at this level include performing the sequence of steps in the program of instructions in the correct order and making sure that each step is properly executed.

3. Cell or system level: This is the manufacturing cell or system level, which operates under instructions from the plant level. A manufacturing cell or system is a group of machines or workstations connected and supported by a material handling system, computer, and other equipment appropriate to the manufacturing process. Production lines are included in this level. Functions include part dispatching and machine loading, coordination among machines and material handling system, and collecting and evaluating inspection data.
4. Plant level: This is the factory or production systems level. It receives instructions from the corporate information system and translates them into operational plans for production. Likely functions include: order processing, process planning, inventory control, purchasing, material requirements planning, shop floor control, and quality control.

5. Enterprise level: This is the highest level, consisting of the corporate information system. It is concerned with all of the functions necessary to manage the company: marketing and sales, accounting, design, research, aggregate planning, and master production scheduling.

Automation Application



Production Types and Automation

- Continuous flow production – fixed automation.
  - Flow process control from start to end,
  - Sensors to measure process variables,
  - Control and optimisations.

Production Types and Automation

- Mass production of discrete products – fixed automation with programmable or flexible automation
  - Automated transfer machines,
  - Automated assembly lines,
  - Industrial robots,
  - Automated material handling systems.

Reasons for Automating

- Increase labour productivity,
- Reduce cost of labour,
- Mitigate labour shortage,
- Reduce or eliminate routine manual and clerical tasks - trend of labour toward service sector – people prefer white colour work to blue colour work (tedious, dirt jobs),

Reasons for Automating

- Improve safety – better relation with workers,
- High cost of raw materials – requires greater efficiency in materials,
- Improved product quality,
- Reduced manufacturing lead time.

Reasons for Not Automating

- Task is too technologically difficult to automate,
- Short product life cycle,
- Customised product – one-of-a-kind,
- Flexibility in coping with changing demand – adaptability.

Automation strategies

1. Specialisation of operations: use of special purpose equipment designed to perform one operation with great efficiency.
2. Combined operations: reduction of the number of distinct production machines or workstations probably accomplished by more than one work to be given to one machine – save set-up time, material handling effort. production occurs as a sequence of operations.

Automation strategies

3. Simultaneous operations: two or more operations performed simultaneously on the same work station.
4. Integration of operations: link several workstations into a single integrated mechanism using automated work handling devices to transfer parts between stations.
5. Increased flexibility: use the same equipment for a variety of products using flexible automation-reduce setup time and programming time.

MRCET

Automation strategies

6. Improved material handling and storage: use of automated system to handling and transferring of the materials.

7. On-line inspection: early warning and correction system, higher quality.

8. Process control and optimisation: more efficient process and equipment use.

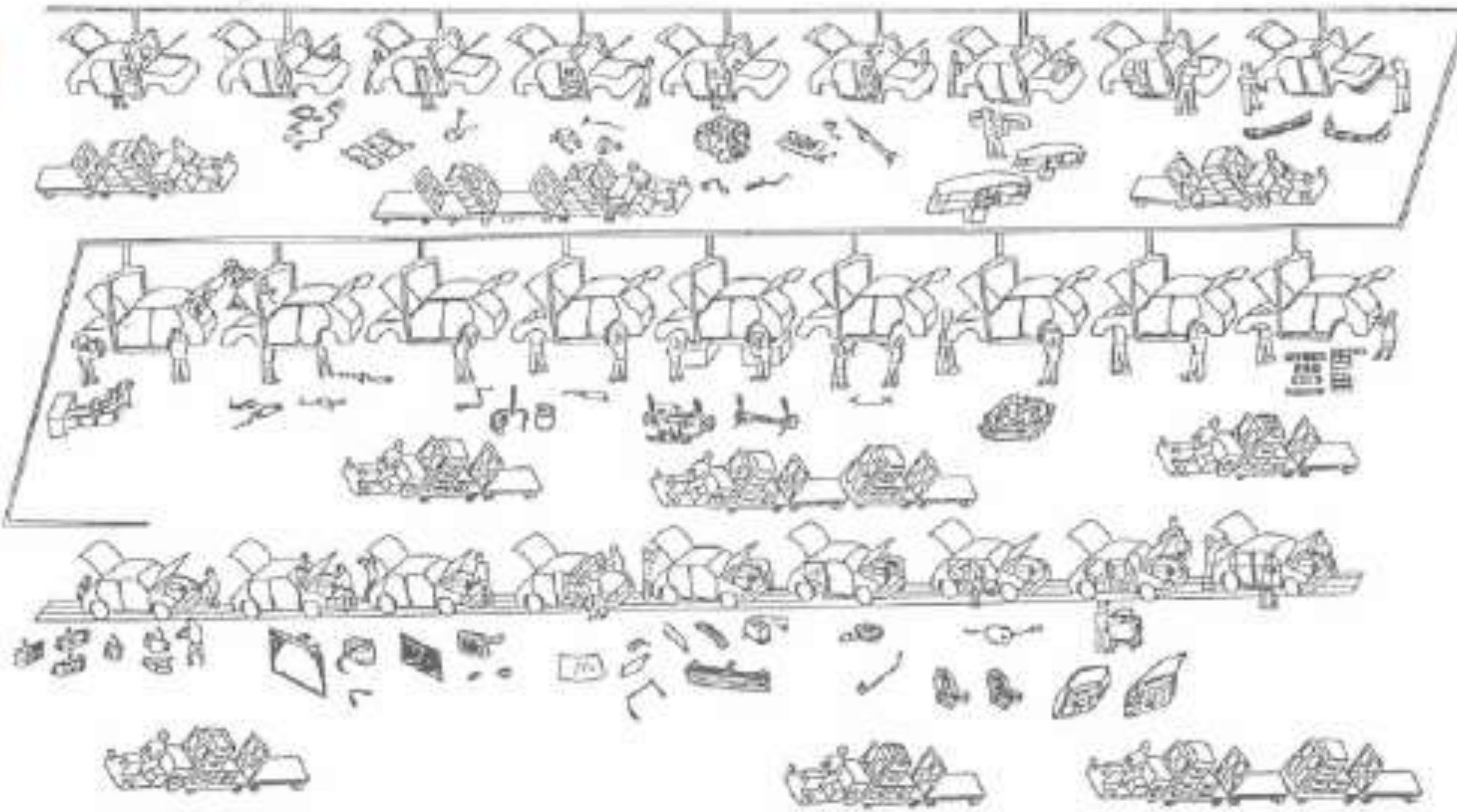
MRCET

Automation strategies

9. Plant operations control: This concerns the control of the whole plant operations. Management and coordination of different departments in the plant.

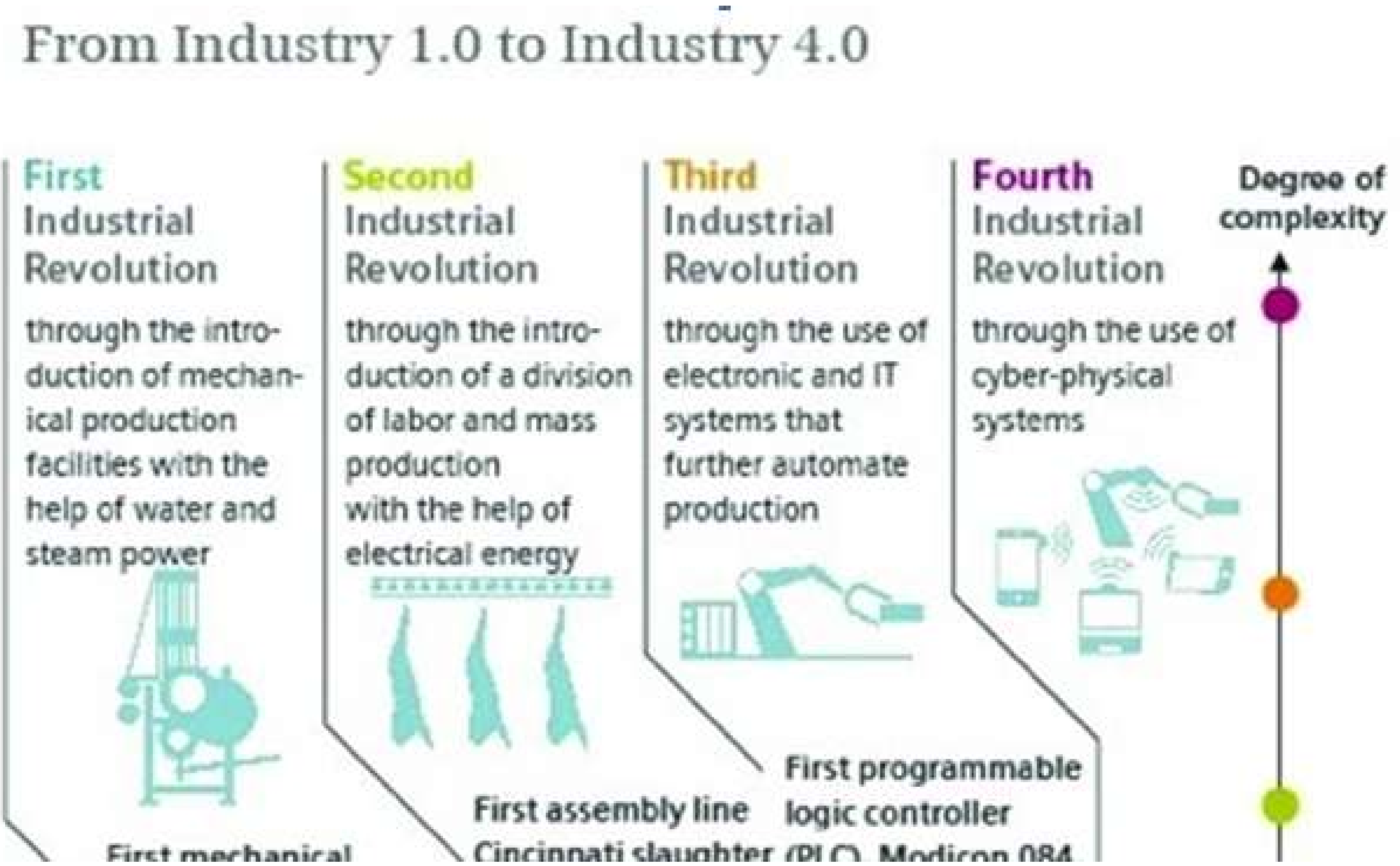
10. Computer integrated manufacturing: extensive use of computers to the whole company.

Multi-stage manufacturing

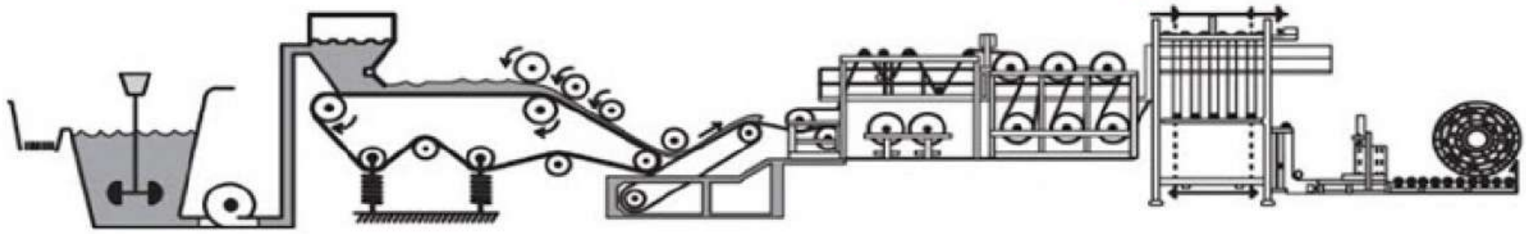


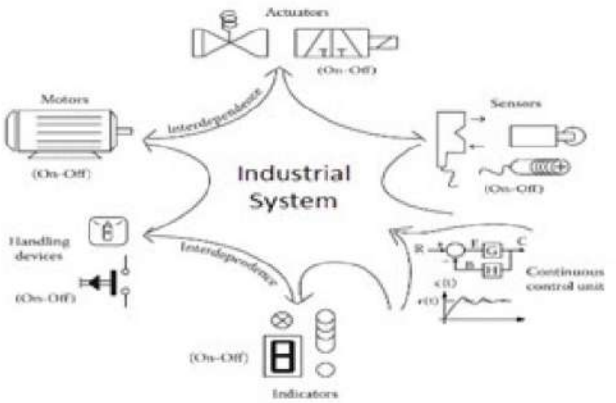
Complexity in material handling, processes → manual operations

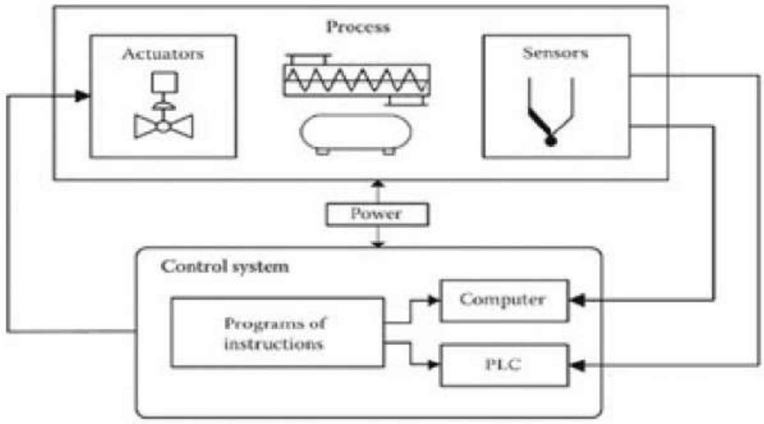
UNIT I
INDUTRIAL APPLICATIONS

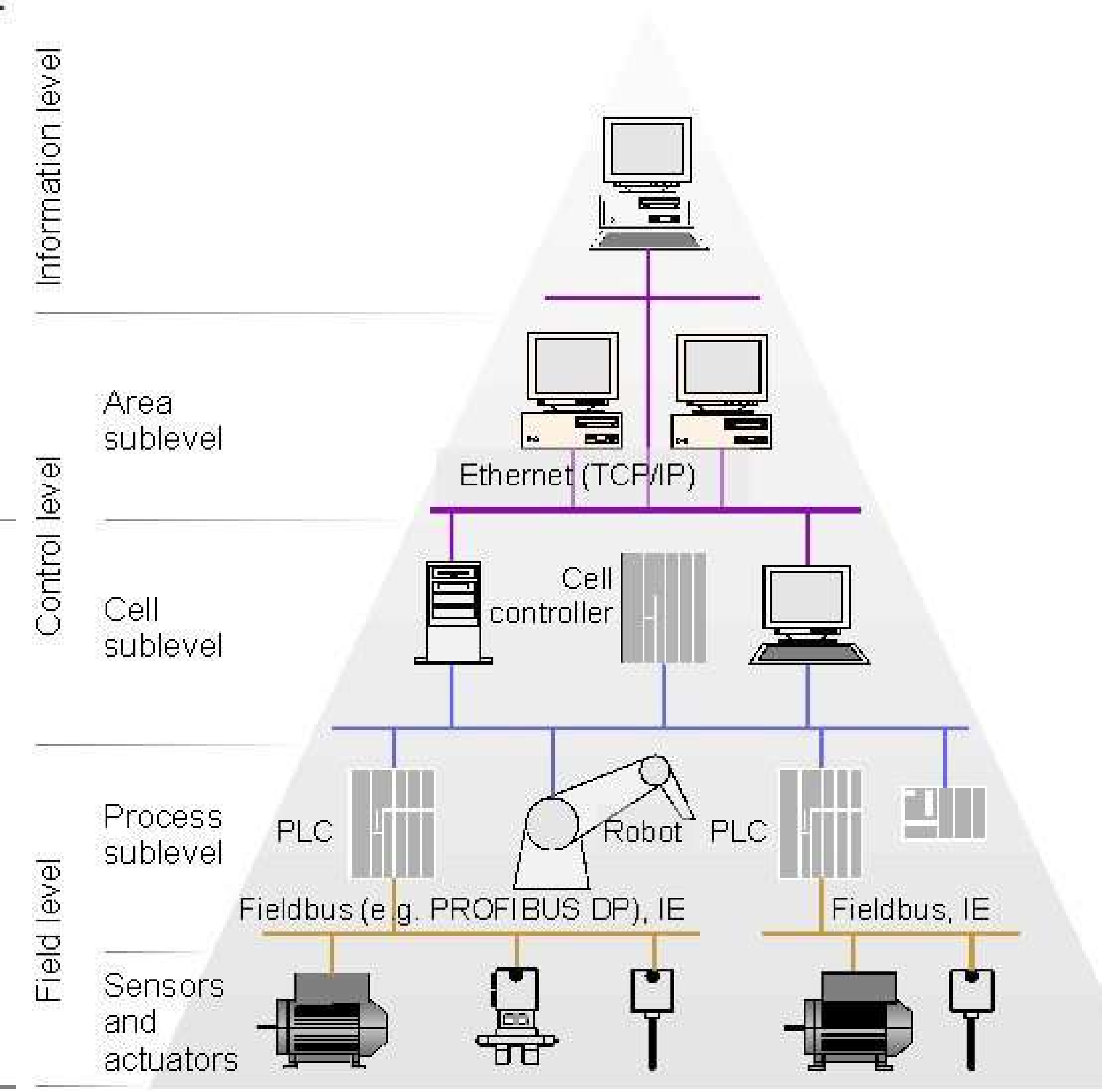

From Industry 1.0 to Industry 4.0
First Industrial Revolution
through the introduction of mechanical production facilities with the help of water and steam power
Second Industrial Revolution
through the introduction of a division of labor and mass production with the help of electrical energy
Third Industrial Revolution
through the use of electronic and IT systems that further automate production
Fourth Industrial Revolution
through the use of cyber-physical systems
Degree of complexity
First mechanical
First assembly line
Cincinnati slaughter
First programmable logic controller
(PLC), Modicon 084

INDUSTRIAL AUTOMATION

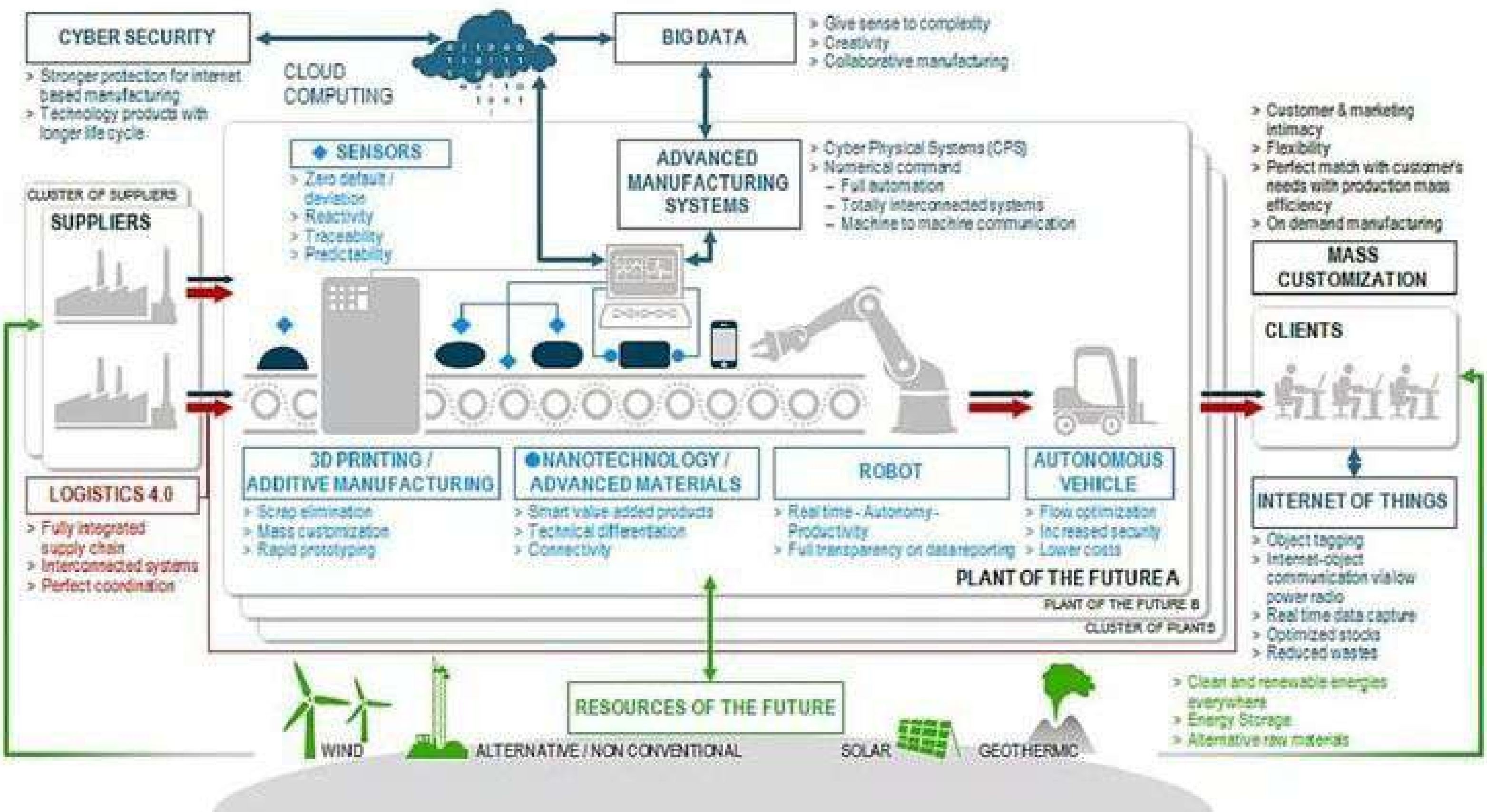







Information level
Control level
Field level
Area sublevel
Cell sublevel
Process sublevel
Sensors and actuators
Ethernet (TCP/IP)
Cell controller
PLC
Robot
PLC
Fieldbus (e.g. PROFIBUS DP), IE
Fieldbus, IE

The Industry 4.0 Ecosystem



UNIT I

ASSIGNMET

Unit-I

1.

a). Differentiate fixed and programmable automation.

b). What are the principles of automation?

2.

a). What are the objectives of flow line automation?

b). What are the design and fabrication considerations in an automated flow lines.

3.

a). Define Automation. Discuss various levels of automation.

b). Differentiate between fixed and flexible automation.

4.

Explain the following linear transfer mechanisms:

(a) Walking beam system.

(b) Powered roller conveyor system.

5. Explain any two mechanical feeding device with neat sketch.

6. Explain ten Strategies of Automation ?

UNIT I

SHORT 'Q' & TUTORIAL

UNIT-I

1. What are the types of Automation?

Automated production systems can be classified into three basic types:

1. Fixed automation,
2. Programmable automation, and
3. Flexible automation.

2. Write short notes on Fixed Automation.

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

The typical features of fixed automation are:

a. High initial investment for custom–Engineered equipment;
b. High production rates; and
c. Relatively inflexible in accommodating product changes.

3. Write short notes on Programmable automation.

In this the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations.

a. Low production rates relative to fixed automation;
b. Flexibility to deal with changes in product configuration

4. Write short notes on Flexible Automation.

A flexible automated system is one that is capable of producing a variety of products (or parts) with virtually no time lost for changeovers from one product to the next.

1. High investment for a custom-engineered system.
2. Continuous production of variable mixtures of products.
3. Medium production rates.
4. Flexibility to deal with product design variations.

5. Differentiate between flexible automation and programmable automation.

The essential features that distinguish flexible automation from programmable automation are:

1. The capacity to change part programs with no lost production time; and
2. The capability to changeover the physical setup, again with no lost production time.

6. What is USA principle in Automation?

USA stands for:

1. Understand the existing process

2. Simplify the process

3. Automate the process.

It may turn out that automation of the process is unnecessary or cannot be cost justified after it has been simplified.

7. **Write any five strategies of automation.**
    1. Specialization of operations
    2. Combined operations
    3. Simultaneous operations
    4. Integration of operations
    5. Increased flexibility

8. **What is hydraulic actuator?**

The hydraulic actuator is a device used to convert the fluid power into mechanical power to do useful work. The actuator may be of the linear type (e.g., hydraulic cylinder) or rotary type (e.g., hydraulic motor) to provide linear or rotary motion, respectively.

9. **What are the functions of pneumatic system?**

1. The pneumatic actuator converts the fluid power into mechanical power to perform useful work.

2. The compressor is used to compress the fresh air drawn from the atmosphere.

3. The storage reservoir is used to store a given volume of compressed air.

4. The valves are used to control the direction, flow rate and pressure of compressed air.

10. **What are Mechanical feeders?**

1. Belt feeders

2. **Apron feeders**

3. **Vibratory feeders**

4. Screw feeders

UNIT II
AUTOMATED FLOW LINES

Objective:

- To understand the different automated flow lines in the Industries.

Outcome:

- Students will get exposure to workstation, which refers to the location in the factory where some well-defined task or operation is accomplished by an automated machine.

Automated flow lines: Methods or work part transport transfer Mechanical buffer storage control function, design and fabrication consideration.
Analysis of Automated flow lines: General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

UNIT-II

AUTOMATED FLOW LINES

An automated flow line consists of several machines or workstations which are linked together by work handling devices that transfer parts between the stations. The transfer of workparts occurs automatically and the workstations carry out their specialized functions automatically. The flow line can be symbolized as shown in Figure1 using the symbols presented in Table1. A raw workpart enters one end of the line and the processing steps are performed sequentially as the part moves from one station to the next. It is possible to incorporate buffer storage zones into the flow line, either al a single location or between every workstation. It is also possible to include inspection stations in the line to automatically perform intermediate checks on the quality of the workparts. Manual stations might also be located along the flow line to perform certain operations which are difficult or uneconomical to automate.

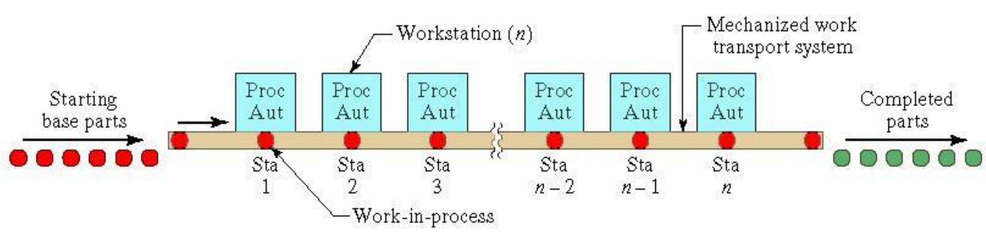


Figure 1 In-line configuration

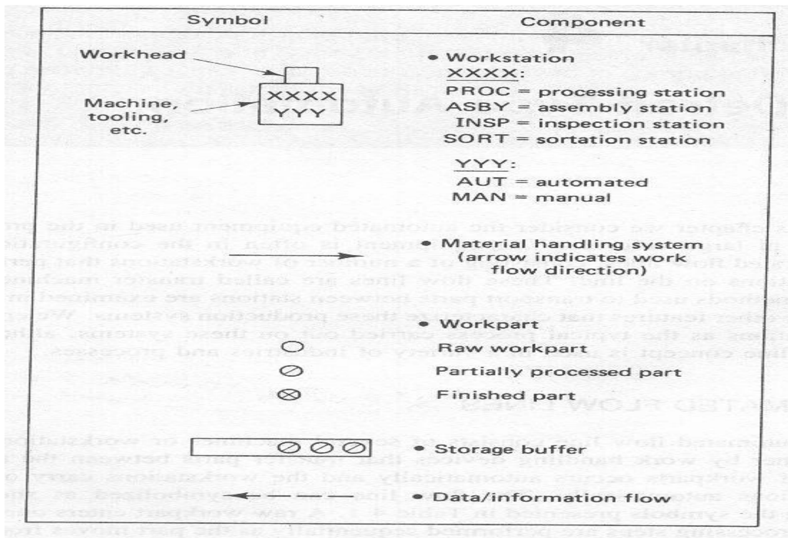


Figure 2 symbols used in production systems diagrams

The objectives of the use of flow line automation are, therefore:

1. To reduce labor costs
2. To increase production rates
3. To reduce work-in-process
4. To minimize distances moved between operations
5. To achieve specialization of operations
6. To achieve integration of operations

Configurations of automated flow line.

1) In-line type

The *in-line* configuration consists of a sequence of workstations in a more-or-less straight-line arrangement as shown in figure 1. An example of an in-line transfer machine used for metal-cutting operations is illustrated in Figure 4 and 5.

Figure 4 Example of 20 stations In-line

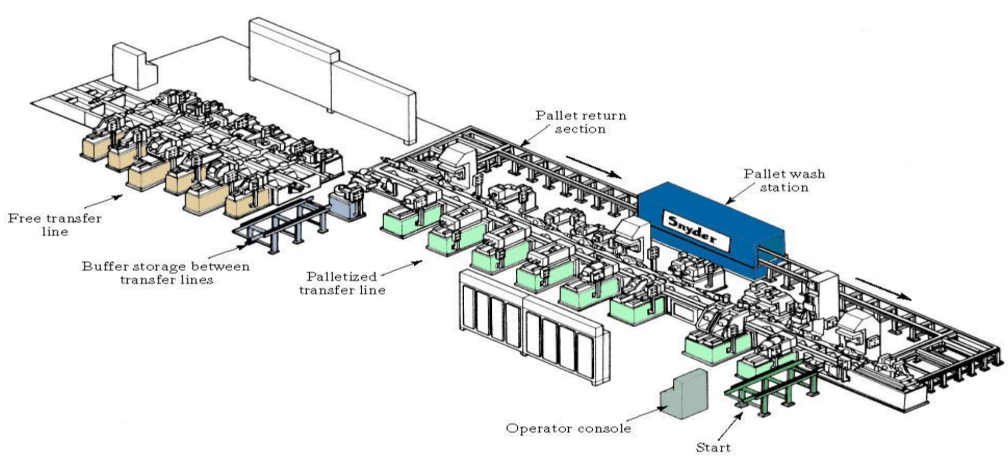


Figure 5 Example of 20 stations In-line configuration

2) Segmented In-Line Type

The segmented *in-line* configuration consists of two or more straight-line arrangement which are usually perpendicular to each other with L-Shaped or U-shaped or Rectangular shaped as shown in figure 5-7. The flow of work can take a few 90° turns, either for workpieces reorientation, factory layout limitations, or other reasons, and still qualify as a straight-line configuration.

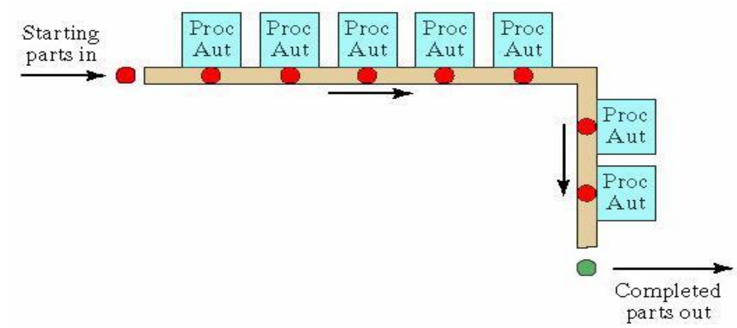


Figure 5 L-shaped configuration

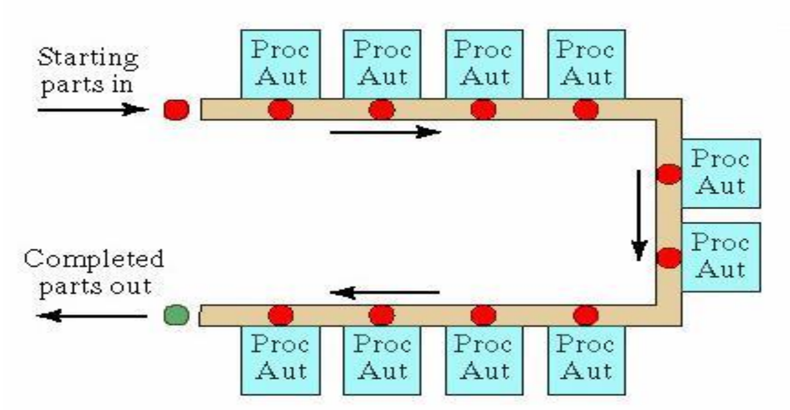


Figure 6 U-shaped configuration

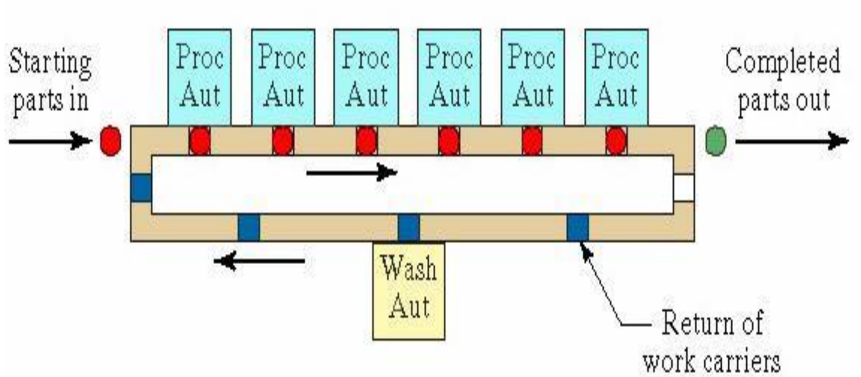


Figure 7 Rectangular-shaped configuration

3) *Rotary type*

In the *rotary* configuration, the workparts are indexed around a circular table or dial. The workstations are stationary and usually located around the outside periphery of the dial. The parts ride on the rotating table and arc registered or positioned, in turn, at each station for its processing or assembly operation. This type of equipment is often referred to as an *indexing machine* or *dial index machine* and the configuration is shown in Figure 8 and example of six station rotary shown in figure 9.

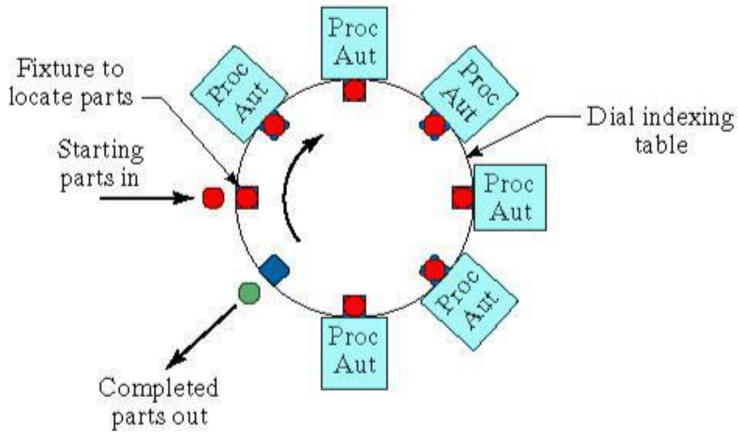


Figure 8 Rotary configuration

Figure 9 Example of 6 station rotary configuration

METHODS OF WORKPART TRANSPORT

The transfer mechanism of the automated flow line must not only move the partially completed workparts or assemblies between adjacent stations, it must also orient and locate the parts in the correct position for processing at each station. The general methods of transporting workpieces on flow lines can be classified into the following three categories:

1. Continuous transfer
2. Intermittent or synchronous transfer
3. Asynchronous or power-and-free transfer

The most appropriate type of transport system for a given application depends on such factors as:

The types of operation to be performed
The number of stations on the line

The weight and size of the work parts

Whether manual stations are included on the line
Production rate requirements

Balancing the various process times on the line

1. Continuous transfer

With the continuous method of transfer, the workparts are moved continuously at Constant speed. This requires the workheads to move during processing in order to maintain continuous registration with the workpart. For some types of operations, this movement of the workheads during processing is not feasible. It would be difficult, for example, to use this type of system on a machining transfer line because of inertia problems due to the size and weight of the workheads. In other cases, continuous transfer would be very practical. Examples of its use are in beverage bottling operations, packaging, manual assembly operations where the human operator can move with the moving flow line, and relatively simple automatic assembly tasks. In some bottling operations, for instance, the bottles are transported around a continuously rotating drum. Beverage is discharged into the moving bottles by spouts located at the drum's periphery. The advantage of this application is that the liquid beverage is kept moving at a steady speed and hence there are no inertia problems.

Continuous transfer systems are relatively easy to design and fabricate and can achieve a high rate of production.

2) Intermittent transfer

As the name suggests, in this method the workpieces are transported with an intermittent or discontinuous motion. The workstations are fixed in position and the parts are moved between stations and then registered at the proper locations for processing. All workparts are transported at the same time and, for this reason, the term "synchronous transfer system" is also used to describe this method of workpart transport.

3) Asynchronous transfer

This system of transfer, also referred to as a "power-and-free system," allows each workpart to move to the next station when processing at the current station has been completed. Each part moves independently of other parts. Hence, some parts are being processed on the line at the same time that others are being transported between sta-tions.

Asynchronous transfer systems offer the opportunity for greater flexibility than do the other two systems, and this flexibility can be a great advantage in certain circumstances. In-process storage of workparts can be incorporated into the asynchronous systems with relative ease. Power-and-free systems can also compensate for line balancing problems where there are significant differences in process times between stations. Parallel stations or several series stations can be used for the longer operations, and single stations can be used for the shorter operations. Therefore, the average production rates can be approximately equalized. Asynchronous lines are often used where there are one or more manually operated stations and cycle-time variations would be a problem on either the continuous or synchronous transport systems. Larger workparts can be handled on the asynchronous systems. A disadvantage of the power-and-free systems is that the cycle rates are generally slower than for the other types.

TRANSFER MECHANISMS

There are various types of transfer mechanisms used to move parts between stations. These mechanisms can be grouped into two types: those used to provide linear travel for in-line machines, and those used to provide rotary motion for dial indexing machines.

Linear transfer mechanisms

We will explain the operation of three of the typical mechanisms; the walking beam transfer bar system, the powered roller conveyor system, and the chain-drive conveyor system. This is not a complete listing of all types, but it is a representative sample.

Walking beam systems

With the walking beam transfer mechanism, the work-parts are lifted up from their workstation locations by a transfer bar and moved one position ahead, to the next station. The transfer bar then lowers the pans into nests which position them more accurately for processing. This type of transfer device is illustrated in Figure10 and 11. For speed and accuracy, the motion of the beam is most often generated by a rotating camshaft powered by an electric motor or a roller movement in a profile powered by hydraulic cylinder. Figure 12 shows the working of the beam mechanish.

Figure 10 Almac Industrial Systems, the Ontario-based manufacturer of material handling equipment- Walking Beam'.

Figure 11 SIKAMA INTERNATIONAL has developed a Walking beam mechanism for FALCON 1200 and 8500

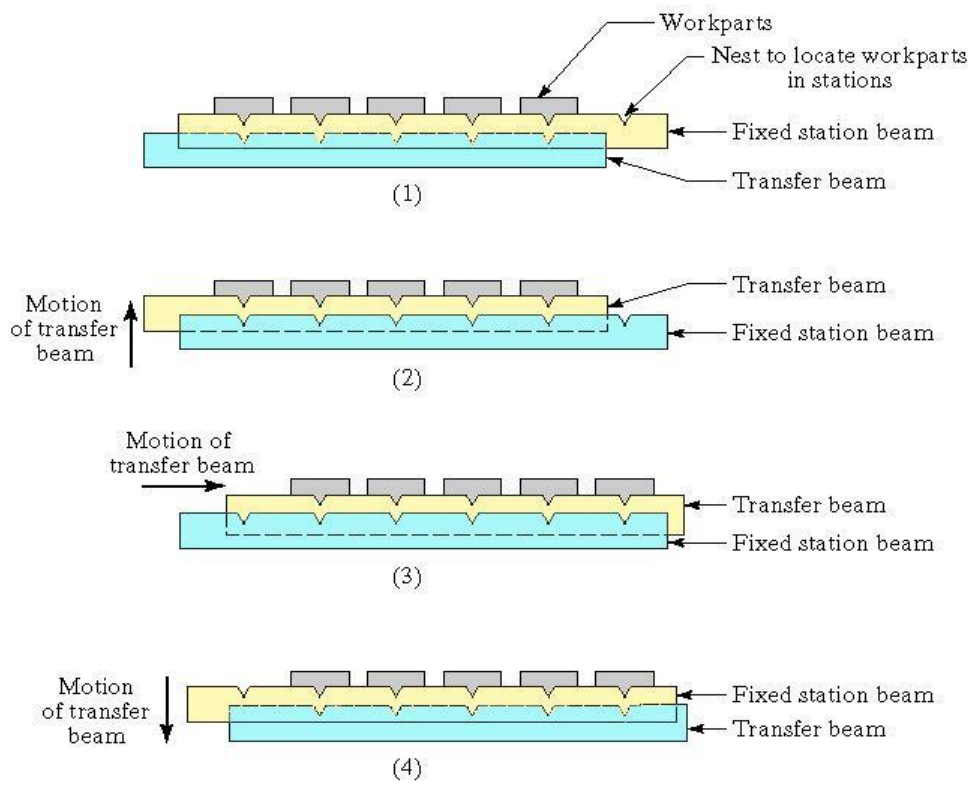


Figure 12 walking beam transfer system, showing various stage during transfer stage

__Powered roller conveyor system__

This type of system is used in general stock handling systems as well as in automated flow lines. The conveyor can be used to move pans or pallets possessing flat riding surfaces. The rollers can be powered by either of two mechanisms. The first is a belt drive, in which a flat moving belt beneath the rollers provides the rotation of the rollers by friction. A chain drive is the second common mechanism used to power the rollers. Powered roller conveyors are versatile transfer systems because they can be used to divert work pallets into workstations or alternate tracks.

(13 a)

(13 b)

Figure 13 a, b and c Power Conveyor

Chain-drive conveyor system

In chain-drive conveyor system either a chain or a flexible steel belt is used to transport the work carriers. The chain is driven by pulleys in either an "over-and-under" configuration, in which the pulleys turn about a horizontal axis, or an "around-the-corner" configuration, in which the pulleys rotate about a vertical axis. Figure 14 shows the chain conveyor transfer system.

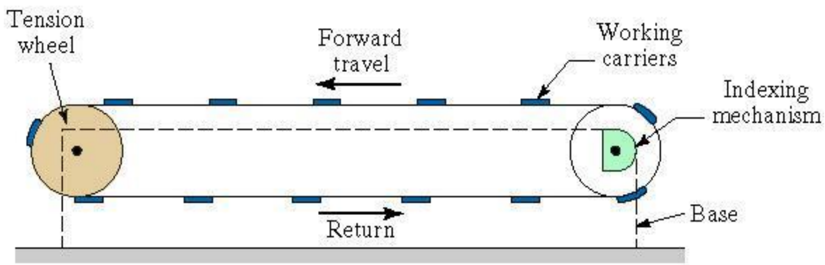


Figure 14 Chain drive conveyor

This general type of transfer system can be used for continuous, intermittent, or nonsynchronous movement of workparts. In the nonsynchronous motion, the workparts are pulled by friction or ride on an oil film along a track with the chain or belt providing the movement. It is necessary to provide some sort of final location for the workparts when they arrive at their respective stations.

Rotary transfer mechanisms

There are several methods used to index a circular table or dial at various equal angular positions corresponding to workstation locations.

Rack and pinion

This mechanism is simple but is not considered especially suited to the high-speed operation often associated with indexing machines. The device is pictured in Figure 4.6 and uses a piston to drive the rack, which causes the pinion gear and attached indexing table to rotate, A clutch or other device is used to provide rotation in the desired direction.

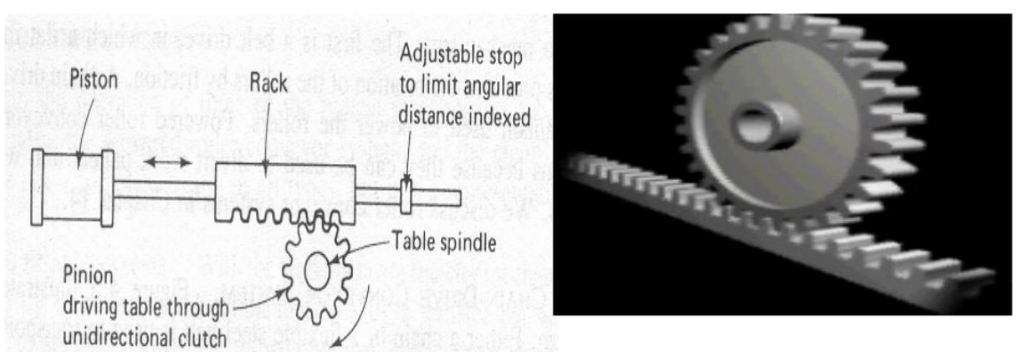


Figure 15 rack and pinion mechanisms

Ratchet and pawl:

A ratchet is a device that allows linear or rotary motion in only one direction, while preventing motion in the opposite direction.

Ratchets consist of a gearwheel and a pivoting spring loaded finger called a pawl that engages the teeth. Either the teeth, or the pawl, are slanted at an angle, so that when the teeth are moving in one direction, the pawl slides up and over each tooth in turn, with the spring forcing it back with a 'click' into the depression before the next tooth. When the teeth are moving in the other direction, the angle of the pawl causes it to catch against a tooth and stop further motion in that direction. This drive mechanism is shown in Figure 16.

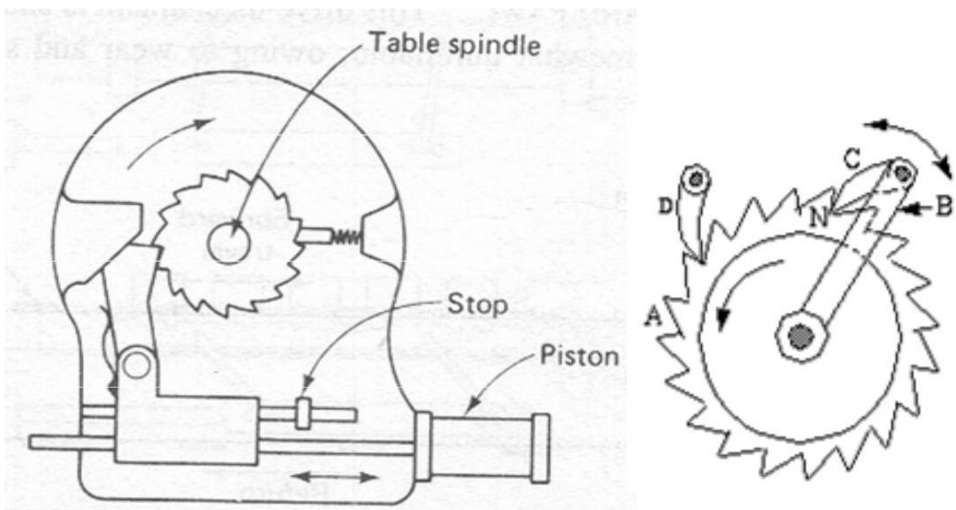
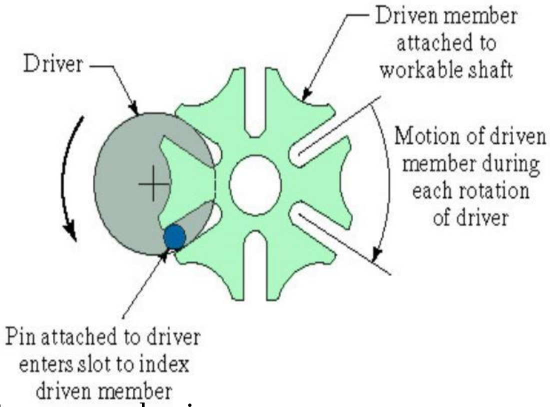


Figure 16 Rachet and pawl mechanism

Geneva mechanism:

The two previous mechanisms convert a linear motion into a rotational motion. The Geneva mechanism uses a continuously rotating driver to index the table, as pictured in Figure 17. If the driven member has six slots for a six-station dial indexing machine, each turn of the driver will cause the table to advance one-sixth of a turn. The driver only causes movement of the table through a portion of its rotation. For a six-slotted driven member, 120° of a complete rotation of the driver is used to index the table. The other 240° is dwell. For a four-slotted driven member, the ratio would be 90° for index and 270° for dwell. The usual number of indexings per revolution of the table is four, five, six, and eight.



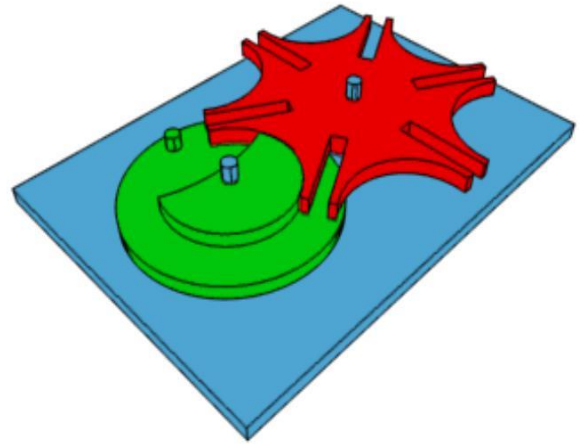
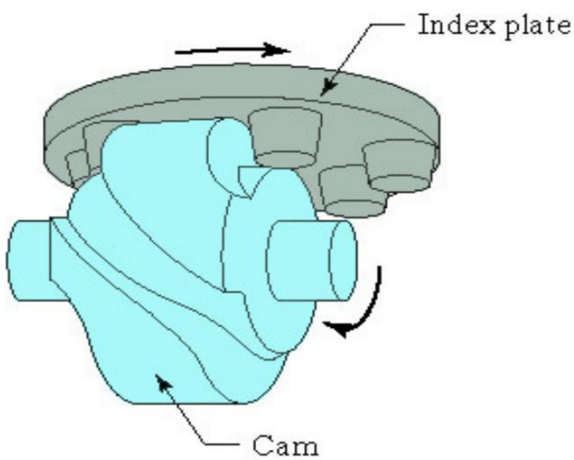
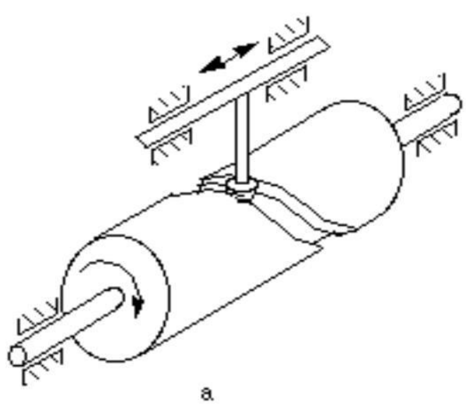


Figure 17 Geneva mechanism

CAM Mechanisms:

Various forms of cam mechanism, an example of which is illustrated in Figure 18, provide probably the most accurate and reliable method of indexing the dial. They are in widespread use in industry despite the fact that the cost is relatively high compared to alternative mechanisms. The cam can be designed to give a variety of velocity and dwell characteristics.





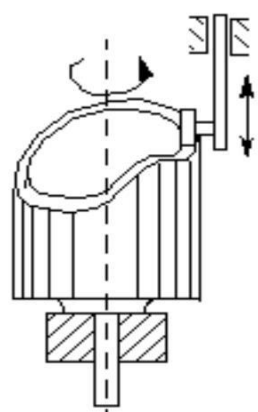


Figure 18 CAM mechanisms

CONTROL FUNCTIONS

Controlling an automated flow line is a complex problem, owing to the sheer number of sequential steps that must be carried out. There are three main functions that are utilized to control the operation of an automatic transfer system. The first of these is an operational requirement, the second is a safety requirement, and the third is dedicated to improving quality.

1. Sequence control.

The purpose of this function is to coordinate the sequence of actions of the transfer system and its workstations. The various activities of the automated flow line must be carried out with split-second timing and accuracy.

Sequence control is basic to the operation of the flow line.

2. Safety monitoring:

This function ensures that the transfer system does not operate in an unsafe or hazardous condition. Sensing devices may be added to make certain that the cutting tool status is satisfactory to continue to process the workpart in the case of a machining-type transfer line. Other checks might include monitoring certain critical steps in the sequence control function to make sure that these steps have all been performed and in the correct order. Hydraulic or air pressures might also be checked if these are crucial to the operation of automated flow lines.

3. Quality monitoring:

The third control function is to monitor certain quality attributes of the workpart. Its purpose is to identify and possibly reject defective workparts and assemblies. The inspection devices required to perform quality monitoring are sometimes incorporated into existing processing stations. In other cases, separate stations are included in the line for the sole purpose of inspecting the workpart as shown in figure 19.

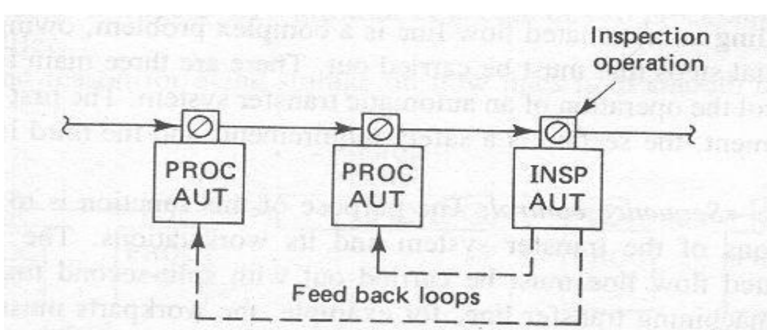


Figure 19 Inspection station with feedback

Conventional thinking on the control of the line has been to stop operation when a malfunction occurred. While there are certain malfunctions representing unsafe con-ditions that demand shutdown of the line, there are other situations where stoppage of the line is not required and perhaps not even desirable. There are alternative control strategies 1.Instantaneous control and 2. Memory control.

Instantaneous control:

This mode of control stops the operation of the flow line immediately when a malfunction is detected. It is relatively simple, inexpensive, and trouble-free. Diagnostic features are often added to the system to aid in identifying the location and cause of the trouble to the operator so that repairs can be quickly made. However, stopping the machine results in loss of production from the entire line, and this is the system's biggest drawback.

Memory control:

In contrast to instantaneous control, the memory system is designed to keep the machine operating. It works to control quality and/or protect the machine by preventing subsequent stations from processing the particular workpart and by segregating the part as defective at the end of the line. The premise upon which memory-type control is based is that the failures which occur at the stations will be random and infrequent. If, however, the station failures result from cause and tend to repeat, the memory system will not improve production but, rather, degrade it. The flow line will continue to operate, with the consequence that bad parts will continue to be produced. For this reason, a counter is sometimes used so that if a failure occurs at the same station for two or three consecutive cycles, the memory logic will cause the machine to stop for repairs.

BUFFER STORAGE

Automated flow lines are often equipped with additional features beyond the basic transfer mechanisms and workstations. It is not uncommon for production flow lines to include storage zones for collecting banks of workparts along the line. One example of the use of storage zones would be two intermittent transfer systems, each without any storage capacity, linked together with a workpart inventory area. It is possible to connect three, four, or even more lines in this manner. Another example of workpart storage on flow lines is the asynchronous transfer line. With this system, it is possible to provide a bank of workparts for every station on the line.

There are two principal reasons for the use of buffer storage zones. The first is to reduce the effect of individual station breakdowns on the line operation. The continuous or intermittent transfer system acts as a single integrated machine. When breakdowns occur at the individual stations or when preventive maintenance is applied to the machine, production must be halted. In many cases, the proportion of time the line spends out of operation can be significant, perhaps reaching 50% or more. Some of the common reasons for line stoppages are:

Tool failures or tool adjustments at individual processing stations Scheduled tool changes

Defective workparts or components at assembly stations, which require that the

Feed mechanism be cleared

Feed hopper needs to be replenished at an assembly station

Limit switch or other electrical malfunction

Mechanical failure of transfer system or workstation

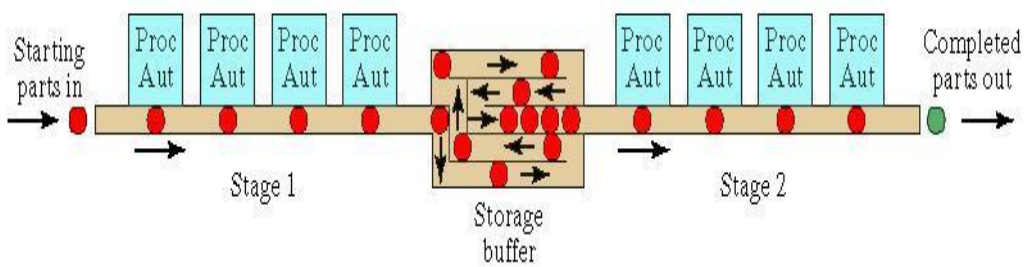


Figure 20 Storage buffer between two stages of a production

When a breakdown occurs on an automated flow line, the purpose of the buffer storage zone is to allow a portion of the line to continue operating while the remaining portion is stopped and under repair. For example, assume that a 20-station line is divided into two sections and connected by a parts storage zone which automatically collects parts from the first section and feeds them to the second section. If a station jam were to cause the first section of the line to stop, the second section could continue to operate as long as the supply of parts in the buffer zone lasts. Similarly, if the second section were to shut down, the first section could continue to operate as long as there is room in the buffer zone to store parts. Hopefully, the average production rate on the first section would be about equal to that of the second section. By dividing the line and using the storage area, the average production rate would be improved over the original 20-station Mow line. Figure 20 shows the Storage buffer between two stages of a production line

Reasons for using storage buffers:

- To reduce effect of station breakdowns
- To provide a bank of parts to supply the line
- To provide a place to put the output of the line
- To allow curing time or other required delay
- To smooth cycle time variations
- To store parts between stages with different production rates

The disadvantages of buffer storage on flow lines are increased factory floor space, higher in-process inventory, more material handling equipment, and greater complexity of the overall flow line system. The benefits of buffer storage are often great enough to more than compensate for these disadvantages.

AUTOMATION FOR MACHINING OPERATIONS

Transfer systems have been designed to perform a great variety of different metal-cutting processes. In fact, it is difficult to think of machining operations that must be excluded from the list. Typical applications include operations such as milling, boring, drilling, reaming, and tapping. However, it is also feasible to carry out operations such as turning and grinding on transfer-type systems.

There are various types of mechanized and automated machines that perform a sequence of operations simultaneously on different work parts. These include dial indexing machines, trunnion machines, and transfer lines. To consider these machines in approximately the order of increasing complexity, we begin with one that really does not belong in the list at all, the single-station machine.

Single-station machine

These mechanized production machines perform several operations on a single workpart which is fixtured in one position throughout the cycle. The operations are performed on several different surfaces by work heads located around the piece. The available space surrounding a stationary workpiece limits the number of machining heads that can be used. This limit on the number of operations is the principal disadvantage of the single-station machine. Production rates are usually low to medium. The single station machine is as shown in figure 21.

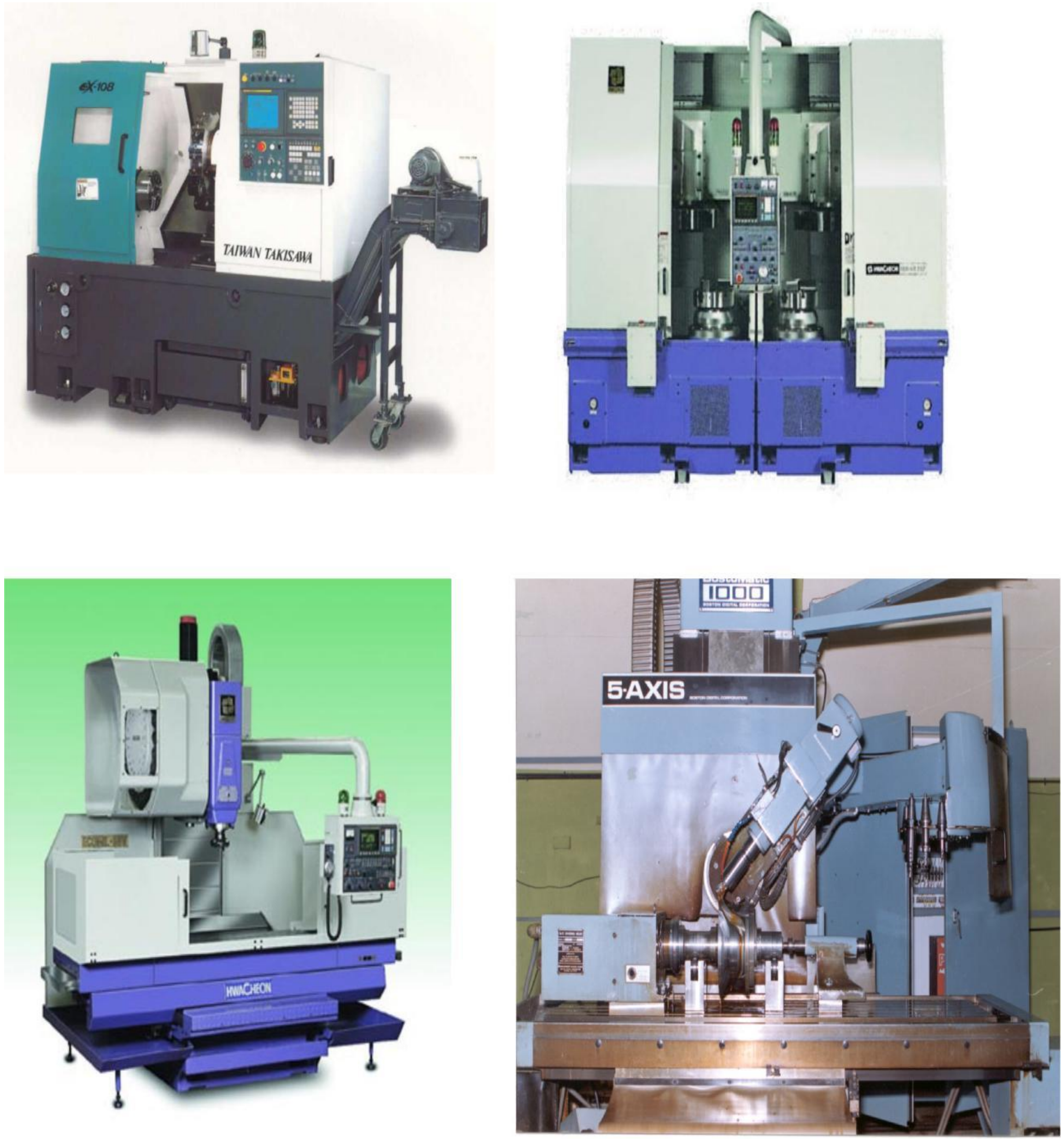


Figure 21 single-station machines

Rotary indexing machine

To achieve higher rates of production, the rotary indexing machine performs a sequence of machining operations on several work parts simultaneously. Parts are fixtured on a horizontal circular table or dial, and indexed between successive stations. An example of a dial indexing machine is shown in Figure 22 and 23.

Figure 22 Example of 6 station rotary configuration

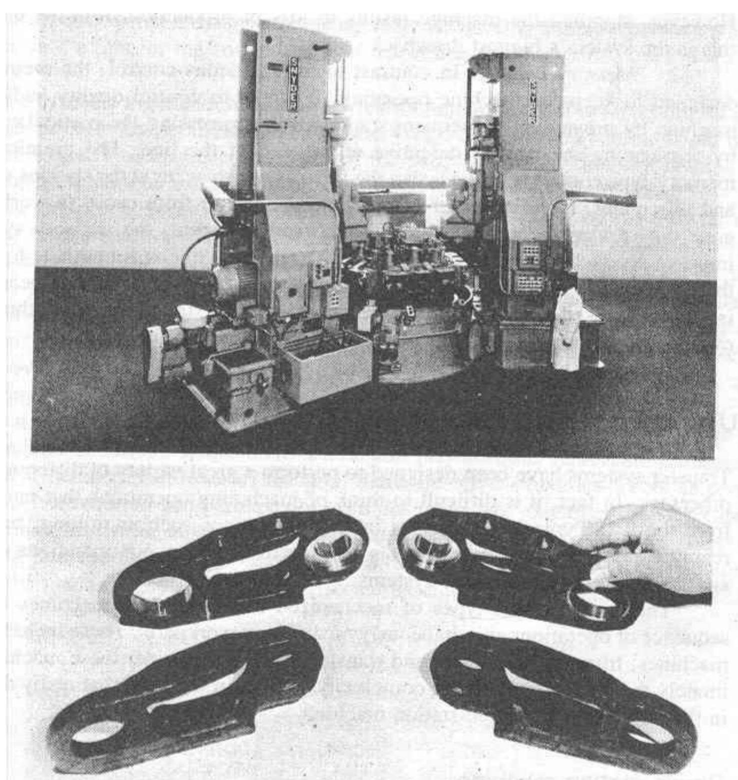


Figure 23 Five station dial index machine showing vertical and horizontal machining centers

Trunnion machine

Trunnion machine is a vertical drum mounted on a horizontal axis, so it is a variation of the dial indexing machine as shown in figure 24. The vertical drum is called a trunnion. Mounted on it are several fixtures which hold the work parts during processing. Trunnion machines are most suitable for small workpieces. The configuration of the machine, with a vertical rather than a horizontal indexing dial, provides the opportunity to perform operations on opposite sides of the workpart. Additional stations can be located on the outside periphery of the trunnion if it is required. The trunnion-type machine is appropriate for work parts in the medium production range.

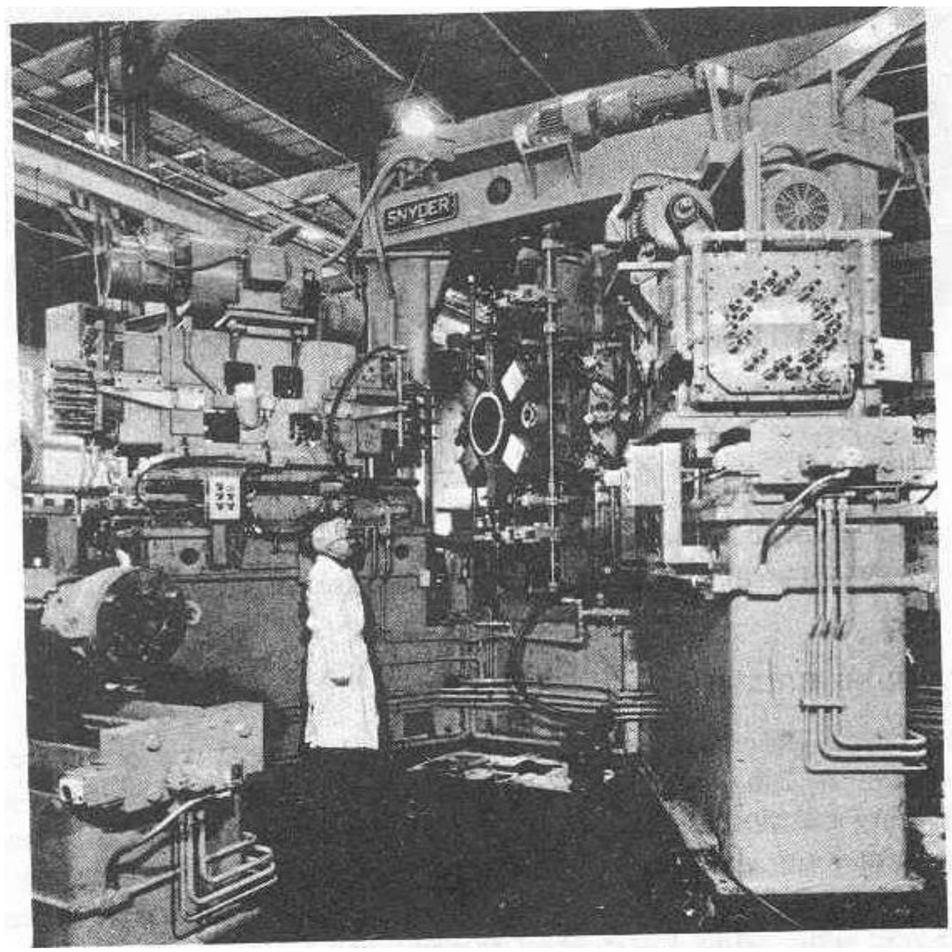


Figure 24 Six station trunnion machine

Center column machine

Another version of the dial indexing arrangement is the center column type, pictured in Figure 25. In addition to the radial machining heads located around the periphery of the horizontal table, vertical units are mounted on the center column of the machine. This increases the number of machining operations that can be performed as compared to the regular dial indexing type. The center column machine is considered to be a high-production machine which makes efficient use of floor space.

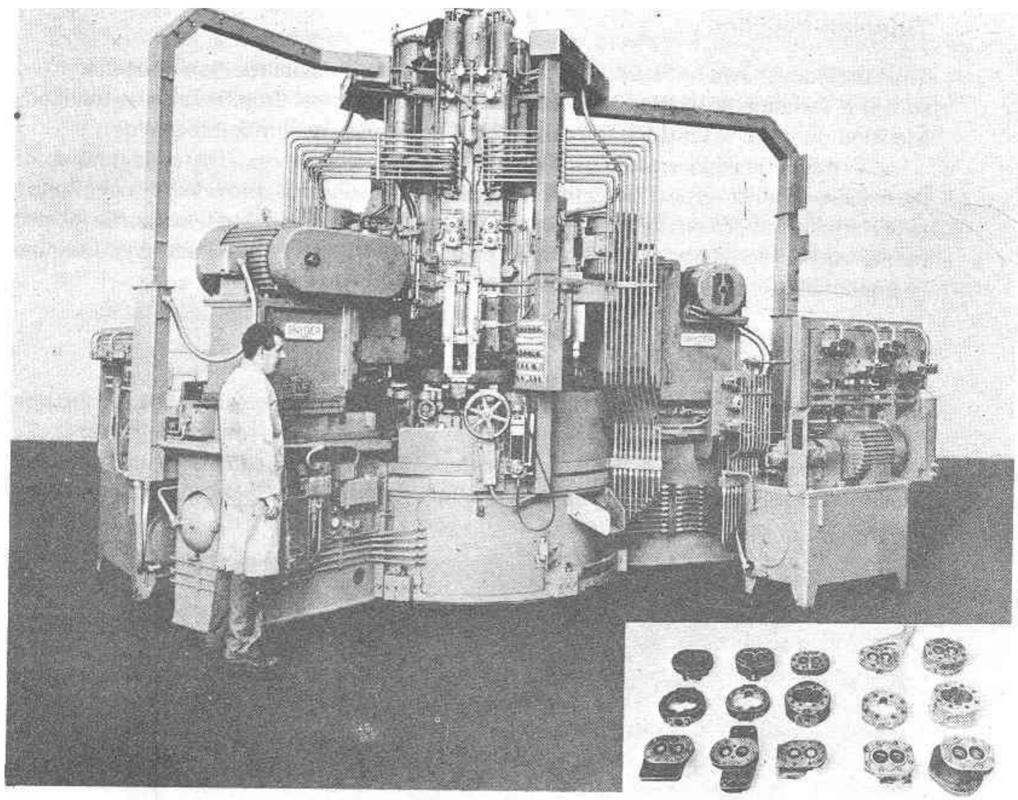


Figure 25 Ten-station center column machine

Transfer machine

The most highly automated and versatile of the machines is the transfer line, as explained earlier the workstations are arranged in a straight-line flow pattern and parts are transferred automatically from station to station. The transfer system can be synchronous or asynchronous, work parts can be transported with or without pallel fixtures, buffer storage can be incorporated into the line operation if desired, and a variety of different monitoring and control features can be used to manage the line. Hence, the transfer machine offers the greatest flexibility of any of the machines discussed. The transfer line can accommodate larger workpieces than the rotary-type indexing systems. Also, the number of stations, and therefore the number of operations, which can be included on the line is greater than for the circular arrangement. The transfer line has traditionally been used for machining a single product in high quantities over long production runs. More recently, transfer machines have been designed for ease of changeover to allow several different but similar workparts to be produced on the same line. These attempts to introduce flexibility into transfer line design add to the appeal of these high-production systems.

Figure 26 Example of 20 stations Transfer line

Figure 27 Example of Transfer line

ANALYSIS OF AUTOMATED FLOW LINE

General Terminology & Analysis:

There are two problem areas in analysis of automated flow lines which must be addressed:

R Process Technology

R Systems Technology

Process Technology refers to the body of knowledge about the theory & principles of the particular manufacturing process used on the production line. E.g. in the manufacturing process, process technology includes the metallurgy & machinability of the work material, the correct applications of the cutting tools, chip control, economics of machining, machine tools alterations & a host of other problems. Many problems encountered in machining can be overcome by application of good machining principles. In each process, a technology is developed by many years of research & practice.

Terminology & Analysis of transfer lines with no Internal storage:

There are a few assumptions that we will have to make about the operation of the Transfer line & rotary indexing machines:

7. The workstations perform operations such as machining & not assembly.
8. Processing times at each station are constant though they may not be equal.
9. There is synchronous transfer of parts.
10. No internal storage of buffers.

In the operation of an automated production line, parts are introduced into the first workstation & are processed and transported at regular intervals to the succeeding stations. This interval defines the ideal cycle time, Tc of the production line. Tc is the processing time for the slowest station of the line plus the transfer time; i.e. :

$$T_c = \max(T_{si}) + T_r \quad \text{----------------} (1)$$

T_c = ideal cycle on the line (min)

T_{si} = processing time at station (min)

T_r = repositioning time, called the transfer time (min)

In equation 1, we use the max (T_{si}) because the longest service time establishes the pace of the production line. The remaining stations with smaller service times will have to wait for the slowest station. The other stations will be idle.

In the operation of a transfer line, random breakdowns & planned stoppages cause downtime on the line.

Common reasons for downtime on an Automated Production line:

4. Tool failures at workstations.
5. Tool adjustments at workstations
6. Scheduled tool charges
7. Limit switch or other electrical malfunctions.

2. Mechanical failure of a workstation.
3. Mechanical failure of a transfer line.
4. Stock outs of starting work parts.
5. Insufficient space for completed parts.
6. Preventive maintenance on the line worker breaks.

The frequency of the breakdowns & line stoppages can be measured even though they occur randomly when the line stops, it is down for a certain average time for each downtime occurrence. These downtime occurrences cause the actual average production cycle time of the line to be longer than the ideal cycle time.

The actual average production time T_p:

$$T_p = T_c + FT_d \quad \text{------------------------ 2}$$

F = downtime frequency, line stops / cycle

Td = downtime per line stop in minutes

The downtime Td includes the time for the repair crew to swing back into action, diagnose the cause of failure, fix it & restart the drive.

FT_d = downtime averaged on a per cycle basis

Production can be computed as a reciprocal of Tp

$$R_p = \frac{1}{T_p} \quad \text{---------------------------- 3}$$

Where, R_p = actual average production rate (pc / min)

T_p = the actual average production time

The ideal production rate is given by

$$R_c = \frac{1}{T_c} \quad \text{----------------------------- 4}$$

Where R_c = ideal production rate (pc / min)

Production rates must be expressed on an hourly basis on automated production lines.

The machine tool builder uses the ideal production rate, Rc, in the proposal for the automated transfer line & calls it as the production rate at 100% efficiency because of downtime. The machine tool builder may ignore the effect of downtime on production rate but it should be stated that the amount of downtime experienced on the line is the responsibility of the company using the production line.

Line efficiency refers to the proportion of uptime on the line & is a measure of reliability more than efficiency.

Line efficiency can be calculated as follows:

$$E = \frac{T_c}{T_p} = \frac{T_c}{T_c} + FT_d \quad \text{---------------- 5}$$

Where E = the proportion of uptime on the production line.

An alternative measure of the performance is the proportion of downtime on the line which is given by:

$$D = \frac{FT_d}{T_p} = \frac{FTd}{Tc} + FT_d \text{ ----------------- } 6$$

Where D = proportion of downtime on the line

$$E + D = 1.0$$

An important economic measure of the performance of an automated production line is the cost of the unit produced. The cost of 1 piece includes the cost of the starting blank that is to processed, the cost of time on the production line & the cost of the tool consumed. The cost per unit can be expressed as the sum of three factors:

$$Cpc = Cm + CoTp + Ct \text{ ------------------------ } 7$$

Where Cpc = cost per piece (Rs / pc)

Cm = cost per minute to operate the time (Rs / min)

Tp = average production time per piece (min / pc)

Ct = cost of tooling per piece (Rs / pc)

Co = the allocation of capital cost of the equipment over the service life, labour to operate the line, applicable overheads, maintenance, & other relevant costs all reduced to cost per min.

Problem on Transfer line performance:

A 30 station Transfer line is being proposed to machine a certain component currently produced by conventional methods. The proposal received from the machine tool builder states that the line will operate at a production rate of 100 pc / hr at 100% efficiency. From a similar transfer line it is estimated that breakdowns of all types will occur at a frequency of F = 0.20 breakdowns per cycle & that the average downtime per line stop will be 8.0 minutes. The starting blank that is machined on the line costs Rs. 5.00 per part. The line operates at a cost for 100 parts each & the average cost per tool = Rs. 20 per cutting edge. Compute the following:

1. Production rate
2. Line efficiency
3. Cost per unit piece produced on the line

Solution:

2. At 100% efficiency, the line produces 100 pc/hr. The reciprocal gives the unit time or ideal cycle time per piece.

$$Tc = \frac{1}{100} = 0.010\text{hr / pc} = 0.6 \text{ mins}$$

The average production time per piece is given by:

Tp = Tc + FTd
1. 0.60 + 0.20 (8.0)
2. 0.60 + 1.60
3. 2.2 mins / piece

Rp = 1 / 2.2m = 0.45 pc / min = 27 pc / hr

Efficiency is the ratio of the ideal cycle time to actual production time

E = 0.6 / 2.2
4. 27 %

Tooling cost per piece

Ct = <u>(30 tools) (Rs 20 / tool)</u>
parts
2. Rs. 6 / piece

The hourly ratio of Rs 100 / hr to operate the line is equivalent to Rs. 1.66 / min.

Cpc = 5 + 1.66 (2.2) + 6
4. 5 + 3.65 + 6
5. Rs 14.65 / piece

Upper Bound Approach:

The upper bound approach provides an upper limit on the frequency on the line stops per cycle. In this approach we assume that the part remains on the line for further processing. It is possible that there will be more than one line stop associated with a given part during its sequence of processing operations. Let

Pr = probability or frequency of a failure at station i where i = 1, 2,………. η
Station i where i = 1, 2, ……………. η

Since a part is not removed from the line when a station jam occurs it is possible that the part will be associated with a station breakdown at every station. The expected number of lines stops per part passing through the line is obtained by summing the frequencies Pi over the n stations. Since each of the n stations is processing a part of each cycle, then the expected frequency of line stops per cycle is equal to the expected frequency of line stops per part i.e.

$$F = \sum_{i=1}^{\eta} Pi \text{ ---------------------------- } 8$$

where F = expected frequency of line stops per cycle
Pi = frequency of station break down per cycle, causing a line stop
1. = number of workstations on the line

If all the Pi are assumed equal, which is unlikely but useful for computation purposes, then

$$F = \eta.p \text{ where all the Pi are equal ---------------- } 9$$

$$p_1 = p_2 = \ldots\ldots\ldots\ldots.. p_\eta = p$$

Lower Bound Approach:

The lower bound approach gives an estimate of the lower limit on the expected frequency of line stops per cycle. Here we assume that a station breakdown results in destruction of the part, resulting in removal of the part from the line & preventing its subsequent processing at the remaining workstations.

Let Pi = the probability that the workpiece will jam at a particular station i.

Then considering a given part as it proceeds through the line, Pi = probability that the part will jam at station 1

(1 - Pi) = probability that the part will not jam station 1 & thus will available for processing at subsequent stations. A jam at station 2 is contingent on successfully making it through station 1 & therefore the probability that the same part will jam at station 2 is given by

P (1 – P)
3. 2

Generalising the quantity

P (1 – Pi - 1) (1 – Pi - 2) = (1 – P2) (1 – P1)

Where i = 1,,2, ………. η

is the probability that a given part will jam at any station i. Summing all these probabilities from i = 1 through i = η gives the probability or frequency of line stops per cycle.

Probability that the given part will pass through all η stations without a line stop is

$$\prod_{i=1}^{\eta} (1 - P_i)$$

Therefore the frequency of line stops per cycle is:

$$F = 1 - \prod_{i=1}^{\eta} (1 - P_i) \quad \text{-----------------------------------} \; 10$$

If all the probabilities, Pi, are equal, Pi = P, then

$$F = 1 - (1 - P)^{\eta}$$

Because of parts removal in the lower bound approach, the number of parts coming of the line is less than the number launched onto the front of the line.

If F= frequency of line stops & a part is removed for every line stop, then the proportion of parts produced is (1 - F). This is the yield of the production line. The production rate equation then becomes:

$$Rap = \frac{1 - F}{Tp} \quad \text{--} \; 11$$

where Rap = average actual production rate of acceptable parts from the line

Tp = average cycle rate of the transfer machine

$Rp = \frac{1}{Tp}$ = average cycle rate of the system

Example 2 Upper Bound v/s Lower Bound Approach

A 2 station transfer line has an ideal cycle time of Tc = 1.2 mins. The probability of station breakdown per cycle is equal for all stations & P = 0.005 breakdowns / cycle. For each of the upper bound & lower bound determine:

2. frequency of line stops per cycle
3. average actual production rate
4. line efficiency

1. **For the Upper bound approach**

F = 20 (0.005) = 0.10 lines per cycle

20 20

F = 1 - (1 – 0.005) = 1 – (0.995)

1. 1 – 0.0946
2. 0.0954 line stops per cycle

For the Upper bound approach the production rate,

Rp = __ 1

20

1. 0.500 pc / min
2. 30 pc /hr

For the lower bound approach the production time we calculate by using the formula for

F Tp = Tc + F (Td)

1. 1.2 + 0.0954 (0.8)
2. 1.9631 mins

Production rate = 0.9046

1.9631

2. 0.4608 pc / min
3. 27.65 pc / hr

The production rate is about 8% lower than that we computed by the upper bound approach.

We should note that:

$$Rp = \frac{1}{0.9631}$$

1. 0.5094 cycles / min
2. 30.56 cycles / hr

which is slightly higher than in the upper bound case.

c) For the upper bound the line efficiency will be

$$E = \frac{1.2}{2.0}$$

1. 0.6
2. 60 %

For the lower bound approach we have

$$E = \frac{1.2}{1.9631}$$

3. 0.6113
4. 61.13 %

Line efficiency is greater with lower bound approach even though production rate is lower. This is because lower bound approach leaves fewer parts remaining on the line to jam.

Analysis of Transfer Lines with Storage Buffers:

In an automated production line with no internal storage of parts, the workstations are interdependent. When one station breaks down all other stations on the line are affected either immediately or by the end of a few cycles of operation. The other stations will be forced to stop for one or two reasons 1) starving of stations 2) Blocking of stations Starving on an automated production line means that a workstation is prevented from performing its cycle because it has no part to work on. When a breakdown occurs at any workstation on the line, the stations downstream from the affected station will either immediately or eventually become starved for parts.

Blocking means that a station is prevented from performing its work cycle because it cannot pass the part it just completed to the neighbouring downstream station. When a break down occurs at a station on the line, the stations upstreams from the affected station become blocked because the broken down station cannot accept the next part for processing from the neighbouring upstream station. Therefore none of the upstream stations can pass their just completed parts for work.

By Adding one or more parts storage buffers between workstations production lines can be designed to operate more efficiently. The storage buffer divides the line into stages that can operate independently for a number of cycles.

The number depending on the storage capacity of the buffer

If one storage buffer is used, the line is divided into two stages.

If two storage buffers are used at two different locations along the line, then a three stage line is formed.

The upper limit on the number of storage buffers is to have a storage between every pair of adjacent stations.

The number of stages will then be equal to the number of workstations.

For an η stage line, there will be $\eta - 1$ storage buffers. This obviously will not include the raw parts inventory at the front of the line or the finished parts inventory that accumulates at the end of the line.

Consider a two – stage transfer line, with a storage buffer separating the stages. If we assume that the storage buffer is half full. If the first stage breaks down, the second stage can continue to operate using parts that are in the buffer. And if the second stage breaks down, the first stage can continue to operate because it has the buffer to receive its output. The reasoning for a two stage line can be extended to production lines with more than two stages.

Limit of Storage Buffer Effectiveness:

Two extreme cases of storage buffer effectiveness can be identified:

1. No buffer storage capacity at all.
2. Infinite capacity storage buffers

If we assume in our Analysis that the ideal cycle time Tc is the same for all stages considered.

In the case of no storage capacity, the production line acts as one stage when a station breaks down the entire line stops. This is the case of a production line with no internal storage.

The line efficiency of a zero capacity storage buffer:

$$E_o = \frac{T_c}{T_c + FT_d} \quad \text{------------------------------} \; 12$$

The opposite extreme is the case where buffer zones of infinite capacity are installed between every pair of stages. If we assume that each storage buffer is half full, then each stage is independent of the next. The presence of the internal storage buffer means that then no stage will ever be blocked or starved because of a breakdown at some other stage.

An infinite capacity storage buffer cannot be realized in practice. If it could then the overall line efficiency will be limited by the bottleneck stage.

i.e. production in all other stages would ultimately be restricted by the slowest stage. The downstream stages could only process parts at the output rate of the bottleneck stage.

Given that the cycle time Tc is the same for all the stages the efficiency for any stage k is given by:

$$E_k = \frac{T_c}{T_c + F_k T_{d_k}}$$

where k is used to identify the stage.

The overall line efficiency would be given by:

$$E_\infty = \text{Minimum} (E_k)$$

where the subscript ∞ identifies E_∞ as the efficiency of a line whose storage buffers have infinite capacity.

By including one or more storage buffers in an automated production line, we expect to improve the line efficiency above E_0, but we cannot expect to achieve E_∞.

The actual value of line efficiency will fall somewhere between these extremes for a given buffer capacity

$$E_0 < E_b < E_\infty$$

Analysis of a Two stage transfer line:

The two stage line is divided by a storage buffer of capacity is expressed in terms of the number of work parts that it can store. The buffer receives the output of stage 1 & forwards it to stage 2, temporarily storing any parts not immediately needed by stage 2 upto its capacity b. The ideal cycle time Tc is the same for both stages. We assume the downtime distributions of each stage to be the same with mean downtime = Td, let F_1 & F_2 be the breakdown rates of stages 1 & 2 respectively.

F_1 & F_2 are not necessarily equal.

Over the long run both stages must have equal efficiencies. If the efficiency of stage 1 is greater than the efficiency of stage 2 then inventory would build up on the storage buffer until its capacity is reached.

Thereafter stage 1 would eventually be blocked when it outproduced stage 2.

Similarly if the efficiency of stage 2 is greater than the efficiency of stage 1 the inventory would get depleted thus stage 2 would be starved.

Accordingly the efficiencies would tend to equalize overtime in the two stages.

The overall efficiency for the two stage line can be expressed as:

$$E_b = E_0 + \{ D_1^1 \ \eta (b) \} E_2 \qquad 13$$

where E_b = overall efficiency for a two stage line with a buffer capacity

2. $_0$ = line efficiency for the same line with no internal storage buffer

$\{ D^1 \eta (b) \} E$ represents the improvement in efficiency that results from having a 1

storage buffer with b > 0

when b = 0

2. $$E_0 = \frac{Tc}{Tc + (F_1 + F_2)\, Td} \quad \text{----------------------------------}14$$

The term D_1^1 can be thought of as the proportion of total time that stage 1 is down

1. $$D_1^1 = \frac{F_1 \, Td}{Tc + (F_1 + F_2)\, Td} \quad 15\text{---}$$

The term *h (b)* is the proportion of the downtime D'_1 (when the stage 1 is down) that stage 2 could be up & operating within the limits of storage buffer capacity *b*. The equations cover several different downtime distributions based on the assumption that both stages are never down at the same time. Four of these equations are presented below:

Assumptions & definitions: Assume that the two stages have equal downtime distributions ($T_{d1} = T_{d2} = T_d$) &

equal cycle times ($T_{c1} = T_{c2} = T_c$).

Let F_1 = downtime frequency for stage 1, & F_2 = downtime frequency for stage 2. Define *r* to be the ration of breakdown frequencies as follows:

$$r = \frac{F_1}{F_2} \quad \text{-------------------} \ 16$$

Equations for *h(b)* :

With these definitions & assumptions, we can express the relationships for *h(b)* for two theoretical downtime distributions :

Constant downtime:

Each downtime occurrence is assumed to be of constant duration T_d. this is a case of no downtime variation. Given buffer capacity b, define B & L as follows:

$$b = B\frac{T_d}{T_c} + L \quad \text{---------------} \; 17$$

Where B is the largest integer satisfying the relation : $b\frac{T_c}{T_d} \ge B$,

& L represents the leftover units, the amount by which b exceeds $B\frac{T_d}{T_c}$.

There are two cases:

Case 1: $r=1.0.h(b)$

$$= \frac{B}{B+1} + L\frac{T_c}{T_d}\frac{1}{(B+1)(B+2)} \quad \text{--------} 18$$

Case 2: $r \neq 1.0.h(b)$

$$= r\,1 - r^{B} + L\frac{T_c}{T_d}\frac{r^B(1-r)^2}{(1-r^{B+1})(1-r^{B+2})} \quad \text{-----} 19$$

Geometric downtime distribution:

In this downtime distribution, the probability that repairs are completed during cycle duration T_c, is independent of the time since repairs began. This a case of maximum downtime variation. There are two cases:

Case 1: $r = 1.0.h(b)$

$$= \frac{B\frac{T_c}{T_d}}{2 + (b-1)\frac{T_c}{T_d}} \qquad 20$$

Case 2: $r \neq 1.0.$

$$\text{Define } K = \frac{1 + r - \frac{T_c}{T_d}}{1 + r - r\frac{T_c}{T_d}} \quad \text{---------------} 21$$

Then $h(b) = r\frac{1 - K^b}{1 - rK^b}$ -------------- 22

Finally, E_2 corrects for the assumption in the calculation of $h(b)$ that both stages are never down at the same time. This assumption is unrealistic. What is more realistic is that when stage 1 is down but stage 2 could be producing because of parts stored in the buffer, there will be times when stage 2 itself breaks down. Therefore E_2 provides an estimate of the proportion of stage 2 uptime when it could be otherwise be operating even with stage 1 being down. E_2 is calculated as:

$$E_2 = \frac{T_c}{T_c + F_2T_d} \quad \text{---------------} 23$$

Two-Stage Automated Production Line:

A 20-station transfer line is divided into two stages of 10 stations each. The ideal cycle time of each stage is T_c = 1.2 min. All of the stations in the line have the same probability of stopping, p = 0.005. We assume that the downtime is constant when a breakdown occurs, T_d

3. 8.0 min. Using the upper-bound approach, compute the line efficiency for the following buffer capacities: (a) b = 0, (b) $b = \infty$, (c) b = 10, (d) b = 100

Solution:

$$F = np = 20(0.005) = 0.10$$

$$E_0 = \frac{1.2}{1.2 + 0.1(8)} = 0.60$$

1. For a two stage line with 20 stations (each stage = 10 stations) & $b = \infty$, we first compute F:

$$F_1 = F_2 = 10(0.005) = 0.05$$

$$E_\infty = E_1 = E_2 = \frac{1.2}{1.2 + 0.05(8)} = 0.75$$

1. For a two stage line with b = 10, we must determine each of the items in equation 13. We have E_0 from part (a). E_0 = 0.60. And we have E_2 from part (b). E_2 = 0.75

$$D'_1 = \frac{0.05\ (8)}{1.2 + (0.05 + 0.05)\ (8)} = \frac{0.40}{2.0} = 0.20$$

Evaluation of $h(b)$ is from equation 18 for a constant repair distribution. In equation 17, the ratio

$$\frac{T_d}{T_c} = \frac{8.0}{1.2} = 6.667.$$

For b = 10, B = 1 & L = 3.333.

Thus,

$h(b) = h(10)$

$$= \frac{1}{1 + 1} + 3.333\ \frac{(1.2)}{(8.0)}\ \frac{1}{(1 + 1)(1 + 2)}$$

3. 0.50 + 0.8333 = 0.5833 We can now use equation 13:

E_{10} = 0.600 + 0.20 (0.5833) (0.75)

= 0.600 + 0.0875 = 0.6875

1. For b = 100, the only parameter in equation 13 that is different from part (c) is $h(b)$. for b = 100, B = 15 & L = 0 in equation 18. Thus, we have:

$$h(b) = h(100) = \frac{15}{15 + 1}$$

20. 0.9375

Using this value,

E_{100} = 0.600 + 0.20 (0.9375) (0.75)
= 0.600 + 0.1406 = 0.7406

The value of $h(b)$ not only serves its role in equation 13 but also provides information on how much improvement in efficiency we get from any given value of b. note in example 15 that the difference between E_∞ & E_0 = 0.75 – 0.60 = 0.15.
For b = 10, $h(b)$ = h(10) = 0.58333, which means we get 58.33% of the maximum possible improvement in line efficiency using a buffer capacity of 10 {E_{10} = 0.6875 = 0.60 + 0.5833)(0.75 – 0.60)}.
For b = 100, $h(b)$ = h(100) = 0.9375, which means we get 93.75% of the maximum improvement with b = 100 {E_{100} = 0.7406 = 0.60 + 0.9375 (0.75 – 0.60)}

We are not only interested in the line efficiencies of a two stage production line. We also want to know the corresponding production rates. These can be evaluated based on knowledge of the ideal cycle time T_c & the definition of line efficiency. According to equation 5, E = T_c / T_p. Since R_p = the reciprocal of T_p, then $E = T_cR_p$. Rearranging this we have:

$$R_p = \frac{E}{T_c} \quad \text{------------------- 24}$$

Production Rates on the Two-Stage Line of the example above:

Compute the production rates for the 4 cases in the above example. The value of T_c = 1.2 min is as before.

Solution:

2. For b = 0, E_0 = 0.60. Applying equation 23, we have

R_p = 0.60/ 1.2 = 0.5 pc/min = 30 pc /hr.

3. For b = ∞, E_∞ = 0.75.

R_p = 0.75 / 1.2 = 0.625 pc / min = 37.5 pc /hr

(c) For b = 10, E_{10} = 0.6875.

R_p = 0.6875 / 1.2 = 0.5729 pc / min = 34.375 pc /hr.

(d) For b = 100, E_{100} = 0.7406

$R_p = 0.7406 / 1.2 = 0.6172$ pc / min = 37.03 pc / hr

Effect of High Variability in Downtimes:

Evaluate the line efficiencies for the two-stage line in above example, except that the geometric repair distribution is used instead of the constant downtime distribution.

Solution:

For parts (a) & (b), the values of E_0 & E_∞ will be the same as in the previous example. $E_0 = 0.600$ & $E_\infty = 0.750$.

1 For $b = 10$, all of the parameters in equation 13 remain the same except

$h(b)$. Using equation 20, we have:

$$h(b) = h(10) = \frac{10(1.2/8.0)}{2 + (10 - 1)(1.2/8.0)} = = 0.4478$$

Now using equation 13, we have

$$E_{10} = 0.600 + 0.20 \quad (0.4478)(0.75)$$
$$= 0.6672$$

(d)For $b = 100$, it will be:

$$h(b) = h(100) = \frac{100(1.2/8.0)}{2 + (100 - 1)(1.2/8.0)} = 0.8902$$

$$E_{100} = 0.600 + 0.20\,(0.8902)(0.75)$$
$$= 0.7333$$

Transfer Lines with More thanTwo Stages:

If the line efficiency of an automated production line can be increased by dividing it into two stages with a storage buffer between, then one might infer that further improvements in performance can be achieved by adding additional storage buffers. Although we do not exact formulas for computing line efficiencies for the general case of any capacity b for multiple storage buffers, efficiency improvements can readily be determined for the case of infinite buffer capacity.

Transfer Lines with more than One Storage Buffer:

For the same 20-station transfer line we have been considering in the previous examples, compare the line efficiencies & production rates for the following cases, where in each case the buffer capacity is infinite: (a) no storage buffers, (b) one buffer, (c) three buffers, &

19 buffers. Assume in cases (b) & (c) that the buffers are located in the line to equalise the downtime frequencies; i.e. all F_i are equal. As before, the computations are based on the upper-bound approach.

Solution:

(a) For the case of no storage buffer, $E_\infty = 0.60$

$R_p = 0.60/1.2 = 0.50$ pc/min = 30 pc/hr

2. For the case of one storage buffer (a two stage line), $E_\infty = 0.75$

$$R_p = 0.75/1.2 = 0.625 \text{ pc/min} = 37.5 \text{ pc/hr}$$

(c) For the case of three storage buffers (a four stage line), we have

$F_1 = F_2 = F_3 = F_4 = 5(0.005) = 0.025$

$T_p = 1.2 + 0.025(8) = 1.4$ min / pc.

$E_\infty = 1.2 / 1.4 = 0.8571$

$R_p = 0.8571/1.2 = 0.7143$ pc/min
= 42.86 pc/hr.

(d) For the case of 19 storage buffers (a 20 stage line, where each stage is one station), we have

$F_1 = F_2 = \ldots\ldots = F_{20} = 1(0.005) = 0.005$

$T_p = 1.2 + 0.005(8) = 1.24$ min / pc.

$E_\infty = 1.2 / 1.24 = 0.9677$

$R_p = 0.9677/1.2 = 0.8065$ pc/min
= 48.39 pc/hr.

This last value is very close to the ideal production rate of $R_c = 50$ pc/hr

Problem:

Suppose that a 10 station transfer machine is under consideration to produce a component used in a pump. The item is currently produced by mass conventional means but demand for the item cannot be met. The manufacturing engineering department has estimated that the ideal cycle time will be
$T_c = 1.0$ min. From similar transfer lines & that the average downtime for line stop occur with a frequency;

F = 0.10 breakdown/cycle & the average downtime per line stop will be 6.0 min. The scrap rate for the current conventional processing method is 5% & this is considered a good estimate for a transfer line. The starting costing for the component costs Rs. 1.50 each & it will cost Rs 60.00 / hr or Rs 1 / min to operate the transfer line. Cutting tools are estimated to cost Rs 0.15/ work part. Compute the following measures of line performance given the foregoing data.

(a) Production rate
(b) Number of hours required to meet a demand of 1500 units/week.
(c) Line efficiency
(d) Cost per unit produced.

Problem:

If a line has 20 work stations each with a probability of breakdown of 0.02, the cycle time of the line is 1 min & each time a breakdown occurs, it takes exactly 5 minutes to repair. The line is to be divided into two stages by a storage buffer so that each stage will consist of 10 stations. Compute the efficiency of the two stage line for various buffer capacities.

Solution:

Let us compute the efficiency of the line with no buffer

F = np = 20(0.02) =0.4

$$Eo = \frac{1.0}{1.0+0.4(10)} = 0.20$$

Next dividing the line into equal stages by a buffer zone of infinite capacity each stage would have an efficiency given by

F1 = F2 = 10 (0.02) = 0.2

$$E1 = E2 = \frac{Tc}{Tc + (F1+F2)Td} = \frac{1.0}{1.0+ 0.2(10)} = 0.333$$

d) The cost per product can be computed except that we must account for the scrap rate.

$$Cpc = \frac{1}{0.95}(1.50+1.00 \times 1.60 + 0.15) = \text{Rs.}3.42/\text{good unit}$$

The Rs.3.42 represents the average cost per acceptable product under the assumption that we are discarding the 5% bad units with no salvage value and no disposal cost. Suppose that we could repair these parts at a cost of Rs.5.00/unit. To compute the cost per piece the repair cost would be added to other components.

Cpc = 1.50 + 1.00 x 1.60 + 0.15 + 0.05 (5.00) = Rs. 3.50/unit.

The policy of scrapping the 5% defects ,yields a lower cost per unit rather than repairing them.

Problem:

An eight station rotary indexing machine operates with an ideal cycle time of 20 secs. The frequency of line stop occurrences is 0.06 stop / cycle on the average. When a stop occurs it takes an average of 3 min to make repairs. Determine the following:

1. Average production time   3. Line efficiency
2. Proportion of downtime   4. Average production rate

Solution

$Tp = Tc + F\,(Td)$

$= 0.33 + 0.06(3)$

$= 0.5133$ minutes.

$Rp = \dfrac{1}{0.5133} = 1.94$ pieces /minutes

Line efficiency $= \dfrac{Tc}{Tp} = \dfrac{0.333}{0.51} = 0.491$

Proportion of downtime can be calculated by $D = \dfrac{F\,Td}{Tp} = \dfrac{0.06(3)}{0.5133} = 0.35$

Partial Automation:

Many assembly lines in industry contain a combination of automated & manual work stations. These cases of partially automated production lines occur for two main reasons:

1. Automation is introduced gradually on an existing manual line.
Suppose that demand for the product made on a manually operated line increases, & it is desired to increase production & reduce labour costs by automating some or all of the stations. The simpler operations are automated first, & the transition toward a fully automated line is accomplished over a long period of time. Meanwhile, the line operates as a partially automated system.

2. Certain manual operations are too difficult or too costly to automate.
Therefore, when the sequence of workstations is planned for the line, certain stations are designed to be automated, whereas the others are designed as manual stations.

Examples of operations that might be too difficult to automate are assembly procedures or processing steps involving alignment, adjustment, or fine-tuning of the work unit. These operations often require special human skills and/or senses to carry out. Many inspection procedures also fall into this category. Defects in a product or a part that can be easily perceived by a human inspector are sometimes extremely difficult to identify by an automated inspection device. Another problem is that the automated inspection device can only check for the defects for which it was designed, whereas a human inspector is capable of sensing a variety of unanticipated imperfections & problems.

To analyze the performance of a partially automated production line, we build on our previous analysis & make the following assumptions:

1. Workstations perform either processing or assembly operations;

2. Processing & assembly times at automated stations are constant, though not necessarily equal at all stations;
3. Synchronous transfer of parts;
4. No internal buffer storage ;
5. The upper bound approach is applicable &
6. Station breakdowns occur only at automated stations.

Breakdowns do not occur at manual workstations because the human workers are flexible enough, we assume, to adapt to the kinds of disruptions & malfunctions that would interrupt the operation of an automated workstation. For example, if a human operator were to retrieve a defective part from the parts bin at the station, the part would immediately be discarded & replaced by another without much lost time. Of course, this assumption of human adaptability is not always correct, but our analysis is based on it.

The ideal cycle time T_c is determined by the slowest stations on the line, which is generally one of the manual stations. If the cycle time is in fact determined by a manual station, then T_c will exhibit a certain degree of variability simply because there is a random variation in any repetitive human activity. However, we assume that the average T_c remains constant over time. Given our assumption that breakdowns occur only at automated stations, let n_a = the number of automated stations & T_d = average downtime per occurrence. For the automated stations that perform processing operations, let p_i = the probability (frequency) of breakdowns per cycle; & for automated stations that perform assembly operations, let q_i & m_i equal, respectively, the defect rate & probability that the defect will cause station i to stop. We are now in a position to define the average actual production time:

$$T_p = T_c + \sum_{i \in n_a} p_i T_d \text{ --------- } 25$$

where the summation applies to the na automated stations only. For those automated stations that perform assembly operations in which a part is added,

$$p_i = m_i q_i$$

If all p_i, m_i, & q_i are equal, respectively to p, m, & q, then the preceding equations reduce to the following:

$$T_p = T_c + n_a p T_d \text{ ---------- } 26$$

and $p = mq$ for those stations that perform assembly consisting of the addition of a part.

Given that n_a is the number of automated stations, then nw = the number of stations operated by manual workers, & $n_a + n_w = n$, where n = the total station count. Let C_{asi} = cost to operate the automatic workstation i ($ / min), C_{wi} = cost to operated manual workstation
i ($ / min), C_{at} = cost to operate the automatic transfer mechanism. Then the total cost to operate the line is given by:

$$C_o = C_{at} + \sum_{i \in n_a} C_{asi} + \sum_{i \in n_w} C_{wi} \text{ -------- } 27$$

where C_o = cost or operating the partially automated production system ($ / min).
For all $C_{asi} = C_{as}$ & all
$C_{wi} = C_w$, then
$C_o = C_{at} + n_a C_{as} + n_w C_w$ -------- 28

Now the total cost per unit produced on the line can be calculated as follows:

$$C_{pc} = \frac{C_m + C_o T_p + C_t}{P_{ap}} \text{ ---------- 29}$$

Where C_{pc} = cost per good assembly ($ / pc), C_m = cost of materials & components being processed & assembled on the line ($ / pc),
C_o = cost of operating the partially automated production system by either of the equations 27 or 28
($ / min), T_p = average actual production time (min / pc), C_t = any cost of disposable tooling ($ / pc), & P_{ap} = proportion of good assemblies.

Problem on Partial Automation:

It has been proposed to replace one of the current manual workstations with an automatic work head on a ten-station production line. The current line has six automatic stations & four manual stations. Current cycle time is 30 sec. The limiting process time is at the manual station that is proposed for replacement. Implementing the proposal would allow the cycle time to be reduced to 24 sec. The new station would cost $0.20/min. Other cost data: C_w = $0.15/min,
C_{as} = $0.10/min, & C_{at} = $0.12/min. Breakdowns occur at each automated station with a probability p = 0.01. The new automated station is expected to have the same frequency of breakdowns. Average downtime per occurrence T_d = 3.0min, which will be unaffected by the new station. Material costs & tooling costs will be neglected in the analysis. It is desired to compare the current line with the proposed change on the basis of production rate & cost per piece. Assume a yield of 100% good product.

Solution:

For the current line,
T_c = 30 sec = 0.50min.
T_p = 0.50 + 6(0.01)(3.0) = 0.68 min.
R_p = 1/0.68 = 1.47 pc/min = 88.2pc/hr
C_o = 0.12 + 4(0.15) + 6 (0.10)
= $1.32 / min
C_{pc} = 1.32 (0.68) = $0.898 / pc

For the proposed line,
T_c = 24 sec = 0.4 min.
R_p = 1/0.61 = 1.64 pc/min = 98.4pc/hr
C_o = 0.12 + 3(0.15)+ 6(0.10)+ 1(0.20)

$= \$1.37/min$
$C_{pc} = 1.67(0.61) = \$0.836$ / pc

Even though the line would be more expensive to operate per unit time, the proposed chage would increase production rate & reduced piece cost.

Storage Buffers:

The preceding analysis assumes no buffer storage between stations. When the automated portion of the line breaks down, the manual stations must also stop for lack of work parts (either due to starving or blocking, depending on where the manual stations are located relative to the automated stations). Performance would be improved if the manual stations could continue to operate even when the automated stations stop for a temporary downtime incident. Storage buffers located before & after the manual stations would reduce forced downtime at these stations.

Problem on Storage Buffers on a Partially Automated Line:

Considering the current line in the above example, suppose that the ideal cycle time for the automated stations on the current line T_c = 18 sec. The longest manual time is 30 sec. Under the method of operation assumed in the above example both manual & automated stations are out of action when a breakdown occurs at an automated station. Suppose that storage buffers could be provided for each operator to insulate them from breakdowns at automated stations. What effect would this have on production rate & cost per piece?

Solution:

Given T_c = 18sec = 0.3min, the average actual production time on the automated stations is computed as follows:

$$T_p = 0.30 + 6(0.01)(3.0) = 0.48\text{min}$$

Since this is less than the longest manual time of 0.50, the manual operation could work independently of the automated stations if storage buffers of sufficient capacity were placed before & after each manual station. Thus, the limiting cycle time on the line would be
T_c = 30sec = 0.50 min, & the corresponding production rate would be:

$R_p = R_c = 1/0.50 = 2.0$pc/min
$= 120.0$ pc/hr

Using the line operating cost from the previous example, C_o = \$1.32/min, we have a piece cost of

$$C_{pc} = 1.32\ (0.50) = \$0.66 \text{ / pc}$$

Comparing with the previous example, we can see that a dramatic improvement in production rate & unit cost is achieved through the use of storage buffers.

Problem on Partial Automation:

A partially automated production line has a mixture of three mechanized & three manual workstations. There are a total of six stations, & the ideal cycle time T_c = 1.0 min, which includes a transfer time T_r = 6 sec. Data on the six stations are listed in the following table. Cost of the transfer mechanism C_{at} = \$0.10/min, cost to run each automated station C_{as} = \$ 0.12/min, & labour cost to operate each manual station C_w = \$ 0.17 /min. It has been proposed to substitute an automated station in place of station 5. The cost of this station is estimated at

C_{as5} = \$ 0.25 / min, & its breakdown rate P_5 = 0.02, but its process time would be only 30 sec, thus reducing the overall cycle time of the line from 1.0 min to 36 sec. Average downtime per breakdown of the current line as well as the proposed configuration is T_d = 3.5 min. Determine the following for the current line & the proposed line: (a) production rate, (b) proportion uptime, & (c) cost per unit. Assume the line operates without storage buffers, so when an automated station stops, the whole line stops, including the manual stations. Also, in computing costs, neglect material & tooling costs.

Station	Type	Process Time (sec)	p_i
1	Manual	36	0
2	Automatic	15	0.01
3	Automatic	20	0.02
4	Automatic	25	0.01
5	Manual	54	0
6	Manual	33	0

Solution : Tc = 1.0 min

Tp = 1.0 + 2(0.01)x3.5 + 1(0.02) x 3.5 = 1.14 mins

Rp = $\frac{1}{1.14}$ = 0.877 pcs /min x 60 = 52.65 pcs / hr

Cp = 0.12 + 3(0.17) + 3(0.10) = \$ 0.93/mins

Cpc = 0.93x 1.14 = \$1.062/piece

For the proposed line Tc = 36 secs = 0.6 mins

Tp = 0.6 + 2(0.01)3.5 + 2(0.02)3.5 = 0.81 mins

Rp = 1.234 pieces / min = 74.07 pieces/hr

Cp = 0.012 + 2(0.17) + 3(0.10) + 1(0.25) = \$ 0.902/min Cpc = 0.90 x 0.81 mins = \$ 0.73062/piece

UNIT II
POWER POINT PRESENTATION SLIDES

INTRODUCTION TO MANUFACTURING HISTORY:

- Manufacturing has been a human activity for a very long time. Ancient man produced stone articles by using his muscular power.
- Earlier manufacturing remained in the hands of Artisans and their apprentices and earlier developments in manufacturing took place in their supervision.
- Probably copper is the first metal melted by man. Excavations of Mohenjo-Daro and Harappa (5000 BC) shows the metal and jewellery work. There are examples of in Greek and Roman civilizations that their craftsman used casting process.
- Invention of copper, bronze and then Iron age converted ancient civilization into Indus valley, China, Egypt, Mesopotamia and Babylon.

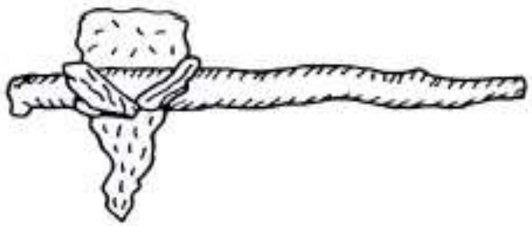
CONTD….

- Concept of machining is also very old. It is believed that the idea of Lathe, the turning machine has been derived from the potter s wheel that existed before 2500 BC.
- The round groove marks on wooden bowls shows that turning was practiced as early as 1700 BC and was perfected before 6th century.

Potter's wheel

CONTD…

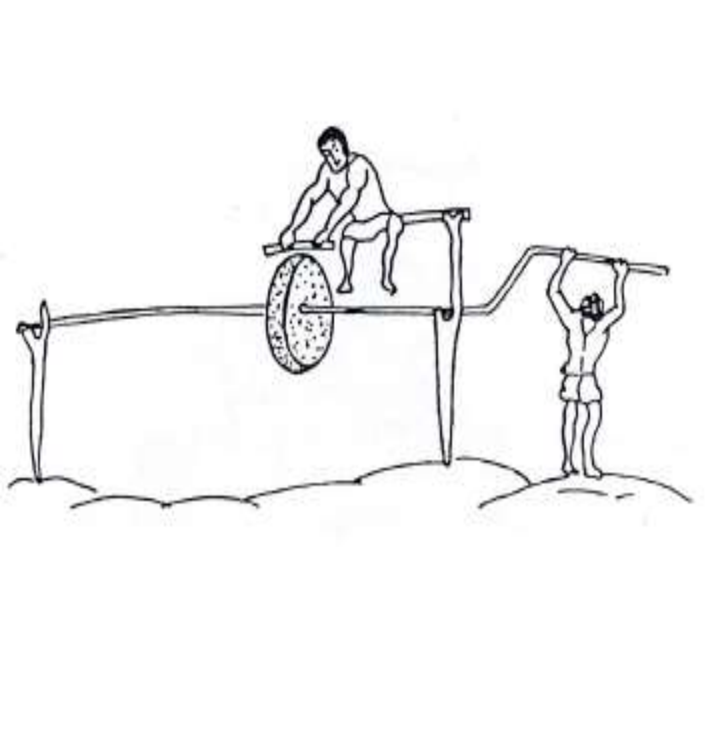
- The concept of tool angles is also not new.
- The primitive man started thinking of tools in which a proper shaped tool used to be tied with wooden branch.
- Later, stone piece was replaced by the metallic piece



Hand-held tool with tree branch as a lever

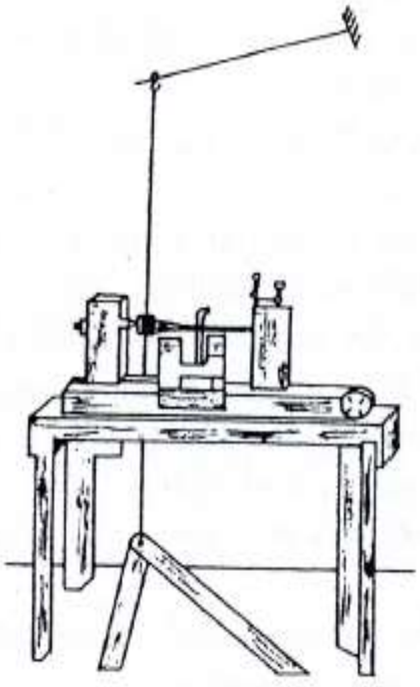
CONTD….

- Idea of rotating stone wheel for producing sharp edges brought the concept of grinding.
- Wheels mounted on the spindle with crank for started appearing around 850 AD



CONTD…

- The earliest known machine tool: Lathe (1400 AD) Earlier alternating motion was given to wooden work piece and tool was kept stationary on hands.
- Later a continuous unidirectional motion was attempted by winding an endless rope around a spindle and passing it over a flywheel which was rotated by hand.
- Wooden plank lath, so name Lathe has derived.



Lathe, 1400 AD (After Steeds, 1969).

CONTD…

- Drilling was carried by winding a cord on the sharp metallic linear piece and attaching its end to the rod.
- The art of forge welding was attempted during 2500 BC but it took a reasonably better shape around 1000 BC.
- Use of filler material

Wire drawing setup (1000 AD).

CONTD…

- After the discovery of iron the development of hot forging, forge welding and grinding became imperative. The concept of grinding was although old but giving it unidirectional motion took many years (1450 AD).
- Many distinguishing features of modern machine tools were anticipated in design by small scale clock makers. During 1480 AD a German clock maker introduced the concept of screw cutting (quality was poor)on Lathe machine.
- After a long around 1780 AD Ramsden produced accurate screw thread cutting lathe by producing a series of screw threads

CONTD…

- During the later half of 17th century use of timber was replaced by coal for iron smelting but it could not lead to good results because used coal was surface coal. Thus deeper mining became a necessity but was a problem as no higher capacity pumps were available.
- Newcomen's engine was installed in coal mines but could not solve the purpose because of their huge size and inefficiency. James Watt (1762 AD) tried to solve the problem by using his steam engine up to a maximum. Watt patented (1769 AD) his engine however he failed to develop full size engine. His

CONTD…

- John Wilkinson (1728-1808 AD), the great iron maker, developed various kinds of water powered boring machines for producing iron cannons. He was the only cylinder maker who could face the challenges made by Watt. In 1775 AD Watt s attempt was successful. Later Wilkinson used Watt s engine to drive his boring machine

CONTD…

- By the end of 18th century the steam engine power was available in large quantities at many locations which caused *First Industrial Revolution.*
- This led to the growth of *Production and Mechanization*. The *Soho Foundry (LONDON) was established in 1796 AD* with steam engines was considered as Engineering Workshop of that time. By 1820 AD steam power driven *machine tools were ready for the sale.*
- Now the need for high strength material was felt which was met by Carbon Steels. Liebig (1831 AD) could perfectly analyze and determine the effect of

CONTD...

- Henry Maudslay (1771-1831 AD) brought several new concepts in machine tool design. He introduced the *tool slide and rest with tool head in 1794 AD. It was equipped* with *lead screw and had provision for taper turning. He* also produced number of screw cutting machines. In 1805 AD, first micrometer was designed by him.
- During 1825-1865 AD machine tools *like planning, shaping, drilling, punching slotting, milling etc. were* developed.
- The need for strong marine vessel led to introduction of *rolling mills that produced iron flats for ships which* crossed Atlantic in 1882 AD

CONTD…

- By the mid of 19th century *Britain became the leading country in* science and technology.
- True industrial revolution started when the concept of *mass production was introduced in 1748 AD to lower the production* cost so that the benefits of engineering could reach to common man.
- Proliferation of machines started and a large number of special purpose machines, automatic and semi automatic machines were designed and developed. The trend was to move towards *mechanization and hard automation*

CONTD…

- Whitney introduced the concept of *interchangeability in the* end of 18th century.
- This needed more close tolerances therefore need for high speed stone tools (grinding) felt and development in *precision grinding took place around 1900 AD.*
- Significant improvement in *welding processes also took* place during this time. Use of *metallic molds and patterns came into scene so that* precise casting could be achieved.
- *Polymer products were developed during 1925-1950*

CONTD…

- *Second industrial revolution started during mid of 20th* century with the enormous growth in solid state electronics and computers, that can perform tasks very rapidly efficiently with lower cost.
- In this age attempt was to enhance and sometimes even *replace the mental efforts.* The trend was now to move towards *flexible automation.*
- Today the era of mass production and hard automation is going away and is being replaced by batch production and flexible automation.

CONTD…

- The first step in this direction is *Numerically Controlled machine tools in which the motion of* slides is controlled by numerals and letters. The microprocessor based systems and feed back devices provide better accuracy and precision.

HISTORICAL DEVELOPMENT OF MANUFACTURING PROCESSES (SUMMARIZED)

Year	Material	Casting	Forming	Machining	Welding
4000 BC	Gold Silver Copper	Clay mould	Cold forging	Stone tools	
2500 BC	Bronze	Lost wax process	Sheet metal forming	Drilling	Brazing
1000 BC	Iron		Hot forging	Iron saw	Forge welding
0 AD	Brass			Wood Turning Stone grinding	

CONTD…

Year	Material	Casting	Forming	Machining	Welding
1000 AD			Wire drawing		
1400 AD		Sand casting	Water hammer	Pole lathe	
1600 AD		Permanent mould	Lead rolling	Wheel lathe	
1800 AD	Carbon steel		Steel rolling Deep drawing Lead extrusion	Turning Boring Screw cutting	

CONTD…

Year	Material	Casting	Forming	Machining	Welding
1900 AD	HSS Al oxide		Tube extrusion	Electric drive, Gear cutting, Hobbing,	Gas welding, Arc welding
1920 AD	WC	Die casting		Special purpose machines	Coated electrodes
1940 AD	Plastics		Hot extrusion		
1950 AD			Cold extrusion	EDM, ECM, USM	TIG, MIG
1980 AD				Robots, CAM, FMS	

MODERN MANUFACTURING APPROACHES AND TECHNOLOGIES

- *Automation* - automated equipment instead of labor
- *Material handling technologies* - because manufacturing usually involves a sequence of activities
- *Manufacturing systems* - integration and coordination of multiple automated or manual workstations
- *Flexible manufacturing* - to compete in the low-volume/high-mix product categories
- *Quality programs* - to achieve the high quality expected by today's customers
- *CIM* - to integrate design, production, and

PRODUCTION SYSTEM DEFINED

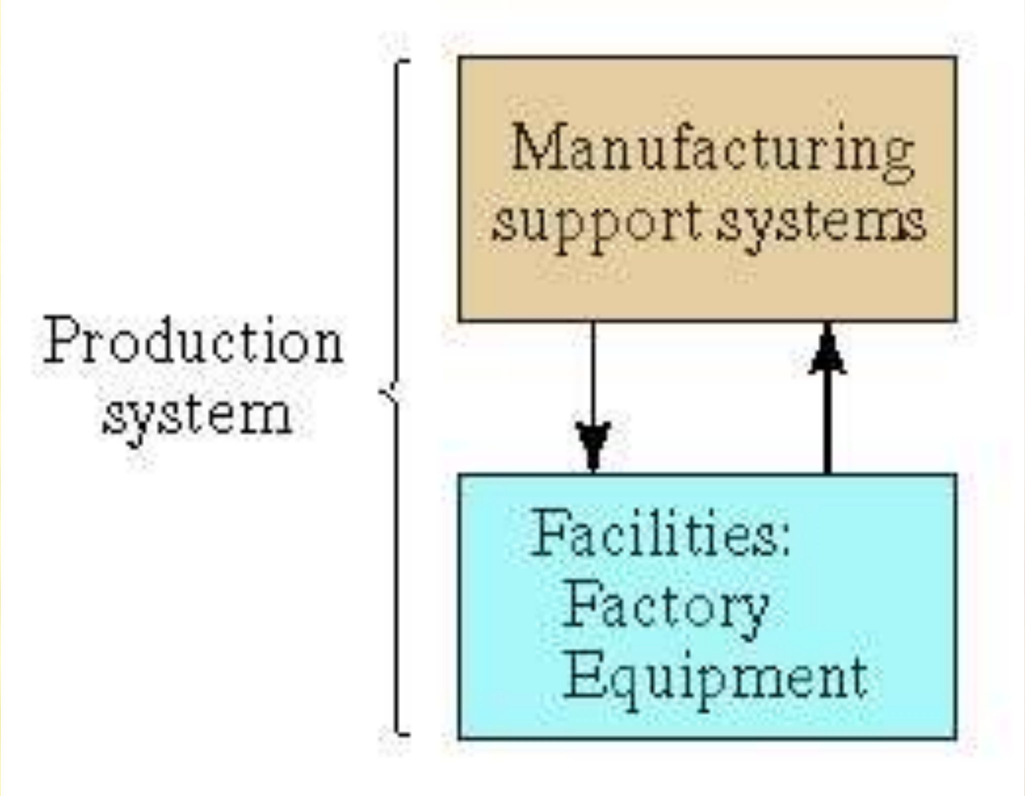
A collection of people, equipment, and procedures organized to accomplish the manufacturing operations of a company

Two categories:

- *Facilities* – the factory and equipment in the facility and the way the facility is organized (plant layout)
- *Manufacturing support systems* – the set of procedures used by a company to manage production and to solve technical and logistics problems in ordering materials, moving work through the factory, and ensuring that products meet quality

THE PRODUCTION SYSTEM

Fig. 1.1



PRODUCTION SYSTEM FACILITIES

Facilities include the factory, production machines and tooling, material handling equipment, inspection equipment, and computer systems that control the manufacturing operations

- *Plant layout* – the way the equipment is physically arranged in the factory
- *Manufacturing systems* – logical groupings of equipment and workers in the factory
  - Production line
  - Stand-alone workstation and worker

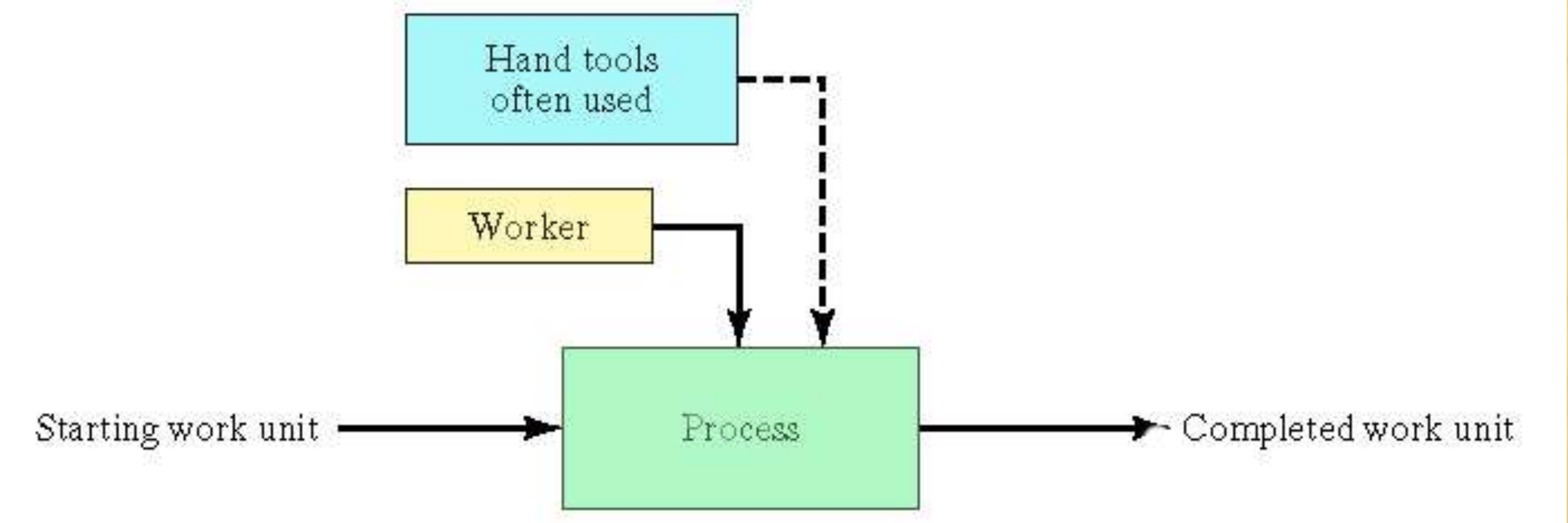
MANUFACTURING SYSTEMS

Three categories in terms of the human participation in the processes performed by the manufacturing system:

1. *Manual work systems* - a worker performing one or more tasks without the aid of powered tools, but sometimes using hand tools
2. *Worker-machine systems* - a worker operating powered equipment
3. *Automated systems* - a process performed by a machine without direct participation of a human

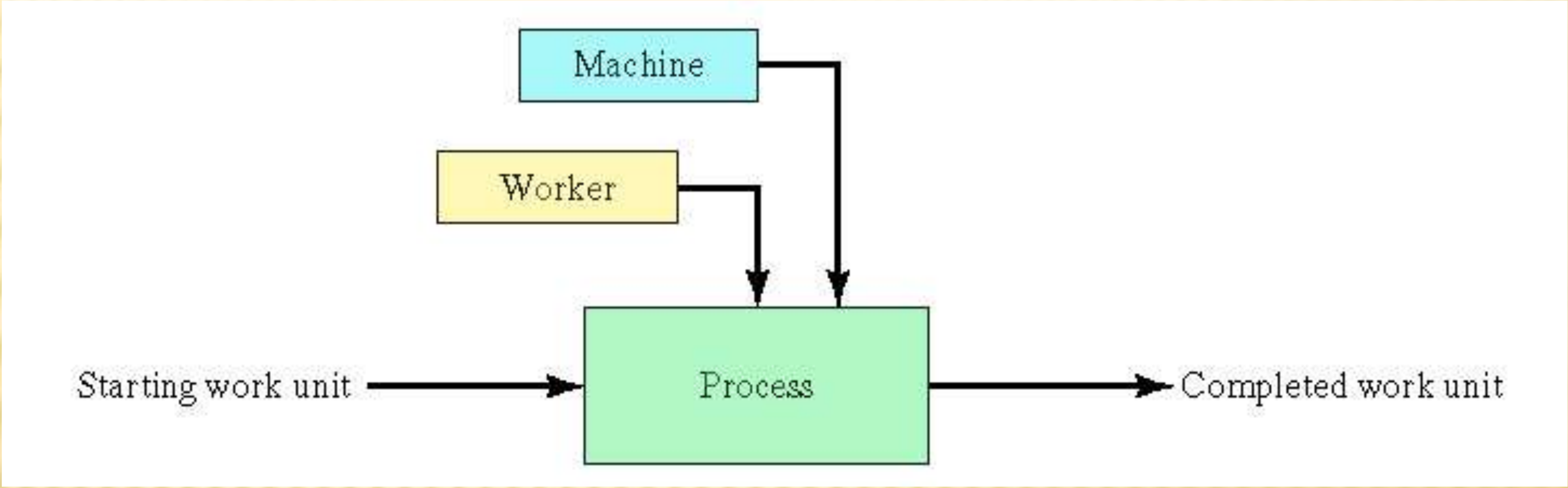
MANUAL WORK SYSTEM

Fig. 1.2 (a)



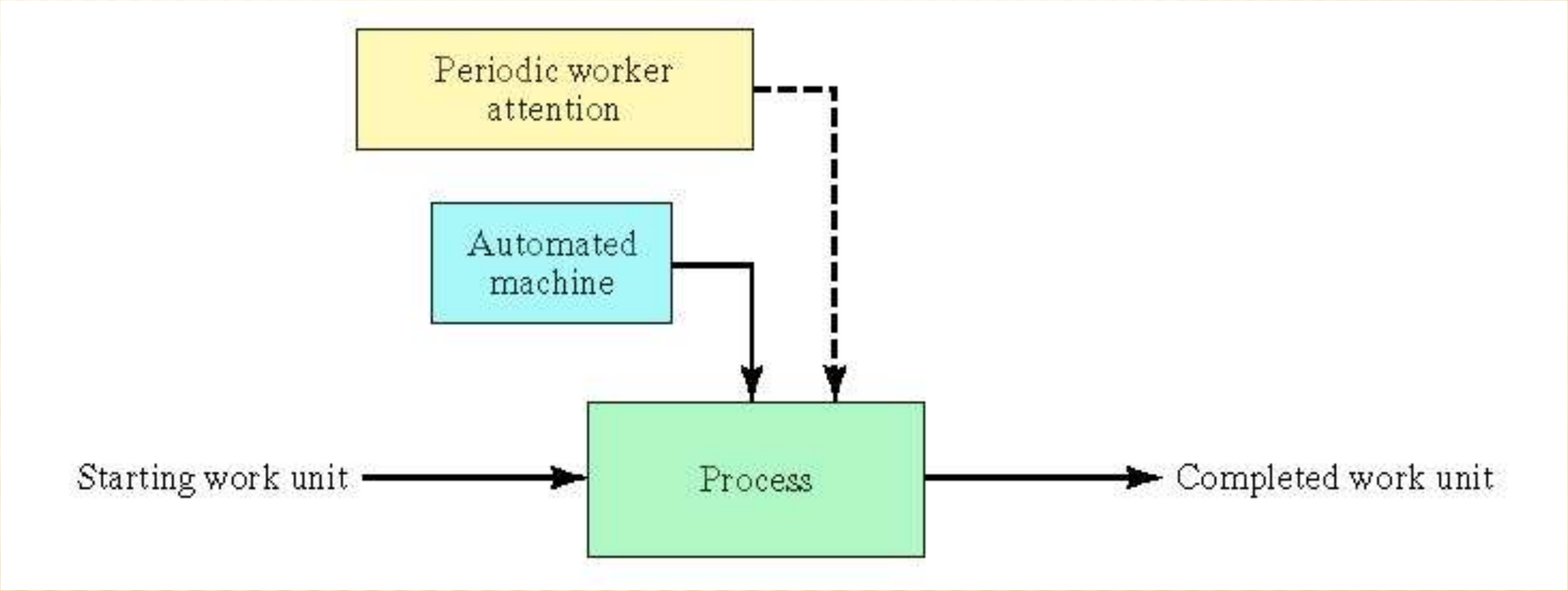
WORKER-MACHINE SYSTEM

Fig. 1.2 (b)



AUTOMATED SYSTEM

Fig. 1.2. (c)



WHAT IS MANUFACTURING?

- The word *manufacture* is derived from two Latin words: *manus* (hand) and *factus* (make); the combination means “made by hand”
- “Made by hand” accurately described the fabrication methods that were used when the English word “manufacture” was first coined around 1567 A.D.
- Most modern manufacturing operations are accomplished by mechanized and automated equipment that is supervised by human workers

MANUFACTURING - TECHNOLOGICALLY

- Application of physical and chemical processes to alter the geometry, properties, and/or appearance of a starting material to make parts or products
- Manufacturing also includes assembly
- Almost always carried out as a sequence of operations

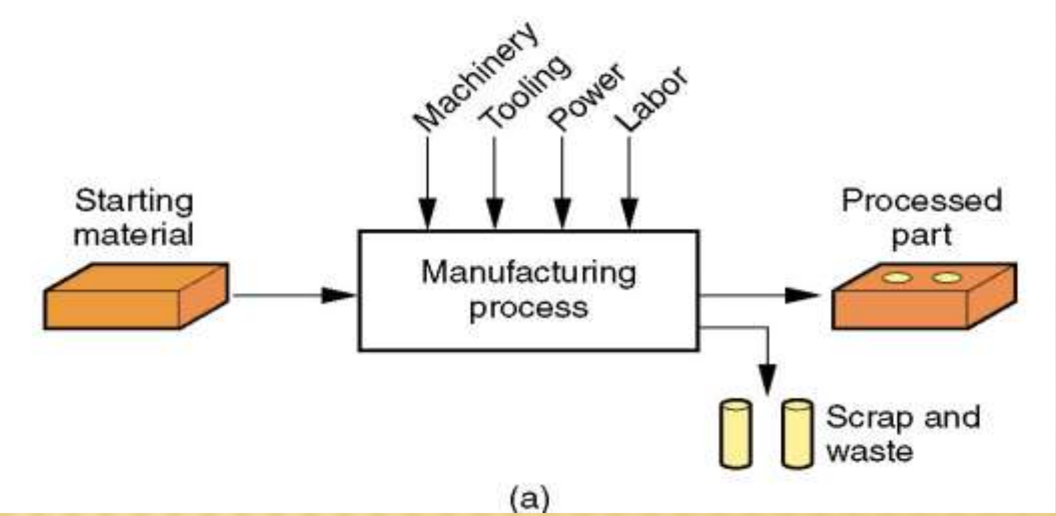


Figure 1.3 (a) Manufacturing as a technical process

PRODUCTION QUANTITY Q

- The quantity of products Q made by a factory has an important influence on the way its people, facilities, and procedures are organized
- Annual production quantities can be classified into three ranges:
- Production range Annual Quantity Q
- Low production 1 to 100 units
- Medium production 100 to 10,000

PRODUCT VARIETY *P*

- Product variety *P* refers to different product types or models produced in the plant
- Different products have different features
  - They are intended for different markets
  - Some have more parts than others
- The number of different product types made each year in a factory can be counted
- When the number of product types made in the factory is high, this

MORE ABOUT PRODUCT VARIETY

- Although *P* is a quantitative parameter, it is much less exact than *Q* because details on how much the designs differ is not captured simply by the number of different designs
- *Soft product variety* - small differences between products, e.g., between car models made on the same production line, with many common parts among models
- *Hard product variety* - products differ substantially, e.g., between a small car and a large truck, with few common parts (if any)

MANUFACTURING PROCESSES

- Two basic types:

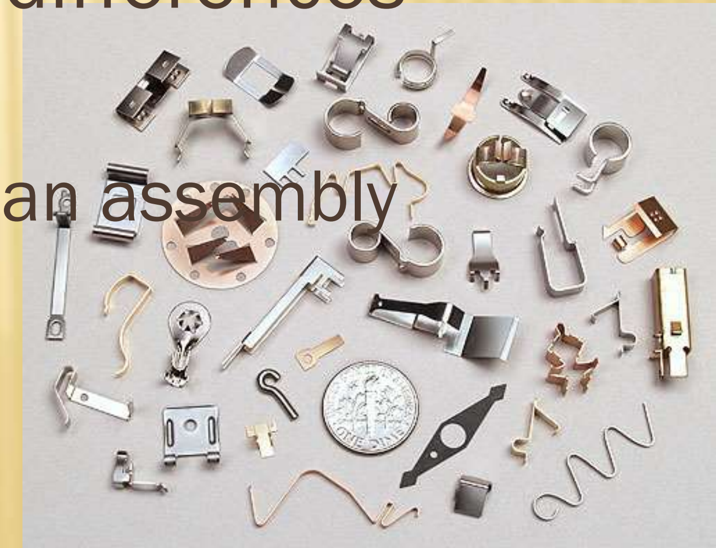
1. Processing operations - transform a work material from one state of completion to a more advanced state
   - Operations that change the geometry, properties, or appearance of the starting material
2. Assembly operations - join two or more components to create a new entity

PRODUCTION FACILITIES

- The factory, production equipment, and material handling systems
- Production facilities "touch" the product
- Includes the way the equipment is arranged in the factory - the *plant layout*
- Equipment usually organized into logical groupings, called *manufacturing systems*
  - Examples:
    - Automated production line
    - Machine cell consisting of an industrial robot and two machine tools

PRODUCT VARIETY (P)

- Number of different product or part designs or types
- 'Hard' product variety – products differ greatly
  - Few common components in an assembly
- 'Soft' product variety – small differences between products
  - Many common components in an assembly



LOW PRODUCTION QUANTITY (Q_{LOW})

Job shop – makes low quantities of specialized and customized products

- Products are typically complex (e.g., specialized machinery, prototypes, space capsules)
- Equipment is general purpose
- Plant layouts:
  - Fixed position
  - Process layout

MEDIUM PRODUCTION

- Two different types of facility, depending on product variety:
- *Batch production*
  - Suited to hard product variety
  - Setups required between batches
- *Cellular manufacturing*
  - Suited to soft product variety
  - Worker cells organized to process parts without setups between different part styles

MEDIUM PRODUCTION QUANTITIES (Q_{MED})

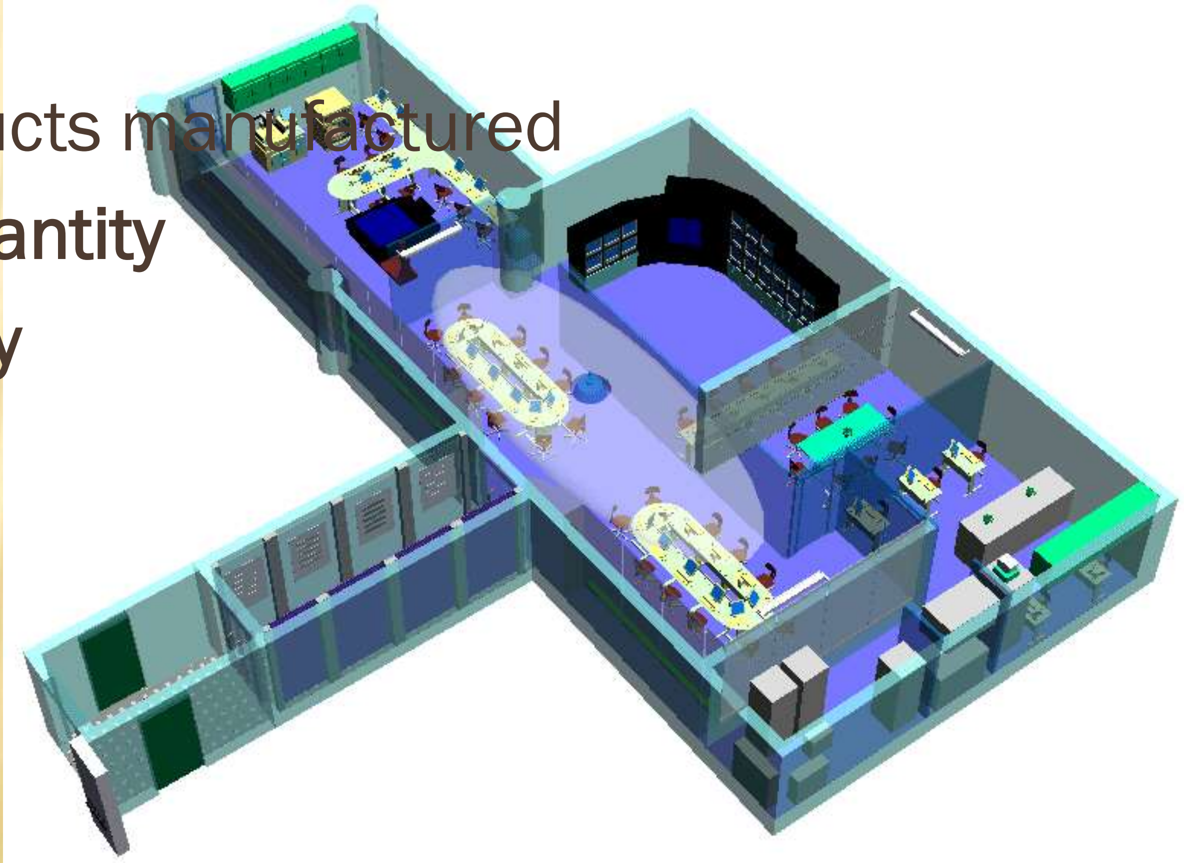
1. Batch production – A batch of a given product is produced, and then the facility is changed over to produce another product
   - Changeover takes time – setup time
   - Typical layout – process layout
   - Hard product variety
2. Cellular manufacturing – A mixture of products is made without significant changeover time between products
   - Typical layout – cellular layout
   - Soft product variety

HIGH PRODUCTION (Q_{HIGH})

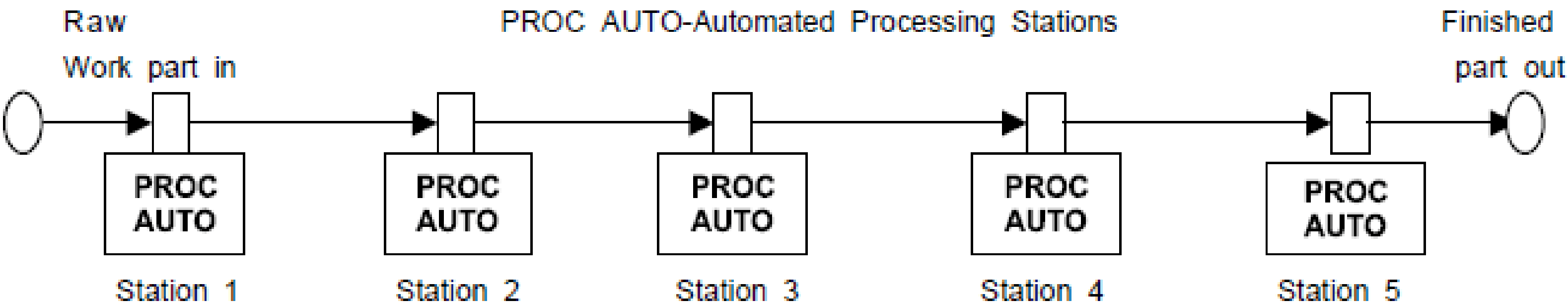
1. Quantity production – Equipment is dedicated to the manufacture of one product
   - Standard machines tooled for high production (e.g., stamping presses, molding machines)
   - Typical layout – process layout
2. Flow line production – Multiple workstations arranged in sequence
   - Product requires multiple processing or assembly steps
   - Product layout is most common

PRODUCTION FACILITIES AND LAYOUT

- Facilities organised in the most efficient way to serve the particular mission of the plant and depends on:
  - Types of products manufactured
  - Production **quantity**
  - Product **variety**



UNIT II
INDUTRIAL APPLICATIONS


Raw
Work part in
PROC AUTO-Automated Processing Stations
Finished
part out
PROC AUTO
Station 1
PROC AUTO
Station 2
PROC AUTO
Station 3
PROC AUTO
Station 4
PROC AUTO
Station 5

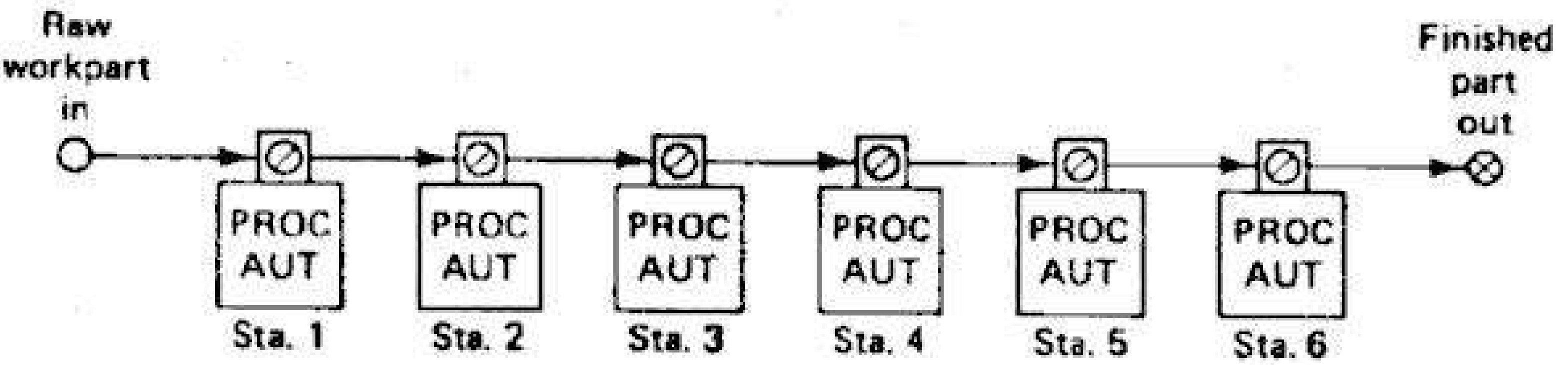


FIGURE 4.1 Configuration of an automated flow line.

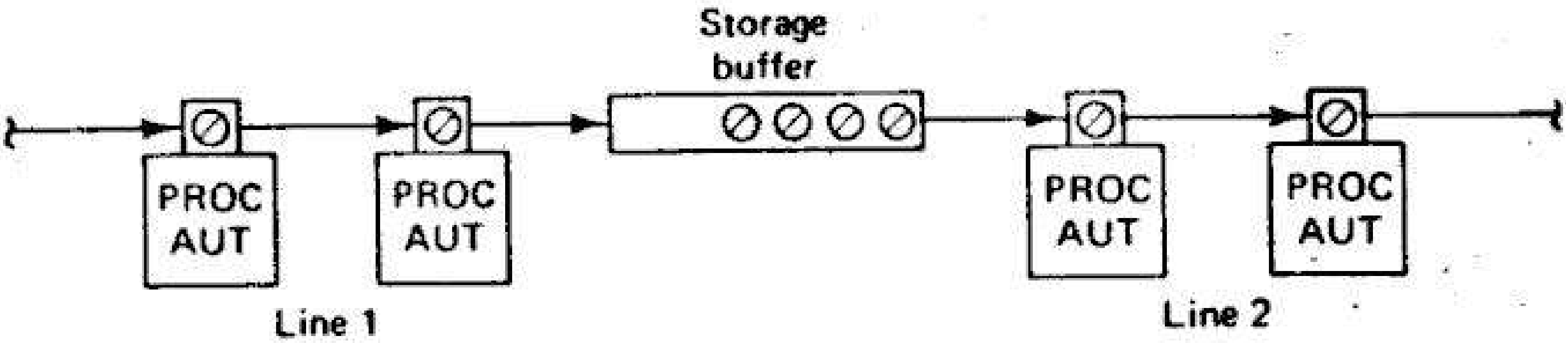


FIGURE 4.10 Two flow lines separated by storage buffer.

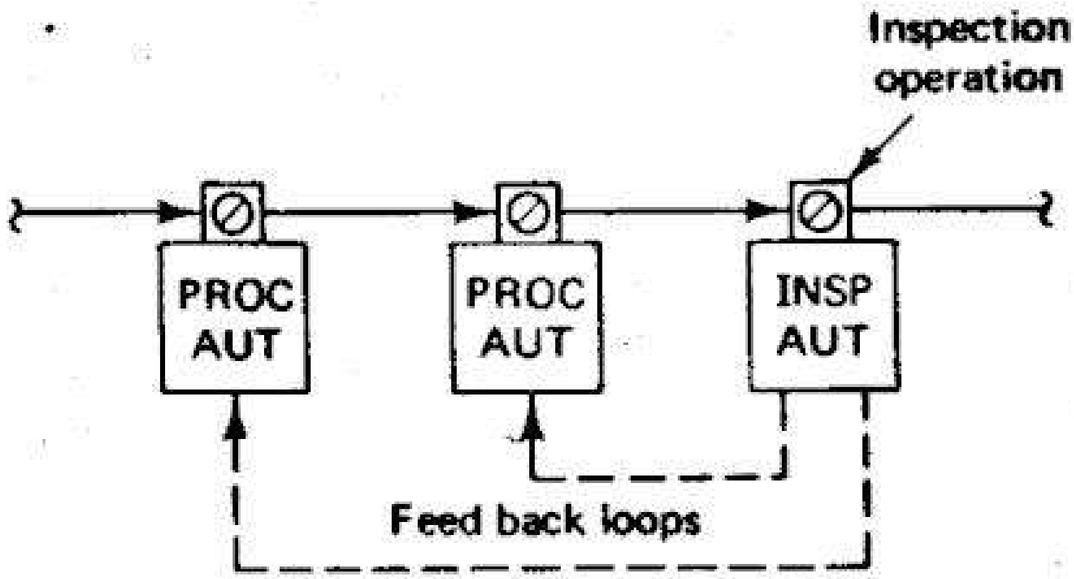


FIGURE 4.11 Inspection station with feedback loops to upstream workstations.

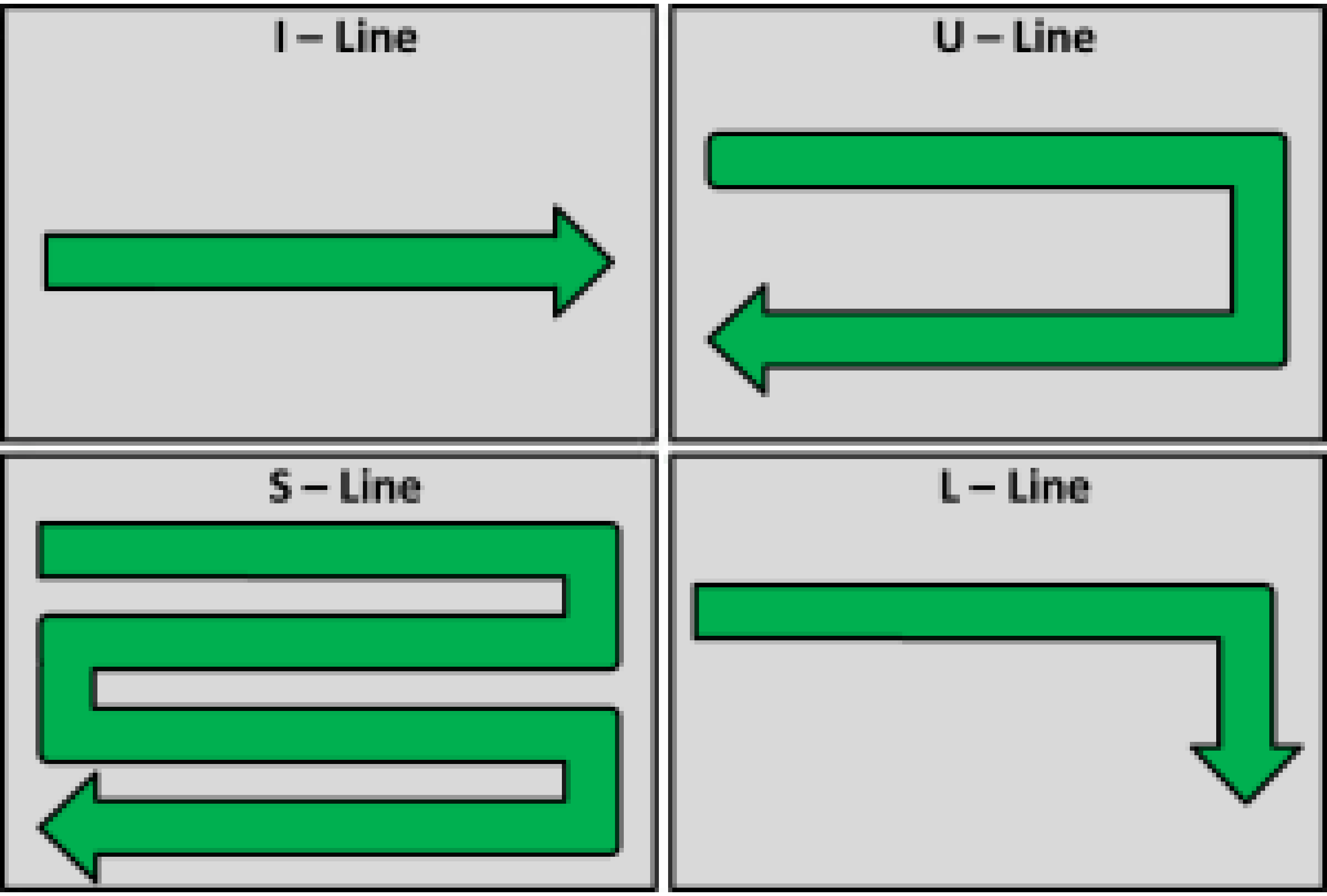
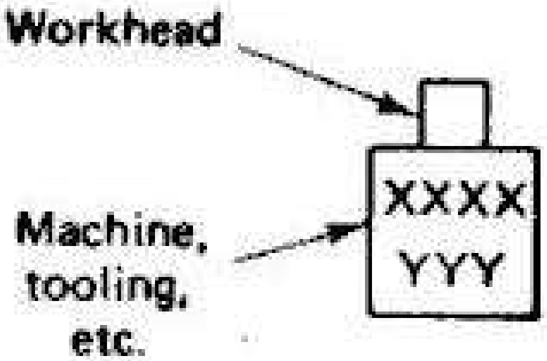
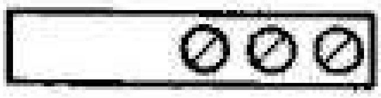

I – Line
U – Line
S – Line
L – Line

TABLE 4.1 Symbols used in the Production Systems Diagrams

Symbol	Component
	• Workstation XXXX: PROC = processing station ASBY = assembly station INSP = inspection station SORT = sortation station YYY: AUT = automated MAN = manual
	• Material handling system (arrow indicates work flow direction)
	• Workpart
○	Raw workpart
⊘	Partially processed part
⊗	Finished part
	• Storage buffer
	• Data/information flow

UNIT II

ASSIGNMET

Unit-II

1. a). What are the methods used in industry to accomplish the assembly process?

   b). What are the two ways in which transfer of workpart takes place between workstations?

2. a). What is Buffer storage? Explain the reasons for the use of Buffer storage zones.

   b). What are the methods of transporting work pieces on flow lines? Explain them.

3. The following data apply to a 10-station in-line transfer machine: P = 0.01 (all stations have an equal probability of failure)

T_c = 0.3 min
T_d = 3.0 min

Using the upper-bound approach. Compute the following for the transfer machine:
(i) F, the frequency of line stops.
(ii) (ii) R_p, the average production rate.
(iii) E, the line efficiency.

4. A 30-station transfer line has an ideal cycle time Tc=0.75 min, an average downtime Td = 6.0 min per line stop occurrence, and a station failure frequency p = 0.01 for all stations. A storage buffer is located between stations 15 and 16 to improve the line efficiency. Using the upper bound approach, determine

(i). The current line efficiency and production rate.

(ii). Maximum possible line efficiency and production rate because of storage buffer.

5.

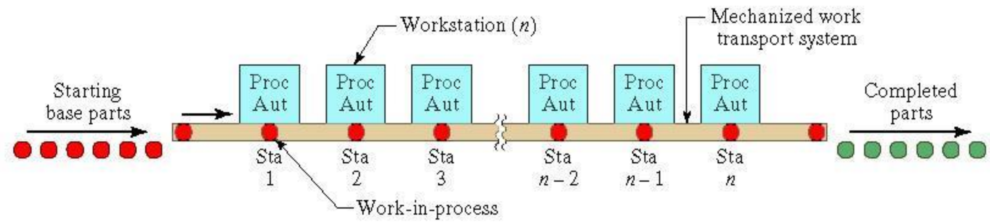
a) What is a transfer line? Explain any two work part transfer methods.
b) Write short note on partial automation.

UNIT II

SHORT ‘Q’ & TUTORIAL

UNIT-II

1. **What is Automated Flow line?**
   An automated flow line consists of several machines or workstations which are linked together by work handling devices that transfer parts between the stations. The transfer of work parts occurs automatically and the workstations carry out their specialized functions automatically.
2. **Draw in-line configuration of automated flow line.**



3. **What are the objectives of flow line automation?**
   The objectives of the use of flow line automation are
   To reduce labor costs

   To increase production rates

   To reduce work-in-process

   To minimize distances moved between operations

4. **What is Segmented In-Line Type configuration?**

   The segmented *in-line* configuration consists of two or more straight-line arrangement which is usually perpendicular to each other with L-Shaped or U-shaped or Rectangular shaped.
   The flow of work can take a few 90° turns, either for work pieces reorientation, factory layout limitations, or other reasons, and still qualify as a straight-line configuration.
5. **What is Rotary type configuration?**

   In the *rotary* configuration, the work parts are indexed around a circular table or dial. The workstations are stationary and usually located around the outside periphery of the dial. The parts ride on the rotating table and arc registered or positioned, in turn, at each station for its processing or assembly operation.

6. **What are the methods of work part transport?**

The general methods of transporting work pieces on flow lines can be classified into the following three categories:

a) Continuous transfer

b) Intermittent or synchronous transfer

c) Asynchronous or power-and-free transfer

7. What are the Reasons for using storage buffers?

- To reduce effect of station breakdowns
- To provide a bank of parts to supply the line
- To provide a place to put the output of the line
- To allow curing time or other required delay
- To smooth cycle time variations

8. What are the disadvantages of buffer storage on flow lines?

The disadvantages of buffer storage on flow lines are increased factory floor space, higher in-process inventory, more material handling equipment, and greater complexity of the overall flow line system.

9. What is Single-station machine?

These mechanized production machines perform several operations on a single work part which is fixtured in one position throughout the cycle. The operations are performed on several different surfaces by work heads located around the piece.

10. What is buffer storage?

Automated flow lines are often equipped with additional features beyond the basic transfer mechanisms and workstations. It is not uncommon for production flow lines to include storage zones for collecting banks of work parts along the line.

UNIT III
ASSEMBLY SYSTEM AND LINE BALANCING

Objective:

- To perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts.

Outcome:

- Worker-and-machine combination or a worker using hand tools

Assembly system and line balancing: Assembly process and systems assembly line, line balancing methods, ways of improving line balance, flexible assembly lines

UNIT- III

ANALYSIS OF AUTOMATED FLOW LINE & LINE BALANCING

General Terminology & Analysis:

There are two problem areas in analysis of automated flow lines which must be addressed:

R Process Technology

R Systems Technology

Process Technology refers to the body of knowledge about the theory & principles of the particular manufacturing process used on the production line. E.g. in the manufacturing process, process technology includes the metallurgy & machinability of the work material, the correct applications of the cutting tools, chip control, economics of machining, machine tools alterations & a host of other problems. Many problems encountered in machining can be overcome by application of good machining principles. In each process, a technology is developed by many years of research & practice.

Terminology & Analysis of transfer lines with no Internal storage:

There are a few assumptions that we will have to make about the operation of the Transfer line & rotary indexing machines:

1. The workstations perform operations such as machining & not assembly.
2. Processing times at each station are constant though they may not be equal.
3. There is synchronous transfer of parts.
4. No internal storage of buffers.

In the operation of an automated production line, parts are introduced into the first workstation & are processed and transported at regular intervals to the succeeding stations. This interval defines the ideal cycle time, Tc of the production line. Tc is the processing time for the slowest station of the line plus the transfer time; i.e. :

$$T_c = \max (T_{si}) + T_r \quad \text{----------------} (1)$$

T_c = ideal cycle on the line (min)

T_{si} = processing time at station (min)

T_r = repositioning time, called the transfer time (min)

In equation 1, we use the max (T_{si}) because the longest service time establishes the pace of the production line. The remaining stations with smaller service times will have to wait for the slowest station. The other stations will be idle.

In the operation of a transfer line, random breakdowns & planned stoppages cause downtime on the line.

Common reasons for downtime on an Automated Production line:

1. Tool failures at workstations.
2. Tool adjustments at workstations
3. Scheduled tool charges
4. Limit switch or other electrical malfunctions.

1. Mechanical failure of a workstation.
2. Mechanical failure of a transfer line.
3. Stock outs of starting work parts.
4. Insufficient space for completed parts.
5. Preventive maintenance on the line worker breaks.

The frequency of the breakdowns & line stoppages can be measured even though they occur randomly when the line stops, it is down for a certain average time for each downtime occurrence. These downtime occurrences cause the actual average production cycle time of the line to be longer than the ideal cycle time.

The actual average production time T_p:

$$T_p = T_c + FT_d \quad \text{------------------------ 2}$$

F = downtime frequency, line stops / cycle

Td = downtime per line stop in minutes

The downtime Td includes the time for the repair crew to swing back into action, diagnose the cause of failure, fix it & restart the drive.

FT_d = downtime averaged on a per cycle basis

Production can be computed as a reciprocal of Tp

$$R_p = \frac{1}{T_p} \quad \text{---------------------------- 3}$$

Where, R_p = actual average production rate (pc / min)

T_p = the actual average production time

The ideal production rate is given by

$$R_c = \frac{1}{T_c} \quad \text{----------------------------- 4}$$

Where R_c = ideal production rate (pc / min)

Production rates must be expressed on an hourly basis on automated production lines.

The machine tool builder uses the ideal production rate, Rc, in the proposal for the automated transfer line & calls it as the production rate at 100% efficiency because of downtime. The machine tool builder may ignore the effect of downtime on production rate but it should be stated that the amount of downtime experienced on the line is the responsibility of the company using the production line.

Line efficiency refers to the proportion of uptime on the line & is a measure of reliability more than efficiency.

Line efficiency can be calculated as follows:

$$E = \frac{T_c}{T_p} = \frac{T_c}{T_c + FT_d} \quad \text{---------------- 5}$$

Where E = the proportion of uptime on the production line.

An alternative measure of the performance is the proportion of downtime on the line which is given by:

$$D = \frac{FT_d}{T_p} = \frac{FTd}{Tc} + FT_d \text{ ----------------- } 6$$

Where D = proportion of downtime on the line

$$E + D = 1.0$$

An important economic measure of the performance of an automated production line is the cost of the unit produced. The cost of 1 piece includes the cost of the starting blank that is to processed, the cost of time on the production line & the cost of the tool consumed. The cost per unit can be expressed as the sum of three factors:

$$Cpc = Cm + CoTp + Ct \text{ ------------------------ } 7$$

Where Cpc = cost per piece (Rs / pc)

Cm = cost per minute to operate the time (Rs / min)

Tp = average production time per piece (min / pc)

Ct = cost of tooling per piece (Rs / pc)

Co = the allocation of capital cost of the equipment over the service life, labour to operate the line, applicable overheads, maintenance, & other relevant costs all reduced to cost per min.

Problem on Transfer line performance:

A 30 station Transfer line is being proposed to machine a certain component currently produced by conventional methods. The proposal received from the machine tool builder states that the line will operate at a production rate of 100 pc / hr at 100% efficiency. From a similar transfer line it is estimated that breakdowns of all types will occur at a frequency of F = 0.20 breakdowns per cycle & that the average downtime per line stop will be 8.0 minutes. The starting blank that is machined on the line costs Rs. 5.00 per part. The line operates at a cost for 100 parts each & the average cost per tool = Rs. 20 per cutting edge. Compute the following:

1. Production rate
2. Line efficiency
3. Cost per unit piece produced on the line

Solution:

2. At 100% efficiency, the line produces 100 pc/hr. The reciprocal gives the unit time or ideal cycle time per piece.

$$Tc = \frac{1}{100} = 0.010\text{hr / pc} = 0.6 \text{ mins}$$

The average production time per piece is given by:

$Tp = Tc + FTd$

1. 0.60 + 0.20 (8.0)
2. 0.60 + 1.60
3. 2.2 mins / piece

Rp = 1 / 2.2m = 0.45 pc / min = 27 pc / hr

Efficiency is the ratio of the ideal cycle time to actual production time

E = 0.6 / 2.2

4. 27 %

Tooling cost per piece

Ct = (30 tools) (Rs 20 / tool)

parts

2. Rs. 6 / piece

The hourly ratio of Rs 100 / hr to operate the line is equivalent to Rs. 1.66 / min.

Cpc = 5 + 1.66 (2.2) + 6

4. 5 + 3.65 + 6
5. Rs 14.65 / piece

Upper Bound Approach:

The upper bound approach provides an upper limit on the frequency on the line stops per cycle. In this approach we assume that the part remains on the line for further processing. It is possible that there will be more than one line stop associated with a given part during its sequence of processing operations. Let

Pr = probability or frequency of a failure at station i where i = 1, 2,………. η

Station i where i = 1, 2, ……………. η

Since a part is not removed from the line when a station jam occurs it is possible that the part will be associated with a station breakdown at every station. The expected number of lines stops per part passing through the line is obtained by summing the frequencies Pi over the n stations. Since each of the n stations is processing a part of each cycle, then the expected frequency of line stops per cycle is equal to the expected frequency of line stops per part i.e.

$$F = \sum_{i=1}^{\eta} P_i \text{ ----------------------------- } 8$$

where F = expected frequency of line stops per cycle

Pi = frequency of station break down per cycle, causing a line stop

1. = number of workstations on the line

If all the Pi are assumed equal, which is unlikely but useful for computation purposes, then

$$F = \eta.p \text{ where all the Pi are equal ---------------- } 9$$

$$p_1 = p_2 = \ldots\ldots\ldots\ldots.. p_{\eta} = p$$

Lower Bound Approach:

The lower bound approach gives an estimate of the lower limit on the expected frequency of line stops per cycle. Here we assume that a station breakdown results in destruction of the part, resulting in removal of the part from the line & preventing its subsequent processing at the remaining workstations.

Let Pi = the probability that the workpiece will jam at a particular station i.

Then considering a given part as it proceeds through the line, Pi = probability that the part will jam at station 1

(1 - Pi) = probability that the part will not jam station 1 & thus will available for processing at subsequent stations. A jam at station 2 is contingent on successfully making it through station 1 & therefore the probability that the same part will jam at station 2 is given by

3. $P(1 - P_2)$

Generalising the quantity

P (1 – Pi - 1) (1 – Pi - 2) = (1 – P2) (1 – P1)

Where i = 1,,2, ………. η

is the probability that a given part will jam at any station i. Summing all these probabilities from i = 1 through i = η gives the probability or frequency of line stops per cycle.

Probability that the given part will pass through all η stations without a line stop is

$$\prod_{i=1}^{\eta} (1 - P_i)$$

Therefore the frequency of line stops per cycle is:

$$F = 1 - \prod_{i=1}^{\eta} (1 - P_i) \quad \text{---------------------------------} \; 10$$

If all the probabilities, Pi, are equal, Pi = P, then

$$F = 1 - (1 - P)^{\eta}$$

Because of parts removal in the lower bound approach, the number of parts coming of the line is less than the number launched onto the front of the line.

If F= frequency of line stops & a part is removed for every line stop, then the proportion of parts produced is (1 - F). This is the yield of the production line. The production rate equation then becomes:

$$Rap = \frac{1 - F}{Tp} \quad \text{-------------------------------------} \; 11$$

where Rap = average actual production rate of acceptable parts from the line

Tp = average cycle rate of the transfer machine

$Rp = \frac{1}{Tp}$ = average cycle rate of the system

Example 2 Upper Bound v/s Lower Bound Approach

A 2 station transfer line has an ideal cycle time of Tc = 1.2 mins. The probability of station breakdown per cycle is equal for all stations & P = 0.005 breakdowns / cycle. For each of the upper bound & lower bound determine:

2. frequency of line stops per cycle
3. average actual production rate
4. line efficiency

1. **For the Upper bound approach**

$$F = 1 - (1 - 0.005)^{20} = 1 - (0.995)^{20}$$

1. 1 – 0.0946
2. 0.0954 line stops per cycle

For the Upper bound approach the production rate,

Rp = __ 1
20

1. 0.500 pc / min
2. 30 pc /hr

For the lower bound approach the production time we calculate by using the formula for F Tp = Tc + F (Td)

1. 1.2 + 0.0954 (0.8)
2. 1.9631 mins

Production rate = $\frac{0.9046}{1.9631}$

2. 0.4608 pc / min
3. 27.65 pc / hr

The production rate is about 8% lower than that we computed by the upper bound approach. We should note that:

$$Rp = \frac{1}{0.9631}$$

1. 0.5094 cycles / min
2. 30.56 cycles / hr

which is slightly higher than in the upper bound case.

c) For the upper bound the line efficiency will be

$$E = \frac{1.2}{2.0}$$

1. 0.6
2. 60 %

For the lower bound approach we have

$$E = \frac{1.2}{1.9631}$$

3. 0.6113
4. 61.13 %

Line efficiency is greater with lower bound approach even though production rate is lower. This is because lower bound approach leaves fewer parts remaining on the line to jam.

Analysis of Transfer Lines with Storage Buffers:

In an automated production line with no internal storage of parts, the workstations are interdependent. When one station breaks down all other stations on the line are affected either immediately or by the end of a few cycles of operation. The other stations will be forced to stop for one or two reasons 1) starving of stations 2) Blocking of stations Starving on an automated production line means that a workstation is prevented from performing its cycle because it has no part to work on. When a breakdown occurs at any workstation on the line, the stations downstream from the affected station will either immediately or eventually become starved for parts.

Blocking means that a station is prevented from performing its work cycle because it cannot pass the part it just completed to the neighbouring downstream station. When a break down occurs at a station on the line, the stations upstreams from the affected station become blocked because the broken down station cannot accept the next part for processing from the neighbouring upstream station. Therefore none of the upstream stations can pass their just completed parts for work.

By Adding one or more parts storage buffers between workstations production lines can be designed to operate more efficiently. The storage buffer divides the line into stages that can operate independently for a number of cycles.

The number depending on the storage capacity of the buffer

If one storage buffer is used, the line is divided into two stages.

If two storage buffers are used at two different locations along the line, then a three stage line is formed.

The upper limit on the number of storage buffers is to have a storage between every pair of adjacent stations.

The number of stages will then be equal to the number of workstations.

For an η stage line, there will be η – 1 storage buffers. This obviously will not include the raw parts inventory at the front of the line or the finished parts inventory that accumulates at the end of the line.

Consider a two – stage transfer line, with a storage buffer separating the stages. If we assume that the storage buffer is half full. If the first stage breaks down, the second stage can continue to operate using parts that are in the buffer. And if the second stage breaks down, the first stage can continue to operate because it has the buffer to receive its output. The reasoning for a two stage line can be extended to production lines with more than two stages.

Limit of Storage Buffer Effectiveness:

Two extreme cases of storage buffer effectiveness can be identified:

1. No buffer storage capacity at all.
2. Infinite capacity storage buffers

If we assume in our Analysis that the ideal cycle time Tc is the same for all stages considered.

In the case of no storage capacity, the production line acts as one stage when a station breaks down the entire line stops. This is the case of a production line with no internal storage.
The line efficiency of a zero capacity storage buffer:

$$E_o = \frac{T_c}{T_c + FT_d} \text{ --------------------------------- } 12$$

The opposite extreme is the case where buffer zones of infinite capacity are installed between every pair of stages. If we assume that each storage buffer is half full, then each stage is independent of the next. The presence of the internal storage buffer means that then no stage will ever be blocked or starved because of a breakdown at some other stage.

An infinite capacity storage buffer cannot be realized in practice. If it could then the overall line efficiency will be limited by the bottleneck stage.
i.e. production in all other stages would ultimately be restricted by the slowest stage. The downstream stages could only process parts at the output rate of the bottleneck stage.

Given that the cycle time Tc is the same for all the stages the efficiency for any stage k is given by:

$$E_k = \frac{T_c}{T_c + F_k T_{d_k}}$$

where k is used to identify the stage.
The overall line efficiency would be given by:

$$E_\infty = \text{Minimum}\ (E_k)$$

where the subscript ∞ identifies E_∞ as the efficiency of a line whose storage buffers have infinite capacity.
By including one or more storage buffers in an automated production line, we expect to improve the line efficiency above E_0, but we cannot expect to achieve E_∞.
The actual value of line efficiency will fall somewhere between these extremes for a given buffer capacity

$$E_0 < E_b < E_\infty$$

Analysis of a Two stage transfer line:

The two stage line is divided by a storage buffer of capacity is expressed in terms of the number of work parts that it can store. The buffer receives the output of stage 1 & forwards it to stage 2, temporarily storing any parts not immediately needed by stage 2 upto its capacity b. The ideal cycle time Tc is the same for both stages. We assume the downtime distributions of each stage to be the same with mean downtime = Td, let F_1 & F_2 be the breakdown rates of stages 1 & 2 respectively.

F_1 & F_2 are not necessarily equal.

Over the long run both stages must have equal efficiencies. If the efficiency of stage 1 is greater than the efficiency of stage 2 then inventory would build up on the storage buffer until its capacity is reached.

Thereafter stage 1 would eventually be blocked when it outproduced stage 2.

Similarly if the efficiency of stage 2 is greater than the efficiency of stage 1 the inventory would get depleted thus stage 2 would be starved.

Accordingly the efficiencies would tend to equalize overtime in the two stages.

The overall efficiency for the two stage line can be expressed as:

$$E_b = E_0 + \{ D_1^{1} \; \eta (b) \} E_2 \qquad 13$$

where E_b = overall efficiency for a two stage line with a buffer capacity

2. $_0$ = line efficiency for the same line with no internal storage buffer

1

{ Dη (b) } E represents the improvement in efficiency that results from having a 1

storage buffer with b > 0

when b = 0

2. $$E_0 = \frac{Tc}{Tc + (F_1 + F_2)\,Td} \quad \text{----------------------------------}14$$

The term D_1^{1} can be thought of as the proportion of total time that stage 1 is down

1. $$D_1^{1} = \frac{F_1 \; Td}{Tc + (F_1 + F_2)\,Td} \quad 15\text{---}$$

The term *h (b)* is the proportion of the downtime D'**1** (when the stage 1 is down) that stage 2 could be up & operating within the limits of storage buffer capacity *b*. The equations cover several different downtime distributions based on the assumption that both stages are never down at the same time. Four of these equations are presented below:

Assumptions & definitions: Assume that the two stages have equal downtime distributions ($T_{d1} = T_{d2} = T_d$) &

equal cycle times ($T_{c1} = T_{c2} = T_c$).

Let F_1 = downtime frequency for stage 1, & F_2 = downtime frequency for stage 2. Define *r* to be the ration of breakdown frequencies as follows:

$$r = \frac{F_1}{F_2} \quad \text{-------------------} \; 16$$

Equations for *h(b)* :

With these definitions & assumptions, we can express the relationships for *h(b)*for two theoretical downtime distributions :

Constant downtime:

Each downtime occurrence is assumed to be of constant duration T_d. this is a case of no downtime variation. Given buffer capacity b, define B & L as follows:

$$b = B\frac{T_d}{T_c} + L \text{ --------------- } 17$$

Where B is the largest integer satisfying the relation : $b\frac{T_c}{T_d} \geq B$,

& L represents the leftover units, the amount by which b exceeds $B\frac{T_d}{T_c}$.

There are two cases:

Case 1: $r=1.0. h(b)$

$$= \frac{B}{B+1} + L\frac{T_c}{T_d}\frac{1}{(B+1)(B+2)} \text{ --------} 18$$

Case 2: $r \neq 1.0. h(b)$

$$= r1 - r^{B} + L\frac{T_c}{T_d}\frac{r^B(1-r)^2}{(1-r^{B+1})(1-r^{B+2})} \text{ -----} 19$$

Geometric downtime distribution:

In this downtime distribution, the probability that repairs are completed during cycle duration T_c, is independent of the time since repairs began. This a case of maximum downtime variation. There are two cases:

Case 1: $r = 1.0. h(b)$

$$= \frac{B\frac{T_c}{T_d}}{2 + (b-1)\frac{T_c}{T_d}} \qquad 20$$

Case 2: $r \neq 1.0.$

$$\text{Define } K = \frac{1 + r - \frac{T_c}{T_d}}{1 + r - r\frac{T_c}{T_d}} \text{ ---------------} 21$$

$$\text{Then } h(b) = r\frac{(1 - K^b)}{1 - rK^b} \text{ --------------} 22$$

Finally, E_2 corrects for the assumption in the calculation of $h(b)$ that both stages are never down at the same time. This assumption is unrealistic. What is more realistic is that when stage 1 is down but stage 2 could be producing because of parts stored in the buffer, there will be times when stage 2 itself breaks down. Therefore E_2 provides an estimate of the proportion of stage 2 uptime when it could be otherwise be operating even with stage 1 being down. E_2 is calculated as:

$$E_2 = \frac{T_c}{T_c + F_2 T_d} \text{ ---------------} 23$$

Two-Stage Automated Production Line:

A 20-station transfer line is divided into two stages of 10 stations each. The ideal cycle time of each stage is T_c = 1.2 min. All of the stations in the line have the same probability of stopping, p = 0.005. We assume that the downtime is constant when a breakdown occurs, T_d

3. 8.0 min. Using the upper-bound approach, compute the line efficiency for the following buffer capacities: (a) b = 0, (b) b = ∞, (c) b = 10, (d) b = 100

Solution:

$$F = np = 20(0.005) = 0.10$$

$$E_0 = \frac{1.2}{1.2 + 0.1(8)} = 0.60$$

1. For a two stage line with 20 stations (each stage = 10 stations) & b = ∞, we first compute F:

$$F_1 = F_2 = 10(0.005) = 0.05$$

$$E_\infty = E_1 = E_2 = \frac{1.2}{1.2 + 0.05(8)} = 0.75$$

1. For a two stage line with b = 10, we must determine each of the items in equation 13. We have E_0 from part (a). E_0 = 0.60. And we have E_2 from part (b). E_2 = 0.75

$$D'_1 = \frac{0.05\ (8)}{1.2 + (0.05 + 0.05)\ (8)} = \frac{0.40}{2.0} = 0.20$$

Evaluation of $h(b)$ is from equation 18 for a constant repair distribution. In equation 17, the ratio

$$\frac{T_d}{T_c} = \frac{8.0}{1.2} = 6.667.$$

For b = 10, B = 1 & L = 3.333.

Thus,

$h(b) = h(10)$

$$= \frac{1}{1 + 1} + 3.333\ \frac{(1.2)}{(8.0)}\ \frac{1}{(1 + 1)(1 + 2)}$$

3. 0.50 + 0.8333 = 0.5833 We can now use equation 13:

E_{10} = 0.600 + 0.20 (0.5833) (0.75)
= 0.600 + 0.0875 = 0.6875

1. For b = 100, the only parameter in equation 13 that is different from part (c) is $h(b)$. for b = 100, B = 15 & L = 0 in equation 18. Thus, we have:

$$h(b) = h(100) = \frac{15}{15 + 1}$$

20. 0.9375

Using this value,

E_{100} = 0.600 + 0.20 (0.9375) (0.75)
= 0.600 + 0.1406 = 0.7406

The value of $h(b)$ not only serves its role in equation 13 but also provides information on how much improvement in efficiency we get from any given value of b. note in example 15 that the difference between E_∞ & E_0 = 0.75 – 0.60 = 0.15.

For b = 10, $h(b)$ = h(10) = 0.58333, which means we get 58.33% of the maximum possible improvement in line efficiency using a buffer capacity of 10 {E_{10} = 0.6875 = 0.60 + 0.5833)(0.75 – 0.60)}.

For b = 100, $h(b)$ = h(100) = 0.9375, which means we get 93.75% of the maximum improvement with b = 100 {E_{100} = 0.7406 = 0.60 + 0.9375 (0.75 – 0.60)}

We are not only interested in the line efficiencies of a two stage production line. We also want to know the corresponding production rates. These can be evaluated based on knowledge of the ideal cycle time T_c & the definition of line efficiency. According to equation 5, E = T_c / T_p. Since R_p = the reciprocal of T_p, then $E = T_c R_p$. Rearranging this we have:

$$R_p = \frac{E}{T_c} \quad \text{-------------------} \; 24$$

Production Rates on the Two-Stage Line of the example above:

Compute the production rates for the 4 cases in the above example. The value of T_c = 1.2 min is as before.

Solution:

2. For b = 0, E_0 = 0.60. Applying equation 23, we have

R_p = 0.60/ 1.2 = 0.5 pc/min = 30 pc /hr.

3. For b = ∞, E_∞ = 0.75.

R_p = 0.75 / 1.2 = 0.625 pc / min = 37.5 pc /hr

(c) For b = 10, E_{10} = 0.6875.

R_p = 0.6875 / 1.2 = 0.5729 pc / min = 34.375 pc /hr.

(d) For b = 100, E_{100} = 0.7406

$$R_p = 0.7406 / 1.2 = 0.6172 \text{ pc / min} = 37.03 \text{ pc / hr}$$

Effect of High Variability in Downtimes:

Evaluate the line efficiencies for the two-stage line in above example, except that the geometric repair distribution is used instead of the constant downtime distribution.

Solution:

For parts (a) & (b), the values of E_0 & E_∞ will be the same as in the previous example. $E_0 = 0.600$ & $E_\infty = 0.750$.

1 For $b = 10$, all of the parameters in equation 13 remain the same

except $h(b)$. Using equation 20, we have:

$$h(b) = h(10) = \frac{10(1.2/8.0)}{2 + (10 - 1)(1.2/8.0)} = 0.4478$$

Now using equation 13, we have

$$E_{10} = 0.600 + 0.20(0.4478)(0.75)$$
$$= 0.6672$$

(d)For $b = 100$, it will be:

$$h(b) = h(100) = \frac{100(1.2/8.0)}{2 + (100 - 1)(1.2/8.0)} = 0.8902$$

$$E_{100} = 0.600 + 0.20\,(0.8902)(0.75)$$
$$= 0.7333$$

Transfer Lines with More thanTwo Stages:

If the line efficiency of an automated production line can be increased by dividing it into two stages with a storage buffer between, then one might infer that further improvements in performance can be achieved by adding additional storage buffers. Although we do not exact formulas for computing line efficiencies for the general case of any capacity b for multiple storage buffers, efficiency improvements can readily be determined for the case of infinite buffer capacity.

Transfer Lines with more than One Storage Buffer:

For the same 20-station transfer line we have been considering in the previous examples, compare the line efficiencies & production rates for the following cases, where in each case the buffer capacity is infinite: (a) no storage buffers, (b) one buffer, (c) three buffers, &

19 buffers. Assume in cases (b) & (c) that the buffers are located in the line to equalise the downtime frequencies; i.e. all F_i are equal. As before, the computations are based on the upper-bound approach.

Solution:

(a) For the case of no storage buffer, $E_\infty = 0.60$

$$R_p = 0.60/1.2 = 0.50 \text{ pc/min} = 30 \text{ pc/hr}$$

2. For the case of one storage buffer (a two stage line), $E_\infty = 0.75$

$$R_p = 0.75/1.2 = 0.625 \text{ pc/min} = 37.5 \text{ pc/hr}$$

(c) For the case of three storage buffers (a four stage line), we have

$F_1 = F_2 = F_3 = F_4 = 5(0.005) = 0.025$

$T_p = 1.2 + 0.025(8) = 1.4$ min / pc.

$E_\infty = 1.2 / 1.4 = 0.8571$

$R_p = 0.8571/1.2 = 0.7143$ pc/min
= 42.86 pc/hr.

(d) For the case of 19 storage buffers (a 20 stage line, where each stage is one station), we have

$F_1 = F_2 = \ldots\ldots = F_{20} = 1(0.005) = 0.005$

$T_p = 1.2 + 0.005(8) = 1.24$ min / pc.

$E_\infty = 1.2 / 1.24 = 0.9677$

$R_p = 0.9677/1.2 = 0.8065$ pc/min
= 48.39 pc/hr.

This last value is very close to the ideal production rate of $R_c = 50$ pc/hr

Problem:

Suppose that a 10 station transfer machine is under consideration to produce a component used in a pump. The item is currently produced by mass conventional means but demand for the item cannot be met. The manufacturing engineering department has estimated that the ideal cycle time will be
$T_c = 1.0$ min. From similar transfer lines & that the average downtime for line stop occur with a frequency;

F = 0.10 breakdown/cycle & the average downtime per line stop will be 6.0 min. The scrap rate for the current conventional processing method is 5% & this is considered a good estimate for a transfer line. The starting costing for the component costs Rs. 1.50 each & it will cost Rs 60.00 / hr or Rs 1 / min to operate the transfer line. Cutting tools are estimated to cost Rs 0.15/ work part. Compute the following measures of line performance given the foregoing data.

(a) Production rate
(b) Number of hours required to meet a demand of 1500 units/week.
(c) Line efficiency
(d) Cost per unit produced.

Problem:

If a line has 20 work stations each with a probability of breakdown of 0.02, the cycle time of the line is 1 min & each time a breakdown occurs, it takes exactly 5 minutes to repair. The line is to be divided into two stages by a storage buffer so that each stage will consist of 10 stations. Compute the efficiency of the two stage line for various buffer capacities.

Solution:

Let us compute the efficiency of the line with no buffer

$F = np = 20(0.02) = 0.4$

$$E_o = \frac{1.0}{1.0+0.4(10)} = 0.20$$

Next dividing the line into equal stages by a buffer zone of infinite capacity each stage would have an efficiency given by

$F1 = F2 = 10\ (0.02) = 0.2$

$$E1 = E2 = \frac{Tc}{Tc + (F1+F2)Td} = \frac{1.0}{1.0+ 0.2(10)} = 0.333$$

d) The cost per product can be computed except that we must account for the scrap rate.

$$Cpc = \frac{1}{0.95}(1.50+1.00 \times 1.60 + 0.15) = Rs.3.42/\text{good unit}$$

The Rs.3.42 represents the average cost per acceptable product under the assumption that we are discarding the 5% bad units with no salvage value and no disposal cost. Suppose that we could repair these parts at a cost of Rs.5.00/unit. To compute the cost per piece the repair cost would be added to other components.

$Cpc = 1.50 + 1.00 \times 1.60 + 0.15 + 0.05\ (5.00) = Rs.\ 3.50/\text{unit}$.

The policy of scrapping the 5% defects ,yields a lower cost per unit rather than repairing them.

Problem:

An eight station rotary indexing machine operates with an ideal cycle time of 20 secs. The frequency of line stop occurrences is 0.06 stop / cycle on the average. When a stop occurs it takes an average of 3 min to make repairs. Determine the following:

1. Average production time 3. Line efficiency
2. Proportion of downtime 4. Average production rate

$= 0.33 + 0.06(3)$

$= 0.5133$ minutes.

$R_p = \dfrac{1}{0.5133} = 1.94$ pieces /minutes

Line efficiency $= \dfrac{T_c}{T_p} = \dfrac{0.333}{0.51} = 0.491$

Proportion of downtime can be calculated by $D = \dfrac{F\,T_d}{T_p} = \dfrac{0.06(3)}{0.5133} = 0.35$

Partial Automation:

Many assembly lines in industry contain a combination of automated & manual work stations. These cases of partially automated production lines occur for two main reasons:

1. Automation is introduced gradually on an existing manual line.
Suppose that demand for the product made on a manually operated line increases, & it is desired to increase production & reduce labour costs by automating some or all of the stations. The simpler operations are automated first, & the transition toward a fully automated line is accomplished over a long period of time. Meanwhile, the line operates as a partially automated system.

2. Certain manual operations are too difficult or too costly to automate.
Therefore, when the sequence of workstations is planned for the line, certain stations are designed to be automated, whereas the others are designed as manual stations.

Examples of operations that might be too difficult to automate are assembly procedures or processing steps involving alignment, adjustment, or fine-tuning of the work unit. These operations often require special human skills and/or senses to carry out. Many inspection procedures also fall into this category. Defects in a product or a part that can be easily perceived by a human inspector are sometimes extremely difficult to identify by an automated inspection device. Another problem is that the automated inspection device can only check for the defects for which it was designed, whereas a human inspector is capable of sensing a variety of unanticipated imperfections & problems.

To analyze the performance of a partially automated production line, we build on our previous analysis & make the following assumptions:

1. Workstations perform either processing or assembly operations;

2. Processing & assembly times at automated stations are constant, though not necessarily equal at all stations;
3. Synchronous transfer of parts;
4. No internal buffer storage ;
5. The upper bound approach is applicable &
6. Station breakdowns occur only at automated stations.

Breakdowns do not occur at manual workstations because the human workers are flexible enough, we assume, to adapt to the kinds of disruptions & malfunctions that would interrupt the operation of an automated workstation. For example, if a human operator were to retrieve a defective part from the parts bin at the station, the part would immediately be discarded & replaced by another without much lost time. Of course, this assumption of human adaptability is not always correct, but our analysis is based on it.

The ideal cycle time T_c is determined by the slowest stations on the line, which is generally one of the manual stations. If the cycle time is in fact determined by a manual station, then T_c will exhibit a certain degree of variability simply because there is a random variation in any repetitive human activity. However, we assume that the average T_c remains constant over time. Given our assumption that breakdowns occur only at automated stations, let n_a = the number of automated stations & T_d = average downtime per occurrence. For the automated stations that perform processing operations, let p_i = the probability (frequency) of breakdowns per cycle; & for automated stations that perform assembly operations, let q_i & m_i equal, respectively, the defect rate & probability that the defect will cause station i to stop. We are now in a position to define the average actual production time:

$$T_p = T_c + \sum_{i \epsilon n_a} p_i T_d \text{ --------- } 25$$

where the summation applies to the n_a automated stations only. For those automated stations that perform assembly operations in which a part is added,

$$p_i = m_i q_i$$

If all p_i, m_i, & q_i are equal, respectively to p, m, & q, then the preceding equations reduce to the following:

$$T_p = T_c + n_a p T_d \text{ ---------- } 26$$

and $p = mq$ for those stations that perform assembly consisting of the addition of a part.

Given that n_a is the number of automated stations, then nw = the number of stations operated by manual workers, & $n_a + n_w = n$, where n = the total station count. Let C_{asi} = cost to operate the automatic workstation i (\$ / min), C_{wi} = cost to operated manual workstation i (\$ / min), C_{at} = cost to operate the automatic transfer mechanism. Then the total cost to operate the line is given by:

$$C_o = C_{at} + \sum_{i \epsilon n_a} C_{asi} + \sum_{i \epsilon n_w} C_{wi} \text{ -------- } 27$$

where C_o = cost or operating the partially automated production system ($ / min). For all $C_{asi} = C_{as}$ & all

$C_{wi} = C_w$, then

$C_o = C_{at} + n_a C_{as} + n_w C_w$ -------- 28

Now the total cost per unit produced on the line can be calculated as follows:

$$C_{pc} = \frac{C_m + C_o T_p + C_t}{P_{ap}} \text{ ---------- } 29$$

Where C_{pc} = cost per good assembly ($ / pc), C_m = cost of materials & components being processed & assembled on the line ($ / pc),

C_o = cost of operating the partially automated production system by either of the equations 27 or 28

($ / min), T_p = average actual production time (min / pc), C_t = any cost of disposable tooling ($ / pc), & P_{ap} = proportion of good assemblies.

Problem On Partial Automation:

It has been proposed to replace one of the current manual workstations with an automatic work head on a ten-station production line. The current line has six automatic stations & four manual stations. Current cycle time is 30 sec. The limiting process time is at the manual station that is proposed for replacement. Implementing the proposal would allow the cycle time to be reduced to 24 sec. The new station would cost $0.20/min. Other cost data: C_w = $0.15/min, C_{as} = $0.10/min, & C_{at} = $0.12/min. Breakdowns occur at each automated station with a probability $p = 0.01$. The new automated station is expected to have the same frequency of breakdowns. Average downtime per occurrence T_d = 3.0min, which will be unaffected by the new station. Material costs & tooling costs will be neglected in the analysis. It is desired to compare the current line with the proposed change on the basis of production rate & cost per piece. Assume a yield of 100% good product.

Solution:

For the current line,

T_c = 30 sec = 0.50min.

T_p = 0.50 + 6(0.01)(3.0) = 0.68 min.

R_p = 1/0.68 = 1.47 pc/min = 88.2pc/hr

C_o = 0.12 + 4(0.15) + 6 (0.10)

= $1.32 / min

C_{pc} = 1.32 (0.68) = $0.898 / pc

For the proposed line,

T_c = 24 sec = 0.4 min.

R_p = 1/0.61 = 1.64 pc/min = 98.4pc/hr

C_o = 0.12 + 3(0.15)+ 6(0.10)+ 1(0.20)

$= \$1.37/min$
$C_{pc} = 1.67(0.61) = \$0.836$ / pc

Even though the line would be more expensive to operate per unit time, the proposed chage would increase production rate & reduced piece cost.

Storage Buffers:

The preceding analysis assumes no buffer storage between stations. When the automated portion of the line breaks down, the manual stations must also stop for lack of work parts (either due to starving or blocking, depending on where the manual stations are located relative to the automated stations). Performance would be improved if the manual stations could continue to operate even when the automated stations stop for a temporary downtime incident. Storage buffers located before & after the manual stations would reduce forced downtime at these stations.

Problem On Storage Buffers on a Partially Automated Line:

Considering the current line in the above example, suppose that the ideal cycle time for the automated stations on the current line T_c = 18 sec. The longest manual time is 30 sec. Under the method of operation assumed in the above example both manual & automated stations are out of action when a breakdown occurs at an automated station. Suppose that storage buffers could be provided for each operator to insulate them from breakdowns at automated stations. What effect would this have on production rate & cost per piece?

Solution:

Given T_c = 18sec = 0.3min, the average actual production time on the automated stations is computed as follows:

$$T_p = 0.30 + 6(0.01)(3.0) = 0.48\text{min}$$

Since this is less than the longest manual time of 0.50, the manual operation could work independently of the automated stations if storage buffers of sufficient capacity were placed before & after each manual station. Thus, the limiting cycle time on the line would be
T_c = 30sec = 0.50 min, & the corresponding production rate would be:

$R_p = R_c = 1/0.50 = 2.0$pc/min
= 120.0 pc/hr

Using the line operating cost from the previous example, C_o = \$1.32/min, we have a piece cost of

$$C_{pc} = 1.32\ (0.50) = \$0.66 / \text{pc}$$

Comparing with the previous example, we can see that a dramatic improvement in production rate & unit cost is achieved through the use of storage buffers.

Problem On Partial Automation:

A partially automated production line has a mixture of three mechanized & three manual workstations. There are a total of six stations, & the ideal cycle time T_c = 1.0 min, which includes a transfer time T_r = 6 sec. Data on the six stations are listed in the following table. Cost of the transfer mechanism C_{at} = \$0.10/min, cost to run each automated station C_{as} = \$ 0.12/min, & labour cost to operate each manual station C_w = \$ 0.17 /min. It has been proposed to substitute an automated station in place of station 5. The cost of this station is estimated at

C_{as5} = \$ 0.25 / min, & its breakdown rate P_5 = 0.02, but its process time would be only 30 sec, thus reducing the overall cycle time of the line from 1.0 min to 36 sec. Average downtime per breakdown of the current line as well as the proposed configuration is T_d = 3.5 min. Determine the following for the current line & the proposed line: (a) production rate, (b) proportion uptime, & (c) cost per unit. Assume the line operates without storage buffers, so when an automated station stops, the whole line stops, including the manual stations. Also, in computing costs, neglect material & tooling costs.

Station	Type	Process Time (sec)	p_i
1	Manual	36	0
2	Automatic	15	0.01
3	Automatic	20	0.02
4	Automatic	25	0.01
5	Manual	54	0
6	Manual	33	0

Solution : Tc = 1.0 min
Tp = 1.0 + 2(0.01)x3.5 + 1(0.02) x 3.5 = 1.14 mins
Rp = 1 = 0.877 pcs /min x 60 = 52.65 pcs / hr 1.14
Cp = 0.12 + 3(0.17) + 3(0.10) = \$ 0.93/mins
Cpc = 0.93x 1.14 = \$1.062/piece
For the proposed line Tc = 36 secs = 0.6 mins
Tp = 0.6 + 2(0.01)3.5 + 2(0.02)3.5 = 0.81 mins
Rp = 1.234 pieces / min = 74.07 pieces/hr
Cp = 0.012 + 2(0.17) + 3(0.10) + 1(0.25) = \$ 0.902/min
Cpc = 0.90 x 0.81 mins = \$ 0.73062/piece

Transfer of Work between Work Stations:

There are two basic ways in which the work (the subassembly that is being built up) is moved on the line between operator workstations.

1. Nonmechanical Lines. In this arrangement, no belt or conveyor is used to move the parts between operator workstations. Instead, the parts are passed from station to station by hand. Several problems result from this mode of operation:

   Starving at stations, where the operator has completed his or her work but must wait for parts from the preceding station.

Blocking of stations, where the operator has completed his or her work but must wait for the next operator to finish the task before passing along the part.

As a result of these problems, the flow of work on a nonmechanical line is usually uneven. The cycle times vary, and this contributes to the overall irregularity. Buffer stocks of parts between workstations are often used to smooth out the production flow.

- Moving conveyor lines. These flow lines use a conveyor (e.g., a moving belt, conveyor, chain-in-the-floor, etc.) to move the subassemblies between workstations. The transport system can be continuous, intermittent (synchronous), or asynchronous. Continuous transfer is most common in assembly lines, although asynchronous transfer is becoming more popular. With the continuously moving conveyor, the following problems can arise:

Starving can occur as with non mechanical lines.

Incomplete items are sometimes produced when the operator is unable to finish the current part & the next part travels right by on the conveyor. Blocking does not occur.

Again, buffer stocks are sometimes used to overcome these problems. Also stations overlaps can sometimes be allowed, where the worker is permitted to travel beyond the normal boundaries of the station in order to complete work.

In the moving belt line, it is possible to achieve a higher level of control over the production rate of the line. This is accomplished by means of the feed rate, which refers to the reciprocal of the time interval between work parts on the moving belt. Let f_p denote this feed rate. It is measured in work pieces per time & depends on two factors: the speed with which the conveyor moves, & the spacing of work parts along the belt. Let V_c equal the conveyor speed (feet per minute or meters per second) & s_p equal the spacing between parts on the moving conveyor (feet or meters per work piece). Then the feed rate is determined by

$$f_p = \frac{V_c}{S_p} \text{ -------------- } 1$$

To control the feed rate of the line, raw work parts are launched onto the line at regular intervals. As the parts flow along the line, the operator has a certain time period during which he or she begin work on each piece. Otherwise, the part will flow past the station. This time period is called the tolerance time T_t. It is determined by the conveyor speed & the length of the workstation. This length we will symbolize by L_s, & it is largely determined by the operator's reach at the workstation. The tolerance time is therefore defined by

$$T_t = \frac{L_s}{V_c} \text{ ----------- } 2$$

For example, suppose that the desired production rate on a manual flow line with moving conveyor were 60 units/h. this would necessitate a feed rate of 1 part/min. This could be achieved by a conveyor speed of 0.6m/min & a part spacing of 0.5m. (Other combinations of V_c & s_p would also provide the same feed rate.) If the length of each workstation were 1.5m. the tolerance time available to the operators for each work piece would be 3 min. It is generally desirable to make the tolerance time large to compensate for worker process time variability.

Mode Variations:

In both nonmechanical lines & moving conveyor lines it is highly desirable to assign work to the stations so as to equalize the process or assembly times at the workstations. The problem is sometimes complicated by the fact that the same production line may be called upon to process more than one type of product. This complication gives rise to the identification of three flow line cases (and therefore three different types of line balancing problems).

The three production situations on flow lines are defined according to the product or products to be made on the line. Will the flow line be used exclusively to produce one particular model? Or, will it be used to produce several different models, & if so how will they be scheduled on line? There are three cases that can be defined in response to these questions:

1. Single-model line. This is a specialized line dedicated to the production of a single model or product. The demand rate for the product is great enough that the line is devoted 100% of the time to the production of that product.
2. Batch-model line. This line is used for the production of two or more models. Each model is produced in batches on the line. The models or products are usually similar in the sense of requiring a similar sequence of processing or assembly operations. It is for this reason that the same line can be used to produce the various models.
3. Mixed-model lines. This line is also used for the production of two or more models, but the various models are intermixed on the line so that several different models are being produced simultaneously rather than in batches. Automobile & truck assembly lines are examples of this case.

To gain a better perspective of the three cases, the reader might consider the following. In the case of the batch-model line, if the batch sizes are very large, the batch-model line approaches the case of the single-model line. If the batch sizes become very small (approaching a batch size of 1), the batch-model line approximates to the case of the mixed-model line.

In principle, the three cases can be applied in both manual flow lines & automated flow lines. However, in practice, the flexibility of human operators makes the latter two cases more feasible on the manual assembly line. It is anticipated that future automated lines will incorporate quick changeover & programming capabilities within their designs to permit the batch-model, & eventually the mixed-model, concepts to become practicable.

Achieving a balanced allocation of work load among stations of the line is a problem in all three cases. The problem is least formidable for the single-model case. For the batch-model line, the balancing problem becomes more difficult; & for the mixed-model case, the problem of line balancing becomes quite complicated.

In this chapter we consider only the single-model line balancing problem, although the same concepts & similar terminology & methodology apply for the batch & mixed model cases.

The Line Balancing Problem:

In flow line production there are many separate & distinct processing & assembly operations to be performed on the product. Invariably, the sequence of processing or assembly steps is restricted, at least to some extent, in terms of the order in which the operations can be carried out. For example, a threaded hole must be drilled before it can be tapped. In mechanical fastening, the washer must be placed over the bolt before the nut can be turned & tightened. These restrictions are called *precedence constraints* in the language of line balancing. It is generally the case that the product must be manufactured at some specified production rate in order to satisfy demand for the product. Whether we are concerned with performing these processes & assembly operations on automatic machines or manual flow lines, it is desirable to design the line so as to satisfy all of the foregoing specifications as efficiently as possible.

The line balancing problem is to arrange the individual processing & assembly tasks at the workstations so that the total time required at each workstation is approximately the same. If the work elements can be grouped so that all the station times are exactly equal, we have perfect balance on the line & we can expect the production to flow smoothly. In most practical situations it is very difficult to achieve perfect balance. When the workstations times are unequal, the slowest station determines the overall production rate of the line.

In order to discuss the terminology & relationships in line balancing, we shall refer to the following example. Later, when discussing the various solution techniques, we shall apply the techniques to this problem.

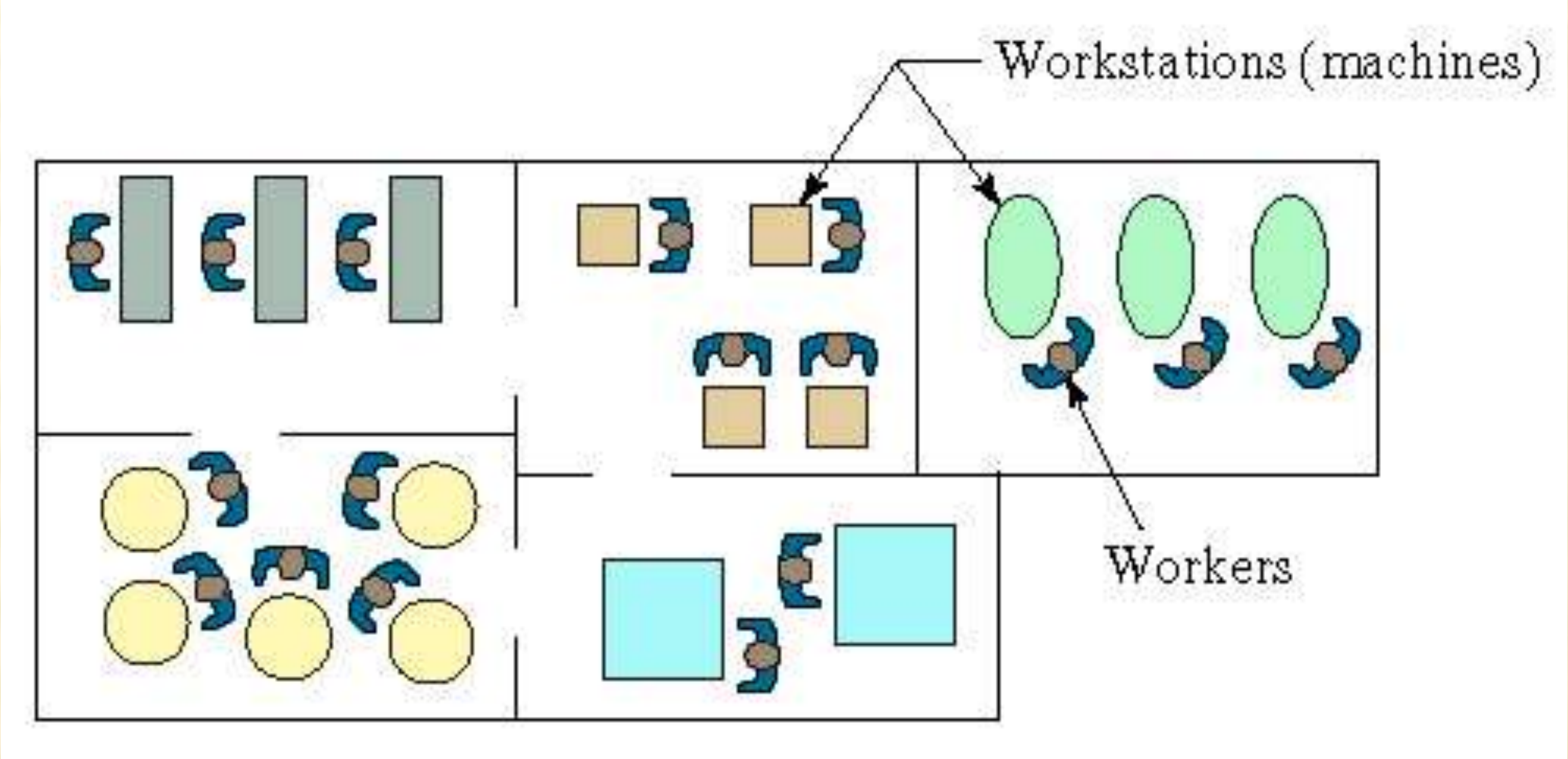
UNIT III
POWER POINT PRESENTATION SLIDES

VARIOUS TYPES OF PLANT LAYOUTS

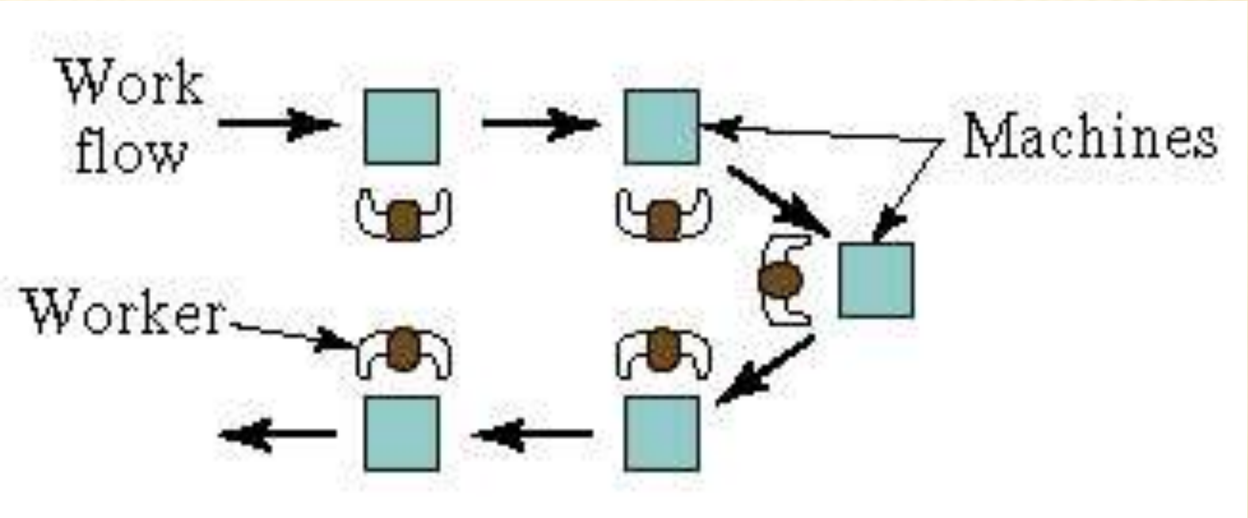
- Fixed position layout
- Process layout
- Cellular layout
- Product layout

FIXED-POSITION LAYOUT

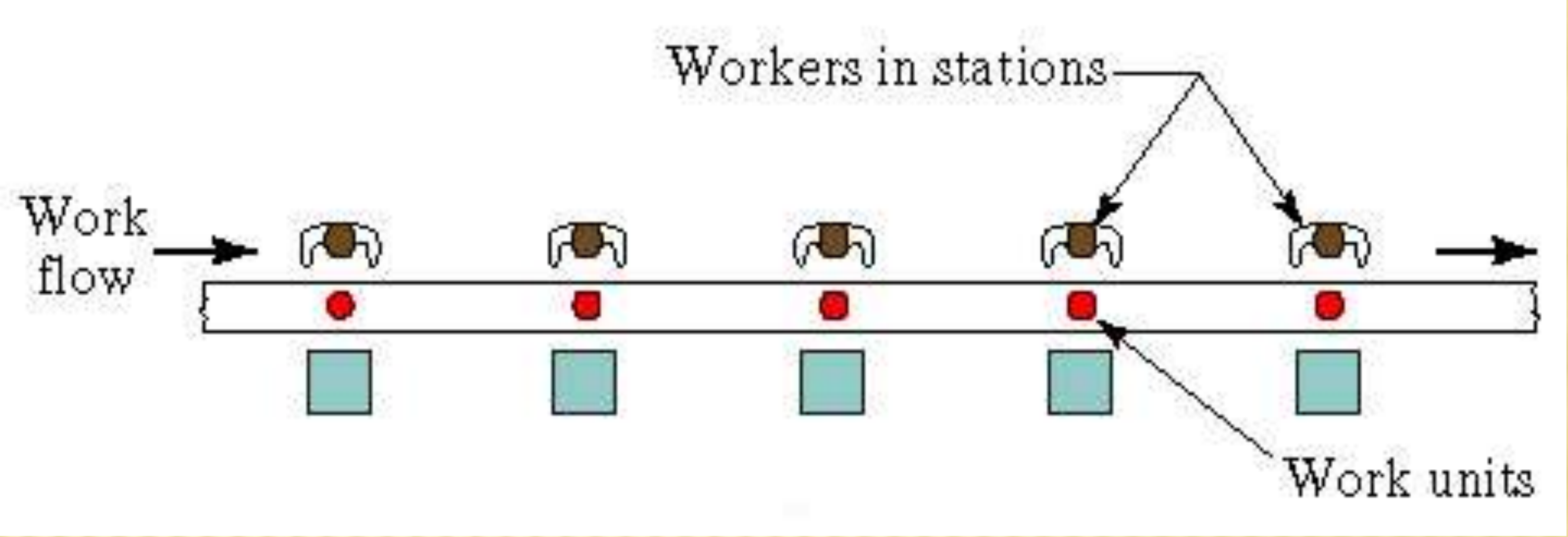
PROCESS LAYOUT



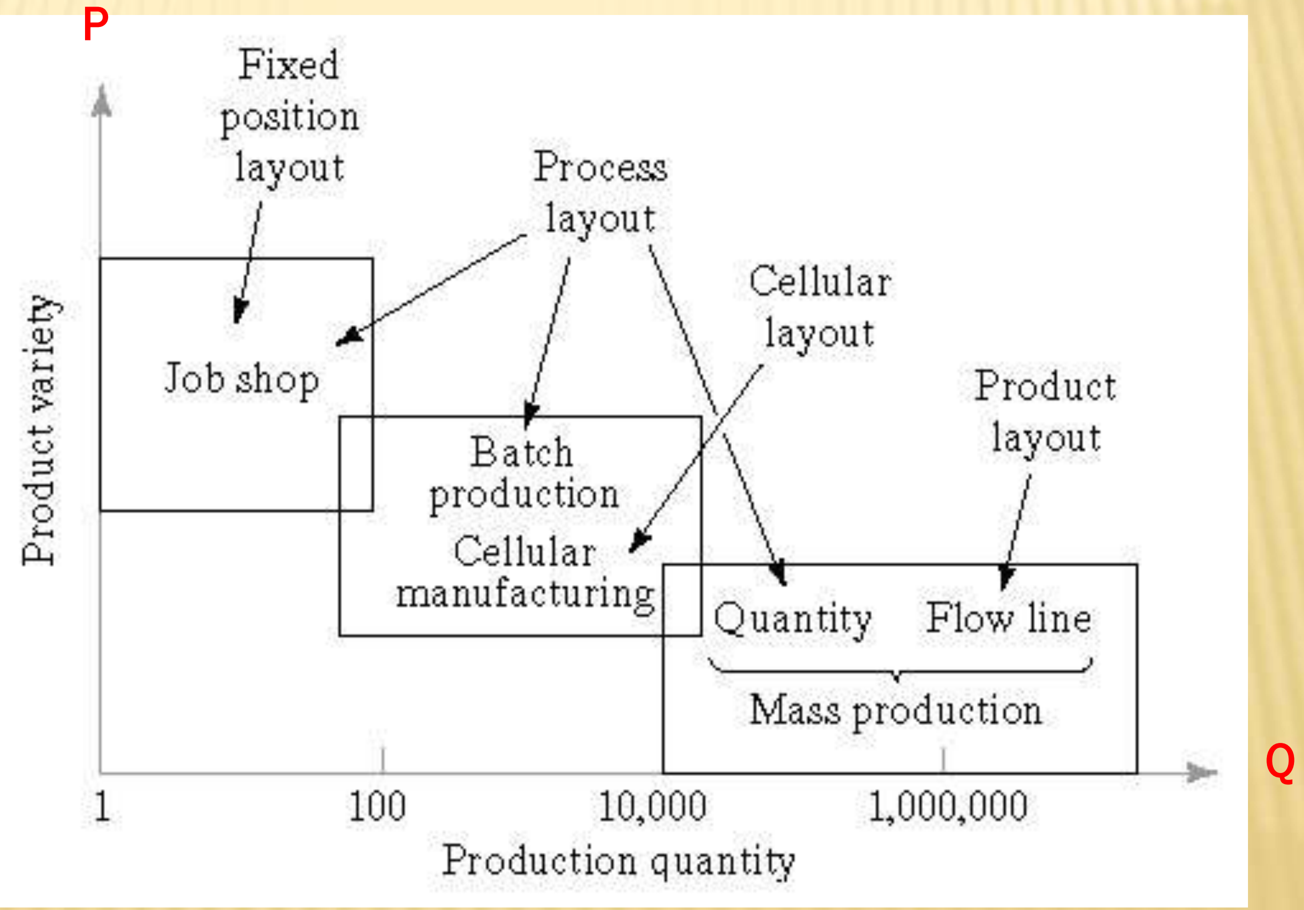
CELLULAR LAYOUT



PRODUCT LAYOUT



PQ RELATIONSHIPS



QUANTITY PRODUCTION

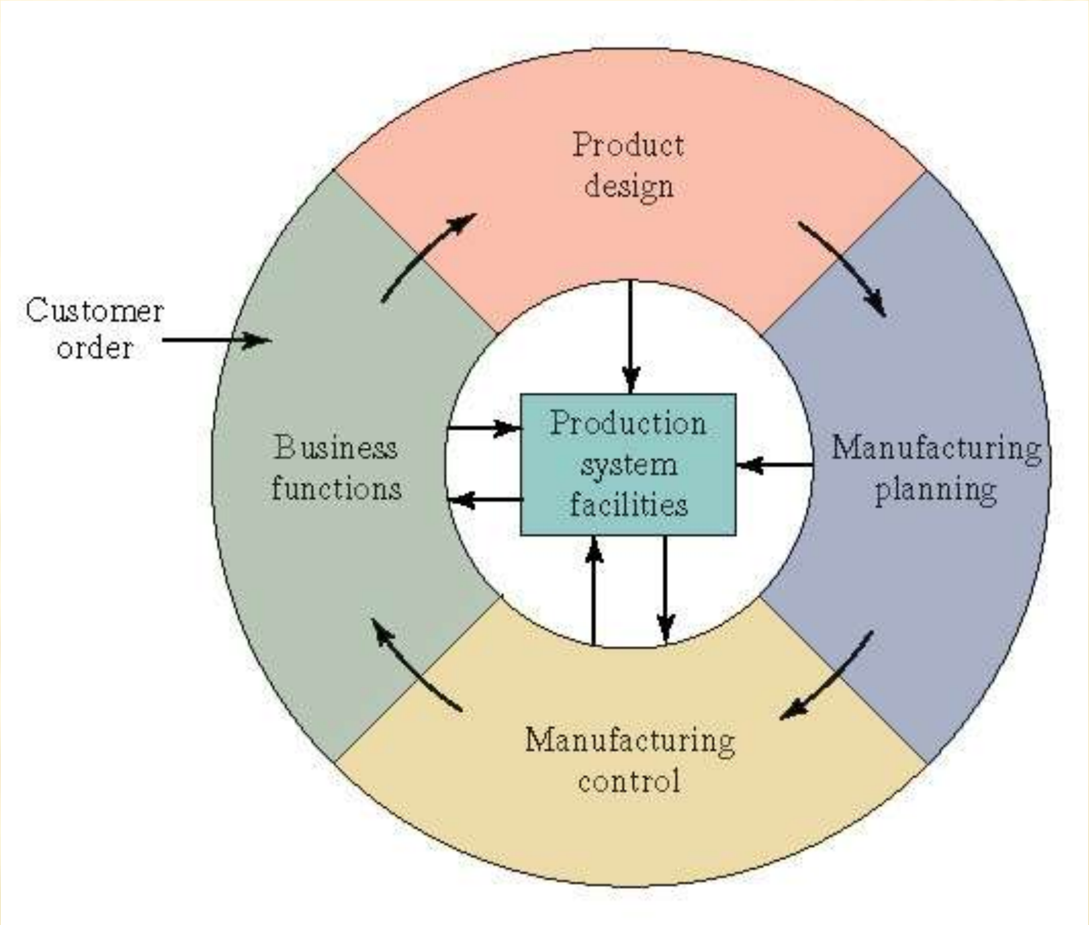
- Mass production of single parts on single machine or small numbers of machines
- Typically involves standard machines equipped with special tooling
- Equipment is dedicated full-time to the production of one part or product type
- Typical layouts used in quantity production are process layout and cellular layout

FLOW LINE PRODUCTION

- Multiple machines or workstations arranged in sequence, e.g., production lines
- Product is complex
  - Requires multiple processing and/or assembly operations
- Work units are physically moved through the sequence to complete the product
- Workstations and equipment are designed specifically for the product to maximize efficiency

INFORMATION PROCESSING CYCLE IN MANUFACTURING SUPPORT SYSTEMS

Fig. 1.6



AUTOMATION IN PRODUCTION SYSTEMS

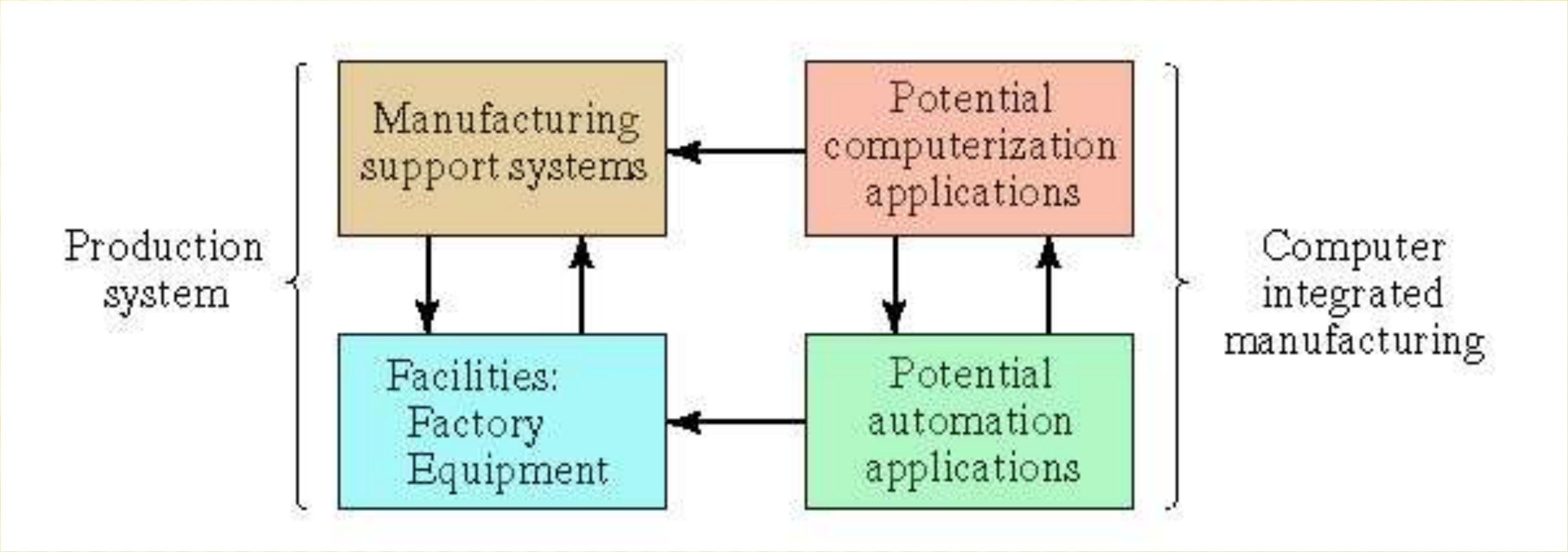
Two categories of automation in the production system:

1. Automation of manufacturing systems in the factory
2. Computerization of the manufacturing support systems

- The two categories overlap because manufacturing support systems are connected to the factory manufacturing systems
  - Computer-Integrated Manufacturing (CIM)

COMPUTER INTEGRATED MANUFACTURING

Fig. 1.7



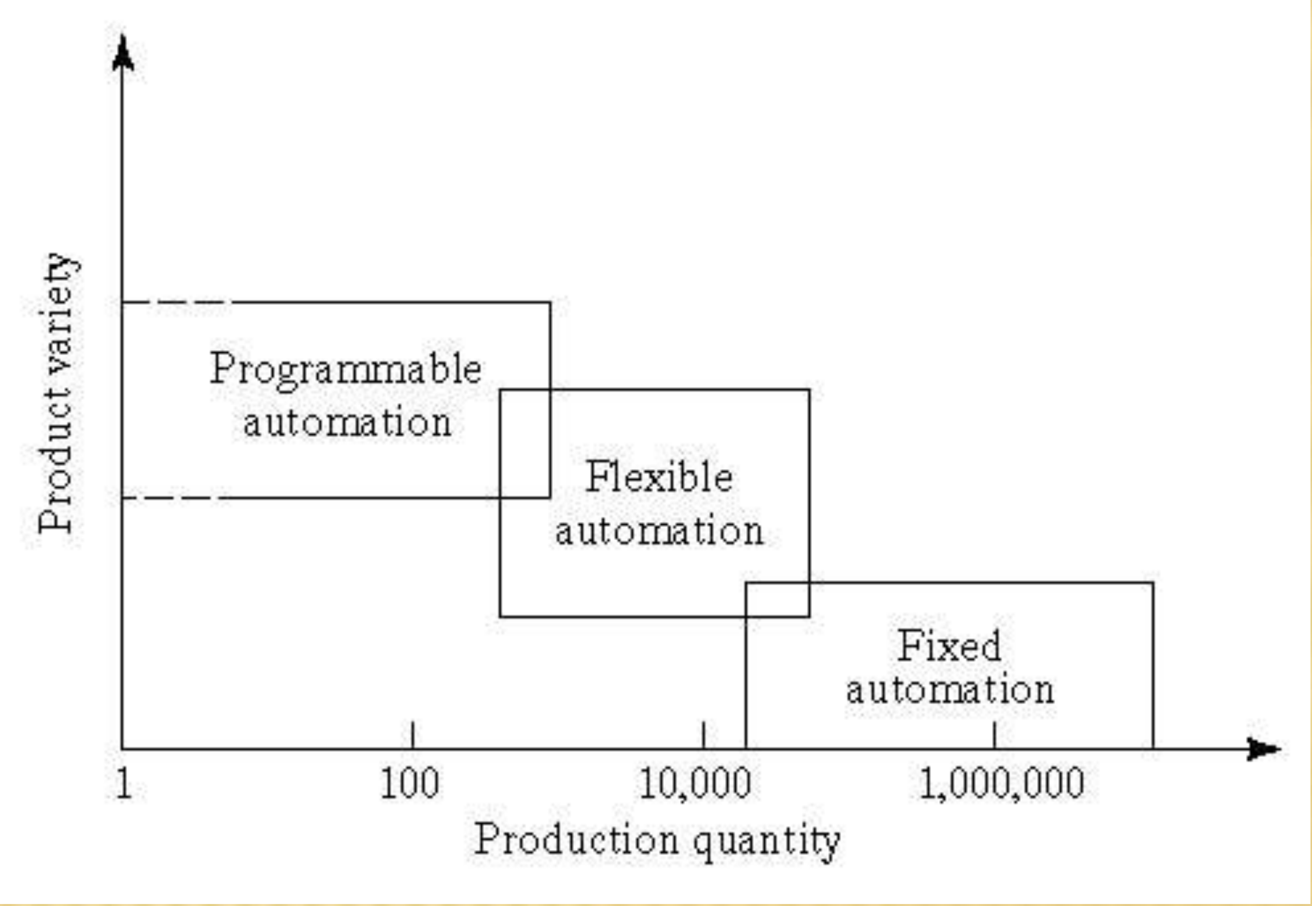
AUTOMATED MANUFACTURING SYSTEMS

Examples:

- Automated machine tools
- Transfer lines
- Automated assembly systems
- Industrial robots that perform processing or assembly operations
- Automated material handling and storage systems to integrate manufacturing operations
- Automatic inspection systems for quality control

PRODUCT VARIETY AND PRODUCTION QUANTITY FOR THREE AUTOMATION TYPES

Fig. 1.8



AUTOMATED MANUFACTURING SYSTEMS

Three basic types:

1. Fixed automation
2. Programmable automation
3. Flexible automation

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

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

REASONS FOR AUTOMATING

1. To increase labor productivity
2. To reduce labor cost
3. To mitigate the effects of labor shortages
4. To reduce or remove routine manual and clerical tasks
5. To improve worker safety
6. To improve product quality
7. To reduce manufacturing lead time
8. To accomplish what cannot be done manually
9. To avoid the high cost of not automating

AUTOMATION PRINCIPLES AND STRATEGIES

1. The USA Principle
2. Ten Strategies for Automation and Process Improvement
3. Automation Migration Strategy

U.S.A PRINCIPLE

1. Understand the existing process
   - Input/output analysis
   - Value chain analysis
   - Charting techniques and mathematical modeling
2. Simplify the process
   - Reduce unnecessary steps and moves
3. Automate the process
   - Ten strategies for automation and production systems

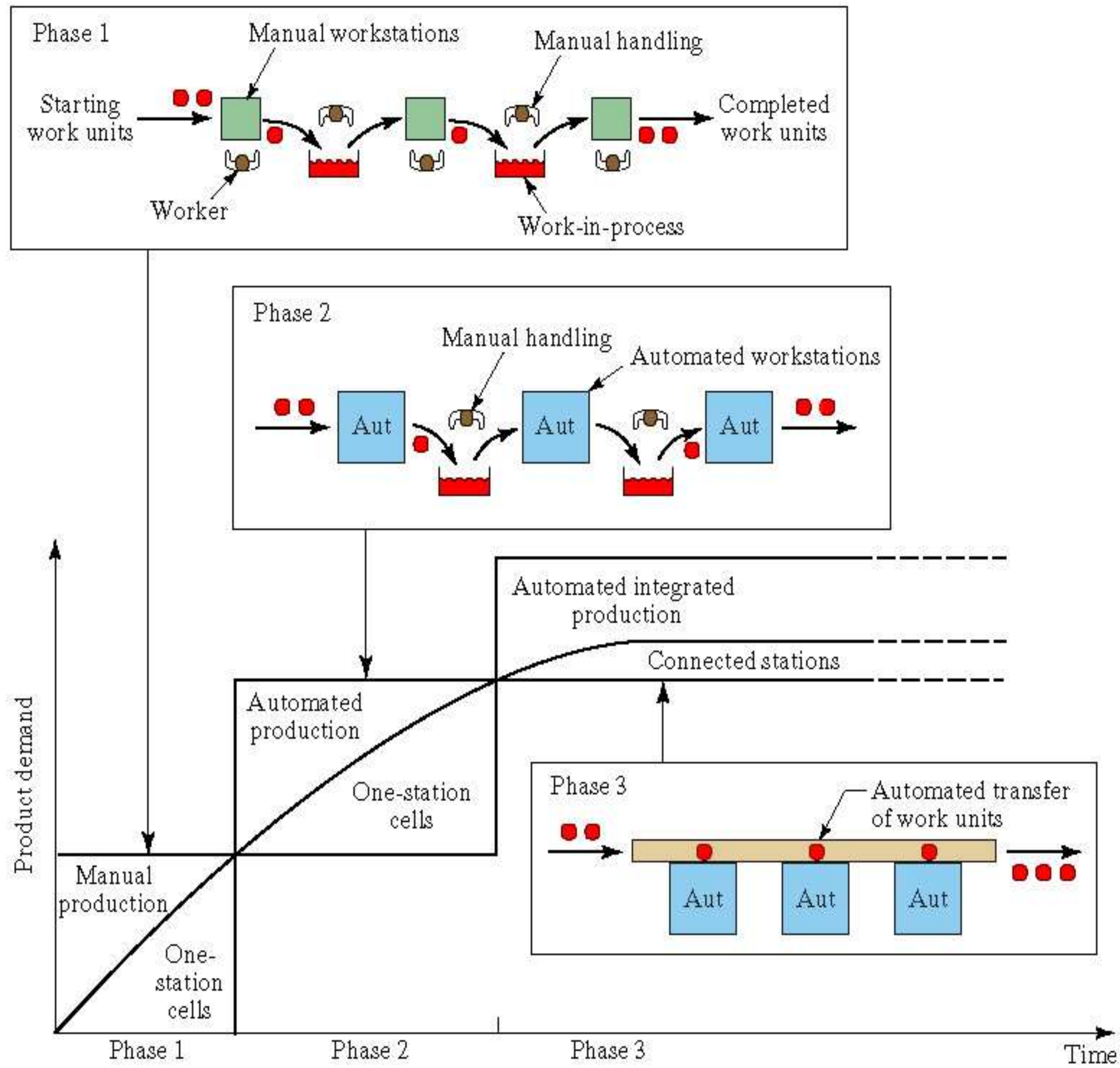
TEN STRATEGIES FOR AUTOMATION AND PROCESS IMPROVEMENT

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

AUTOMATION MIGRATION STRATEGY FOR INTRODUCTION OF NEW PRODUCTS

1. Phase 1 – Manual production
   - Single-station manned cells working independently
   - Advantages: quick to set up, low-cost tooling
2. Phase 2 – Automated production
   - Single-station automated cells operating independently
   - As demand grows and automation can be justified
3. Phase 3 – Automated integrated production
   - Multi-station system with serial operations and automated transfer of work units between

Automation Migration Strategy



PROCESSING OPERATIONS




- Shaping operations
  - Solidification processes
  - Particulate processing
  - Deformation processes
  - Material removal processes
- Property-enhancing operations (heat treatments)
- Surface processing operations
  - Cleaning and surface treatments
  - Coating and thin-film deposition

ASSEMBLY OPERATIONS

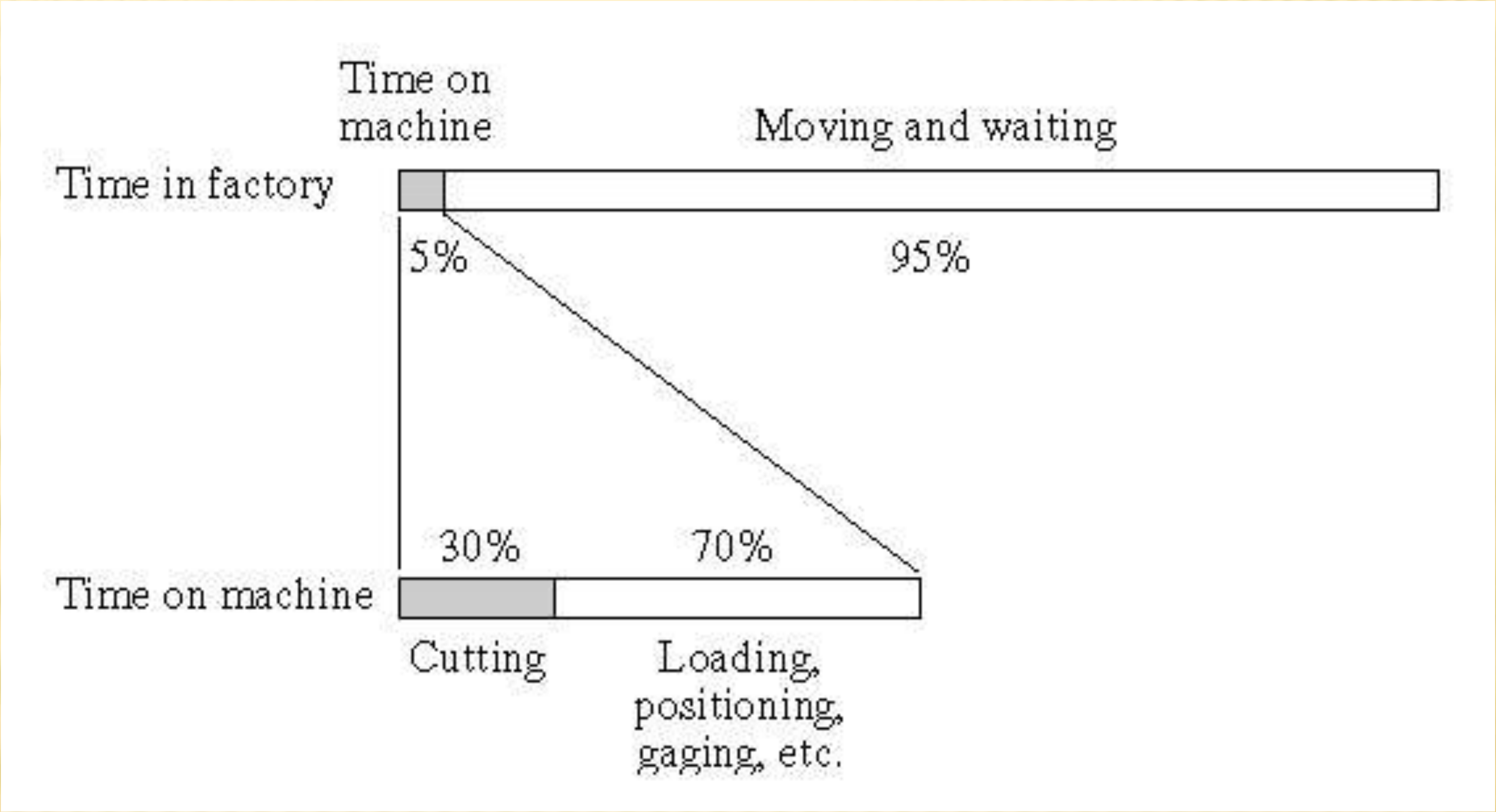
- Joining processes
  - Welding
  - Brazing and soldering
  - Adhesive bonding
- Mechanical assembly
  - Threaded fasteners (e.g., bolts and nuts, screws)
  - Rivets
  - Interference fits (e.g., press fitting, sh
  - Other

MATERIAL HANDLING

- Material transport
  - Vehicles, e.g., forklift trucks, AGVs, monorails
  - Conveyors
  - Hoists and cranes

- Storage systems
- Unitizing equipment
- Automatic identification and data capture
  - Bar codes
  - RFID
  - Other AIDC

TIME SPENT IN MATERIAL HANDLING



INSPECTION AND TESTING

Inspection – conformance to design specifications

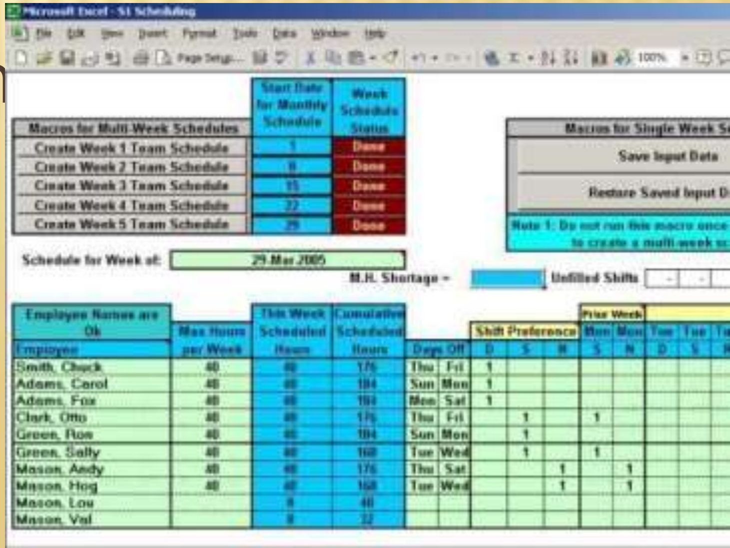
- Inspection for variables - measuring
- Inspection of attributes – gauging

Testing – observing the product (or p

mbly) during ope

COORDINATION AND CONTROL

- Regulation of the individual processing and assembly operations
  - Process control
  - Quality control
- Management of plant level activities
  - Production planning and con
  - Quality control



PRODUCT QUANTITY AND VARIETY

- Let Q_j = annual quantity of variety ‘j’
- P = variety of products from ‘1’ to ‘j’
- Total number of product units = $Q_f = \sum_{j=1}^{P} Q_j$

UTILIZATION AND AVAILABILITY

Utilization: $U = \frac{Q}{PC}$

where Q = quantity actually produced, and

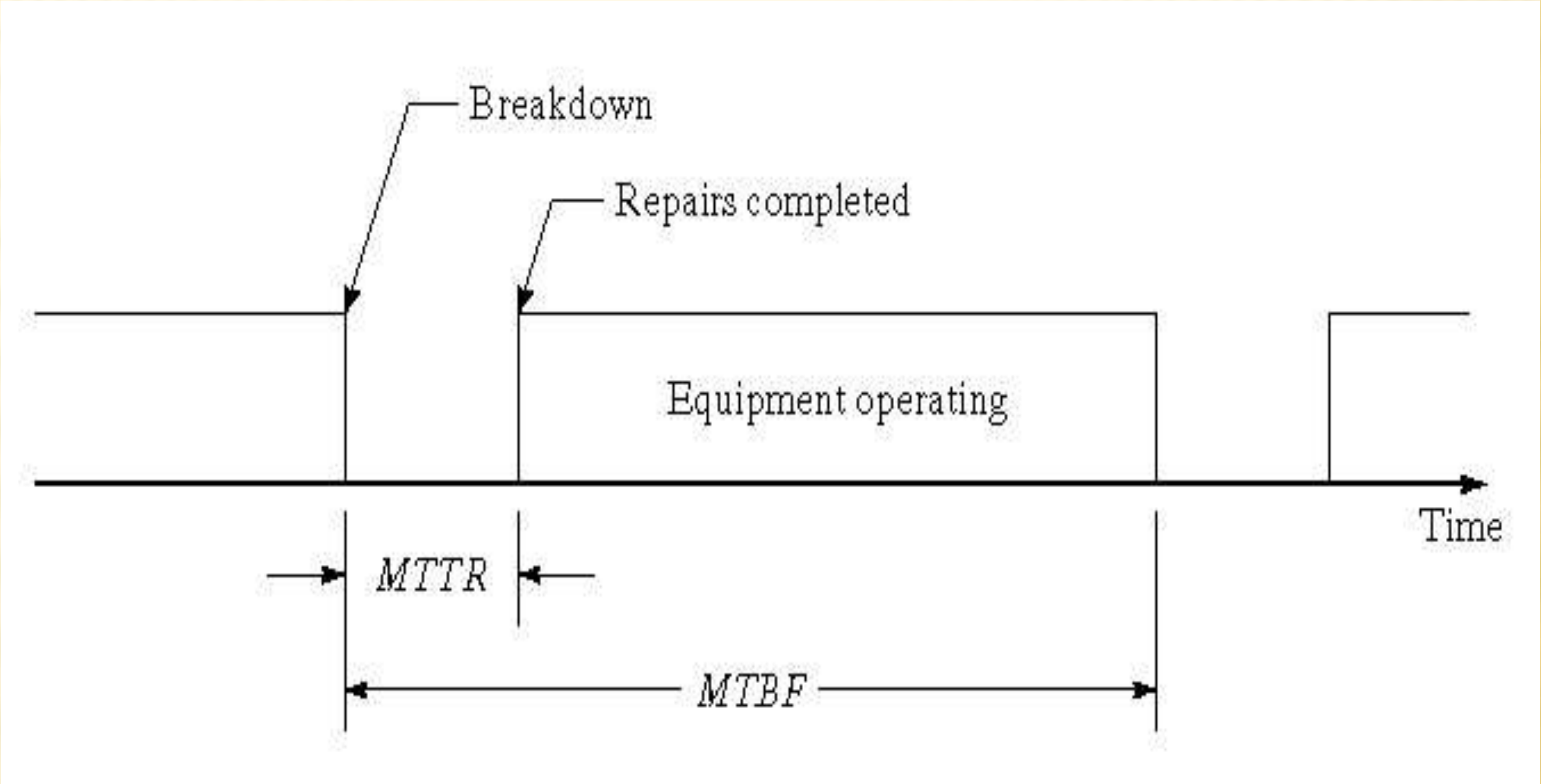
PC = plant capacity

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

where $MTBF$ = mean time between failures, and

$MTTR$ = mean time to repair

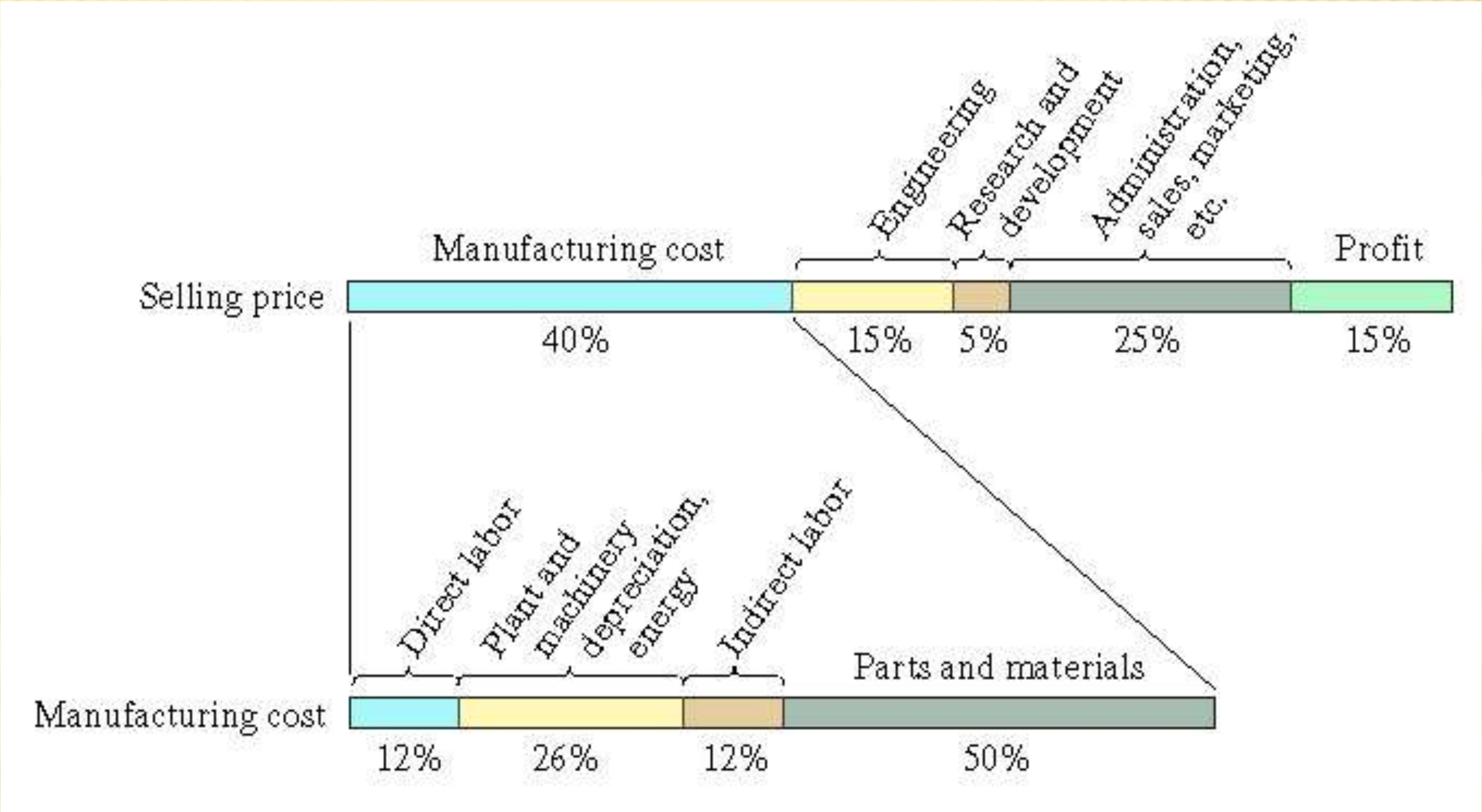
AVAILABILITY - *MTBF* AND *MTTR* DEFINED



MANUFACTURING COSTS

- Alternative classification of manufacturing costs:
  1. Direct labor - wages and benefits paid to workers
  2. Materials - costs of raw materials
  3. Overhead - all of the other expenses associated with running the manufacturing firm
     - Factory overhead
     - Corporate overhead

TYPICAL MANUFACTURING COSTS



MANUFACTURING CAPABILITY

- Technological processing capability - the available set of manufacturing processes
- Physical size and weight of product
- Production capacity (plant capacity) - production quantity that can be made in a given time

AUTOMATION DEFINED

Automation is the technology by which a process or procedure is accomplished without human assistance.

- Basic elements of an automated system:
  1. *Power* - to accomplish the process and operate the automated system
  2. *Program of instructions* – to direct the process
  3. *Control system* – to actuate the instructions

ELECTRICITY -THE PRINCIPAL POWER SOURCE

- Widely available at moderate cost
- Can be readily converted to alternative forms, e.g., mechanical, thermal, light, etc.
- Low level power can be used for signal transmission, data processing, and communication
- Can be stored in long-life batteries

POWER TO ACCOMPLISH THE AUTOMATED PROCESS

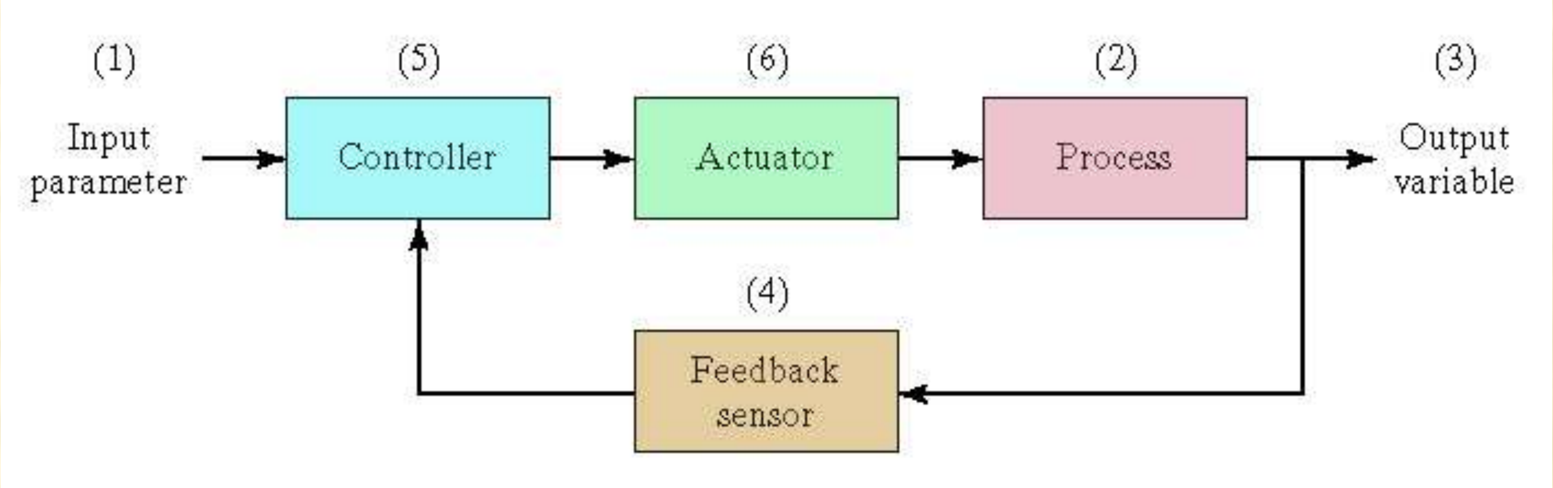
- *Power for the process*
  - To drive the process itself
  - To load and unload the work unit
  - Transport between operations
- *Power for automation*
  - Controller unit
  - Power to actuate the control signals
  - Data acquisition and information processing

CONTROL SYSTEM – TWO TYPES

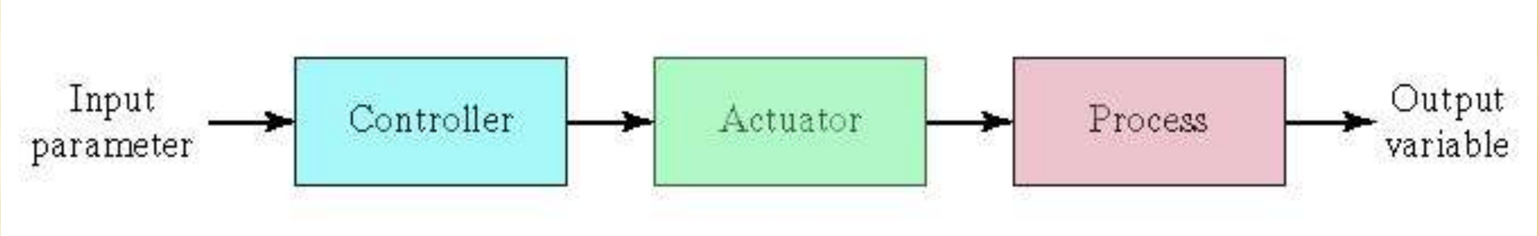
1. *Closed-loop (feedback) control system* – a system in which the output variable is compared with an input parameter, and any difference between the two is used to drive the output into agreement with the input
2. *Open-loop control system* – operates without the feedback loop
   - Simpler and less expensive
   - Risk that the actuator will not have the intended effect

(A) FEEDBACK CONTROL SYSTEM AND (B) OPEN-LOOP CONTROL SYSTEM

(a)



(b)



ADVANCED AUTOMATION FUNCTIONS

1. Safety monitoring
2. Maintenance and repair diagnostics
3. Error detection and recovery

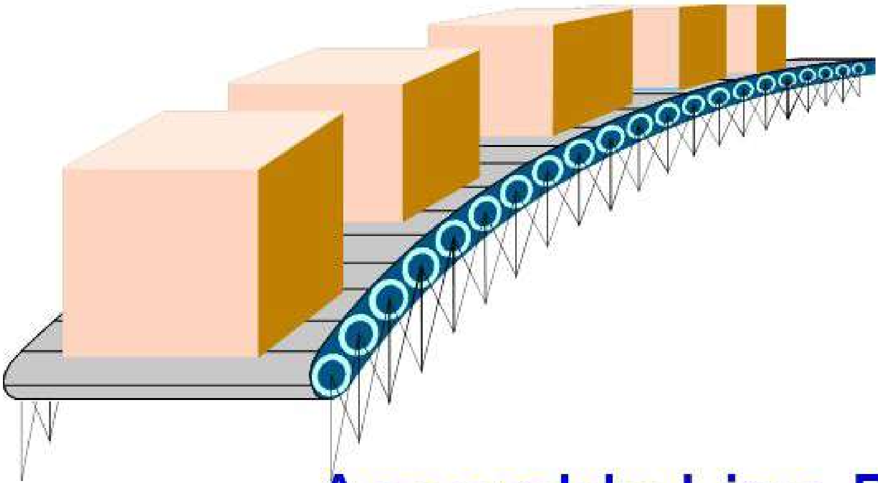
SAFETY MONITORING

Use of sensors to track the system's operation and identify conditions that are unsafe or potentially unsafe

- Reasons for safety monitoring
  - To protect workers and equipment
- Possible responses to hazards:
  - Complete stoppage of the system
  - Sounding an alarm
  - Reducing operating speed of process
  - Taking corrective action to recover from the safety violation

UNIT III

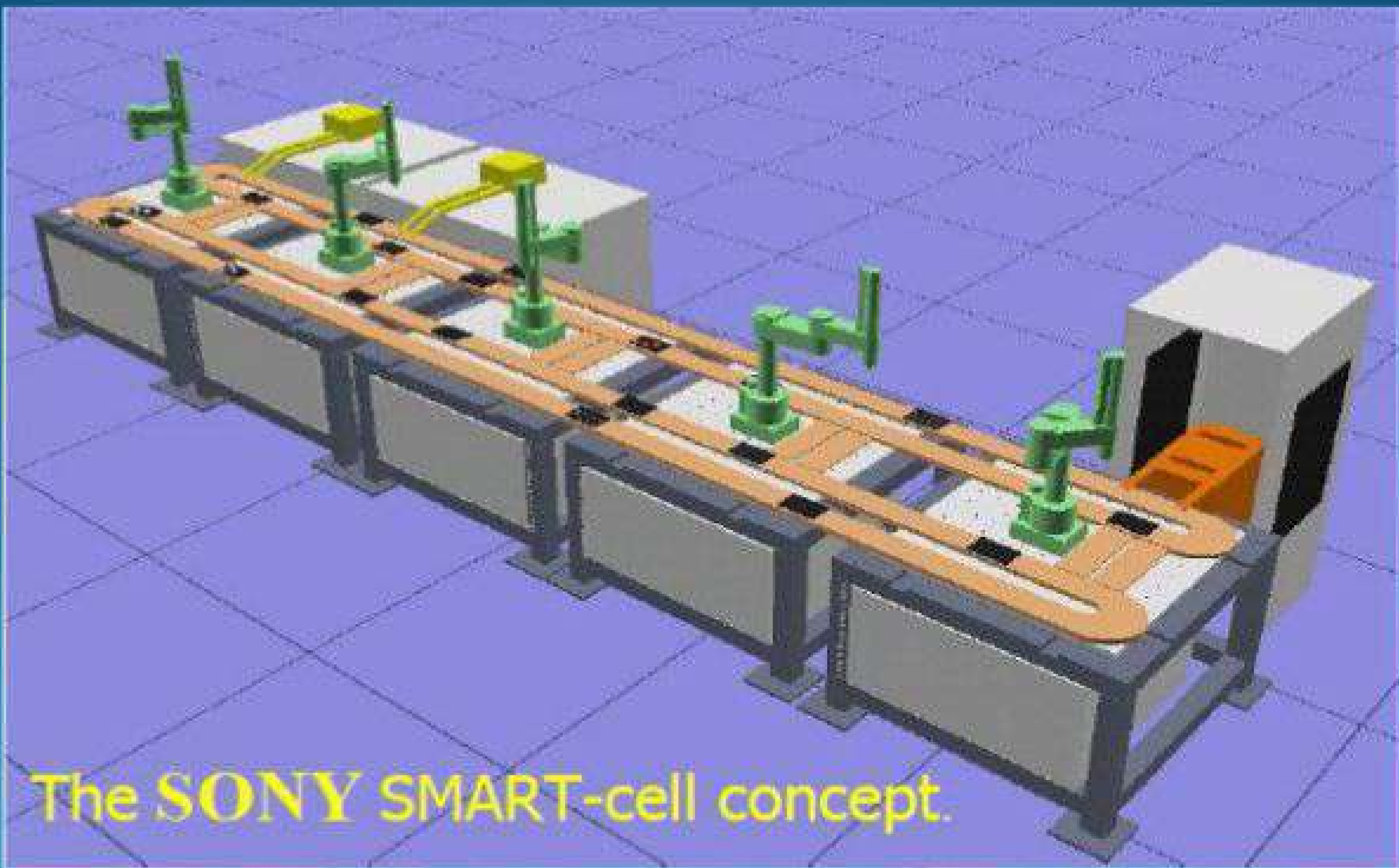
INDUTRIAL APPLICATIONS



Assembly Line Balancing

The assembly line is a production line where material moves continuously through a series of workstations where assembly work is performed.

Automated Assembly System:



The SONY SMART-cell concept.

Assembly Line Balancing

The purpose of the assembly line balancing technique is:

1. To equalize the work load among the assemblers
2. To identify the bottleneck operation
3. To establish the speed of the assembly line
4. To determine the number of workstations
5. To determine the labor cost of assembly and pack out
6. To establish the percentage workload of each operator
7. To assist in plant layout
8. To reduce production cost

UNIT III

ASSIGNMET

Unit-III

1. a). Discuss the different types of assembly systems.

   b). Explain the other ways to improve line balancing in flexible assembly lines.

2. Theory from Automated Assembly

3. Problems from Line Balancing

UNIT III

SHORT ‘Q’ & TUTORIAL

UNIT-III

1. **What is Line Balancing in Automation?**
   In flow line production there are many separate & distinct processing & assembly operations to be performed on the product. Invariably, the sequence of processing or assembly steps is restricted, at least to some extent, in terms of the order in which the operations can be carried out. For example, a threaded hole must be drilled before it can be tapped. In mechanical fastening, the washer must be placed over the bolt before the nut can be turned & tightened.
2. **What is Partial Automation?**

Many assembly lines in industry contain a combination of automated & manual work stations. These cases of partially automated production lines occur for two main reasons:

   a) Automation is introduced gradually on an existing manual line
   b) Certain manual operations are too difficult or too costly to automate.

3. **What are the reasons for downtime on an Automated Production line?**
   a) Tool failures at workstations.
   b) Tool adjustments at workstations
   c) Scheduled tool charges
   d) Limit switch or other electrical malfunctions.

4. **Write short note on Storage Buffers.**
   The preceding analysis assumes no buffer storage between stations. When the automated portion of the line breaks down, the manual stations must also stop for lack of work parts. Storage buffers located before & after the manual stations would reduce forced downtime at these stations.
5. **What are assumptions for the operation of the Transfer line & rotary indexing machines?**

   -The workstations perform operations such as machining & not assembly.
   -Processing times at each station are constant though they may not be equal.
   -There is synchronous transfer of parts.
   -No internal storage of buffers.

6. What is ideal cycle time on the line?

Tc is the processing time for the slowest station of the line plus the transfer time;

$$T_c = \max(T_{si}) + T_r \quad \text{---------------} (1)$$

7. Write short note on Upper Bound Approach.

The upper bound approach provides an upper limit on the frequency on the line stops per cycle. In this approach we assume that the part remains on the line for further processing. It is possible that there will be more than one line stop associated with a given part during its sequence of processing operations.

8. Write short note on Lower Bound Approach.

The lower bound approach gives an estimate of the lower limit on the expected frequency of line stops per cycle. Here we assume that a station breakdown results in destruction of the part, resulting in removal of the part from the line & preventing its subsequent processing at the remaining workstations.

9. What is the Limit of Storage Buffer Effectiveness?

Two extreme cases of storage buffer effectiveness can be identified:

No buffer storage capacity at all.
Infinite capacity storage buffers

If we assume in our Analysis that the ideal cycle time is the same for all stages considered. In the case of no storage capacity, the production line acts as one stage when station breaks down the entire line stops.

10. How Automation is introduced gradually on an existing manual line?

- Suppose that demand for the product made on a manually operated line increases, & it is desired to increase production & reduce labor costs by automating some or all of the stations.

-The simpler operations are automated first, & the transition toward a fully automated line is accomplished over a long period of time. Meanwhile, the line operates as a partially automated system

UNIT IV
AUTOMATED MATERIAL HANDLING

Objective:

- To perform a sequence of automated or mechanized assembly operations Flexible manufacturing system (FMS)—a highly automated machine cell that produces part

Outcome:

- Understand the Automated Material handling equipments and types

Automated material handling: Types of equipment, functions, analysis and design of material handling systems conveyor systems, automated guided vehicle systems.
Automated storage systems: Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

UNIT-IV

Automated Material Handling and Storage Systems

AUTOMATED MATERIAL HANDLING

INTRODUCTION

Automated material handling (AMH) systems improve efficiency of transportation, storage and retrieval of materials. Examples are computerized conveyors, and automated storage and retrieval systems (AS/RS) in which computers direct automatic loaders to pick and place items. Automated guided vehicle (AGV) systems use embedded floor wires to direct driverless vehicles to various locations in the plant. Benefits of AMH systems include quicker material movement, lower inventories and storage space, reduced product damage and higher labour productivity.

Objectives

After studying this unit, you should be able to understand the

- Importance of AGV in a computer-integrated manufacturing system,
- Role of industrial robots in a computer-integrated manufacturing systems, and
- Alternative for automated material handling system.

INTRODUCTION TO AGVS

A material-handling system can be simply defined as an integrated system involving such activities as handling, and controlling of materials. Materials include all kinds of raw material, work-in-progress, sub-assemblies, and finished assemblies. The main motto of an effective material-handling system is to ensure that the material in the right amount is safely delivered to the desired destination at the right time and at minimum cost. It is an integral part of any manufacturing activity. Role of AGVs and Robots have become strategic with respect to the modern material handling practices followed in the present day industry. The next section deals with the automated guided vehicles (AGVs). In Section 3.2, we have introduced the modern industrial robots and the attributes related with them, which are essential for their understanding.

Automated Guided Vehicles

Automated guided vehicle systems (AGVs), commonly known as driverless vehicles, are turning out to be an important part of the automated manufacturing system. With the shift from mass production to mid-volume and mid-variety, flexible manufacturing systems, are increasingly in use. They require not only machine flexibility but also material-handling, storage, and retrieval flexibility. Hence, the importance of AGVs has grown in manifold. It is a battery-powered driverless vehicle with programming capabilities for destination, path selection, and positioning. The AGVs belongs to a class of highly flexible, intelligent, and versatile material-handling systems used to transport materials from various loading locations to various unloading locations throughout the facility. The capability related to collision avoidance is nicely inbuilt in AGVS. Therefore, the vehicle comes to a dead stop before any damage is done to the personnel, materials, or structures. They are becoming an integral part of flexible manufacturing system installations.

Now-a-days, AGVS are versatile in nature and possess flexible material-handling system. They use modern microprocessor technology to guide a vehicle along a prescribed path and makes correction if the vehicle strays from the path. A system controller receives instructions directly from the host computer, communicates with other vehicles, and issues appropriate commands to each vehicle. To avoid collision, communication is necessary among the AGVs. To facilitate the communication, they are connected through a wire in the floor or by radio.

Components of AGVS

- There are four main components of an automated guided vehicle system. They are as follows :
- ***The Vehicle*** **:** It is used to move the material within the system without a human operator.
- ***The Guide Path*** **:** It guides the vehicle to move along the path.
- ***The Control Unit*****:** It monitors and directs system operations including feedback on moves, inventory, and vehicles.
- ***The Computer Interface*** **:** It is connected with other computers and systems such as mainframe host computer, the Automated Storage and Retrieval System (AS/RS), and the Flexible Manufacturing System.

Different Types of AGVS

- There are different types of automated guided vehicles that are able to cater different service requirements. The vehicle types include :
- AGVS towing vehicles
- AGVS unit load transporters
- AGVS pallet trucks
- AGVS forklift trucks
- AGVS light-load transporters
- AGVS assembly line vehicles

The level of sophistication of the AGVS has increased to allow automatic positioning and pickup and drop-off (P/D) of cargo, and they also perform P/D services between machining work centers, storage racks, and the AS/RS. They are also capable of two-way travel on the same path and real-time dispatching under the control of the computer. The different types of AGVS are discussed in the section to follow.

AGVS Towing Vehicle

AGVS towing vehicles were the earliest variety to be introduced. A towing vehicle is an automated guided tractor. A wide variety of tractors can be used, such as flatbed trailers, pallet trucks, custom trailers, and bin trailers. Different types of loading equipment used for loading and unloading the trailer include an AGV-pulled train, hand pallet truck, cranes, forklift truck, automatic transfer equipment, manual labor, shuttle transfer, and programmed automatic loading and unloading device.

AGVS Pallet Trucks

AGVS pallet trucks are designed to lift, maneuver, and transport palletized loads. It is used for picking up or dropping off loads from and on to floor level, than removing the need for fixed load stands. No special accessories are needed for loading and unloading the AGVS pallet except that the loads should be on a pallet. It is basically used in floor-level loading and unloading operation. Loading and unloading can be done in two ways viz. automatically or manually. For the transportation of load, the normal course followed by the vehicle is determined by the storage area destination. Normal operations carried out in pallet trucks are :

(i) loads are pulled off onto a spur,

(ii) lowering of the pallet forks to the floor,

(iii) pulling out from the pallet, and

(iv) finally automatically returns empty to the loading area.

AGVS Forklift Trucks

An AGVS forklift truck has the capability to pick up and drop off palletized loads both at floor level and on stands, and the pickup height can be different from the drop-off height. They are capable of picking up and dropping off a palletized load automatically. It has the ability to position its forks at any height so that conveyors or load stands with different heights in the material-handling system can be serviced. AGVS forklift trucks are one of the most expensive AGVS types. Therefore, they are used in the case of full automation. The truck is accoutered with sensors at the fork end, so that it can handle high-level stacking on its own. These systems have the advantage of greater flexibility in integrating with other subsystems with various loading and unloading heights throughout the material handling system.

AGVS Light Load Transporters

They are applied in handling small, light parts over a moderate distance and distribute the parts between storage and number of work stations.

AGVS Assembly-Line Vehicles

AGVS assembly line vehicles are an acclimatization of the light-load transporters for applications involving serial assembly processes. The guided vehicle carries major sub-assemblies such as motors, transmissions, or even automobiles. As the vehicle moves from one station to the next, succeeding assembly operations are performed. After the loading of part onto the vehicle, the vehicle moves to an assembly area and stops for assembly. As the assembly process is completed, the operator releases the vehicle that proceeds to the next part's staging area for new parts. After that the vehicle moves forward to the next assembly station. The process is repeated until the final unloading station is reached.

The main advantage of the AGVS assembly line is its lower expense and ease of installation compared with "hard" assembly lines. The line can be easily reconfigured by altering the guide path and by reprogramming. Variable speeds and dwell intervals can be easily programmed into the system. However, an extensive planning and complex computer control is needed in the case of overall integration. Some of the guiding factors determining the functioning of the AGVS are :

(i) Guidance Systems

(ii) Routing

(iii) AGVS Control Systems

(iv) Load Transfers

(v) Interfacing with other subsystems

Next section deals with the guidance systems designed for keeping the vehicle on predetermined path.

Guidance Systems for AGVS

The main purpose of a guidance system is to keep the vehicle in the predestinated path. The main advantage of AGVS guidance system is that the guide path can be changed easily at low cost compared to the high cost of modifying fixed-path equipment such as conveyors, chains, and tow lines. Many guidance systems are available and their selection will depend on need, application, and environmental constraints. Some of the familiar guidance systems are wire-guided guidance system, optical guidance system, inertial guidance system, infrared guidance system, laser guidance system, and teaching-type guidance system.

Routing of the AGVS

AGVS routing means determining how the vehicle conforms the path and takes a shortest path between the two points. The commonly used methods are : "*frequency selection method* " and the "*path switch selection method* ".

AGVS Control Systems

Three types of AGVS control systems are available.

(i) Computer-controlled system

(ii) Remote dispatch control system

(iii) Manual control system

Computer Controlled System

Here, all the exchanges and AGVS vehicle movements are controlled and monitored by the system controller. A detailed sketch of the computer-controlled system is shown in Figure 3.1. The guide path controller controls the guide path of the AGVS and transfers the information to the AGVS process controller. Movements of AGVS vehicle are directly controlled by the AGVS process controller.

Remote Dispatch Control System

Here, a human operator controls the movement of AGVS through a remote control station. The control system sends destination instructions directly to the vehicle.

Manual Control System

In this type of system, the operator loads the vehicle and enters a destination into the onboard control panel of the vehicle. The efficiency of the system depends on the skill of the operator.

Interface with Other Subsystems

The computer-controlled system can link the AGVS materials-handling system with other subsystems in the organisation. These subsystems include:

(i) Automated storage and retrieval systems.

(ii) Computer numerical control (CNC) machines.

(iii) Shop floor control system.

(iv) Process control equipment.

(v) Flexible manufacturing systems.

They may be linked by a distributed data processing network and the host computer. In the distributed data processing network, the system control computers communicate with each other directly without the intermediate or host computer.

In the next section, we will elucidate the main features considered for designing the AGVS system.

AGVS Design Features

Many design features pertaining to AGVS are common to other material handling systems. However, there are several special features unique to the AGVS, such as stopping accuracy, facilities, safety, and maintenance.

A very important attribute of the AGVS system is “Stopping Accuracy” and it varies considerably with the nature and requirements of the system. A system with automatic load transfer requires high stopping accuracy. In case of manual load transfer, lower stopping accuracy is required. In addition to that, unit load transporters are used for systems that require higher accuracy. In an AGVS, the stopping accuracy is provided by the feedback of Computer Control Systems. Stopping accuracy depends on the applications, for example, , 1 inch or more for towing and light-load vehicles, and 3 inch for a manual system. erfacesinttool r machine inch fo001 .0

Many considerations are undertaken while designing the AGVS, like incorporation of automatic door-opening devices, elevators etc. Safety features such as emergency contact bumpers and stop buttons, object detectors, automatic warning signals, and stopping devices must be built in the AGVS. These features must be of paramount importance in the minds of the designers so as to avoid the human injuries and damage to other equipment, materials, and vehicle itself.

System Design of AGVS

The decision process related to the system design is very complex in nature. A number of issues are to be addressed which includes:

(i) Guide path layout

(ii) Number of vehicles required

(iii) Flow path design

(iv) Selection of guide path type and vehicle type

(v) Type of flow path within the layout

(vi) Location and number of load transfer points and load transfer station storage space.

Operational issues such as the routes used by the vehicles during operation are also taken into consideration. There must be a synergy between the operational and design features for the successful implementation of AGVS.

Flow Path Design

The flow path design is one of the most important processes in the AGVS design. Some of the important decisions involved in flow path design are:

(i) Type of guide path layout.

(ii) Flow path within the layout.

(iii) The number and locations of load transfer points.

(iv) Load transfer function station storage space.

Areas of application of the AGVS determine the critical issues like guide path layout, P/D (Place and Delivery) location points, and load transfer station storage space. However, the complexity of controls and economic considerations influence the direction of flows.

Vehicle blocking, congestion, and unloaded vehicle travel are the issues to be taken into consideration and depend on the number of the vehicles and the requests for vehicles from various pickup and delivery stations. Simulation is used to develop the realistic design under aforementioned circumstances. The type of information required for developing a simulation model would include layout of departments, aisles, location of load transfer stations, and charts containing the material flow intensities between departments.

Automated storage and retrieval systems:

Imagine any plant/manufacturing sector without cluttered aisles, excess inventory, lost or damaged products, inaccurate records, endless searching, climbing, bending and frustration. Imagine a highly profitable operation that adds value and decreases expense.

AS/RS are means to high density hands free buffering of materials in distribution and manufacturing environments. AS/RS is a complete system designed to transport, stage/store, retrieve, and report on every item in any industrial inventory with up-to-the minute accuracy.

FUNCTIONS OF STORAGE SYSTEM AND DEFINITION OF AS/RS

An automated storage/retrieval system (AS/RS) can be defined as a storage system under which a defined degree of automation is to be implemented to ensure precision accuracy and speed in performing storage and retrieval operations. These automated storage and mechanized systems eliminate human intervention in performing basic sets of operations that includes :

- Removal of an item from a storage location automatically
- Transferring the above item to a specific processing or interface point
- After receiving an item from a processing or interface point, it is automatically stored at a predetermined location.

AS/RS COMPONENTS AND TERMINOLOGY

An AS/RS consists of one or more storage aisles that are serviced by a storage/retrieval (S/R) machine. The stored materials are held by storage racks of aisles. The S/R machines are used to deliver and retrieve materials in and out of inventory. There are one or more input/output stations in each AS/RS aisle for delivering the material into the storage system or moving it out of the system. In

AS/RS terminology, the input/output stations are called pickup-and-deposit (P&D) stations.

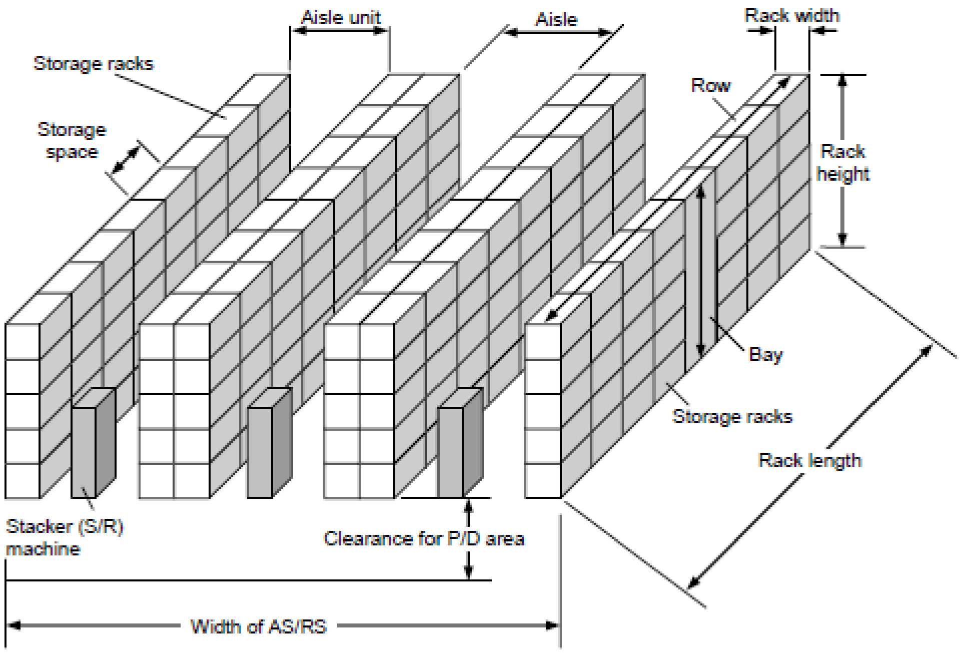


Figure 4.1 : Generic Structure of as AS/RS

Storage Space

It is the three-dimensional space in the storage racks used to store a single load unit of material.

Storage Racks

This structural entity comprises storage locations, bays and rows.

Bay

It is the height of the storage rack from floor to the ceiling.

Row

It is a series of bays placed side by side.

Aisle

It is the spacing between two rows for the machine operations of AS/RS.

Aisle Unit

It encompasses aisle space and racks adjacent to an aisle.

Storage Structure

It is the rack framework, made of fabricated steel that supports the loads contained in the AS/RS and is used to store inventory items.

Storage/Retrieval Machine

It is used to move items in and out of inventory. An S/R machine is capable of both horizontal and vertical movement. A rail system along the floor guides the machine and a parallel rail at the top of the storage structure is used to maintain its alignment.

Storage Modules

These are the unit load containers used to hold the inventory items. These include pallets, steel wire baskets and containers, pans and special drawers. These modules are generally made to a standard base size capable of being stored in the structure and moved by the S/R machines.

Pickup and Deposit (P/D) Stations

P/D stations are where inventory are transferred into and out of the AS/RS. They are generally located at the end of the aisles to facilitate easy access by the S/R machines from the external material-handling system. The location and number of P/D stations depends upon the origination point of incoming loads and the destination of output loads.

TYPES OF AS/RS

Several important categories of AS/RS can be distinguished based on certain features and applications. The following are the principle types :

Unit Load AS/RS

The unit load AS/RS is used to store and retrieve loads that are palletized or stored in standard-sized containers. The system is computer controlled. The S/R machines are automated and designed to handle the unit load containers. Usually, a mechanical clamp mechanism on the S/R machine handles the load. However, there are other mechanisms such as a vacuum or a magnet-based mechanism for handling sheet metal. The loads are generally over 500 lb per unit. The unit load system is the generic AS/RS.

Mini Load AS/RS

This system is designed to handle small loads such as individual parts, tools, and supplies that are contained in bins or drawers in the storage system. Such a system is applicable where the availability of space is limited. It also finds its use where the volume is too low for a full-scale unit load system and too high for a manual system. A mini load AS/RS is generally smaller than a unit load AS/RS and is often enclosed for security of items stored.

Deep-lane AS/RS

This is a high-density unit load storage system that is appropriate for storing large quantities of stock. The items are stored in multi deep storage with up to 10 items in a single rack, one load behind the next. Each rack is designed for flow-through, with input and output on the opposite side. Machine is used on the entry side of the rack for input load and loads are retrieved from other side by an S/R- type machine. The S/R machines are similar to unit load S/R machine except that it has specialized functions such as controlling rack-entry vehicles.

Man-on-board AS/RS

This system allows storage of items in less than unit load quantities. Human operator rides on the carriage of the S/R machine to pick up individual items from a bin or drawer. The system permits individual items to be picked directly at their storage locations. This provides an opportunity to increase system throughput. The operator can select the items and place them in a module. It is then carried by the S/R machine to the end of the aisle or to a conveyor to reach its destination.

Automated Item Retrieval System

This system is designed for retrieval of individual items or small product cartoons. The items are stored in lanes rather than bins or drawers. When an item is retrieved from the front by use of a rear-mounted pusher bar, it is delivered to the pickup station by pushing it from its lane and dropping onto a conveyor. The supply of items in each lane is periodically replenished and thus permitting first-in/first-out inventory rotation. After moving itself to the correct lane, the picking head activates the pusher mechanism to release the required number of units from storage.

UNIT IV
POWER POINT PRESENTATION SLIDES

MAINTENANCE AND REPAIR DIAGNOSTICS

- *Status monitoring*
  - Monitors and records status of key sensors and parameters during system operation
- *Failure diagnostics*
  - Invoked when a malfunction occurs
  - Purpose: analyze recorded values so the cause of the malfunction can be identified
- *Recommendation of repair procedure*
  - Provides recommended procedure for the repair crew to effect repairs

ERROR DETECTION AND RECOVERY

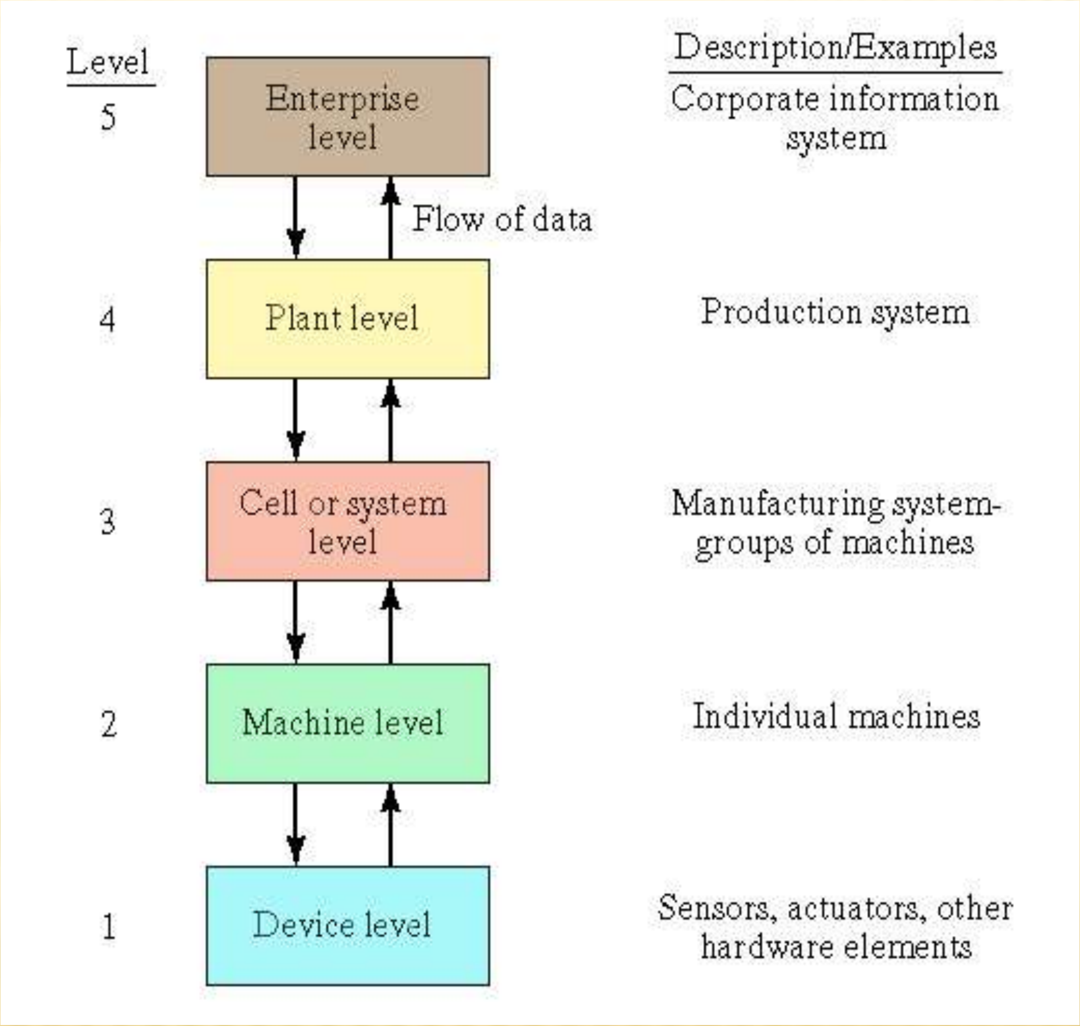
1. *Error detection* – functions:
   - Use the system's available sensors to determine when a deviation or malfunction has occurred
   - Correctly interpret the sensor signal
   - Classify the error
2. *Error recovery* – possible strategies:
   - Make adjustments at end of work cycle
   - Make adjustments during current work cycle
   - Stop the process to invoke corrective action
   - Stop the process and call for help

LEVELS OF AUTOMATION

1. *Device level* – actuators, sensors, and other hardware components to form individual control loops for the next level
2. *Machine level* – CNC machine tools and similar production equipment, industrial robots, material handling equipment
3. *Cell or system level* – manufacturing cell or system
4. *Plant level* – factory or production systems level
5. *Enterprise level* – corporate information system

LEVELS OF AUTOMATION

Fig. 2.6



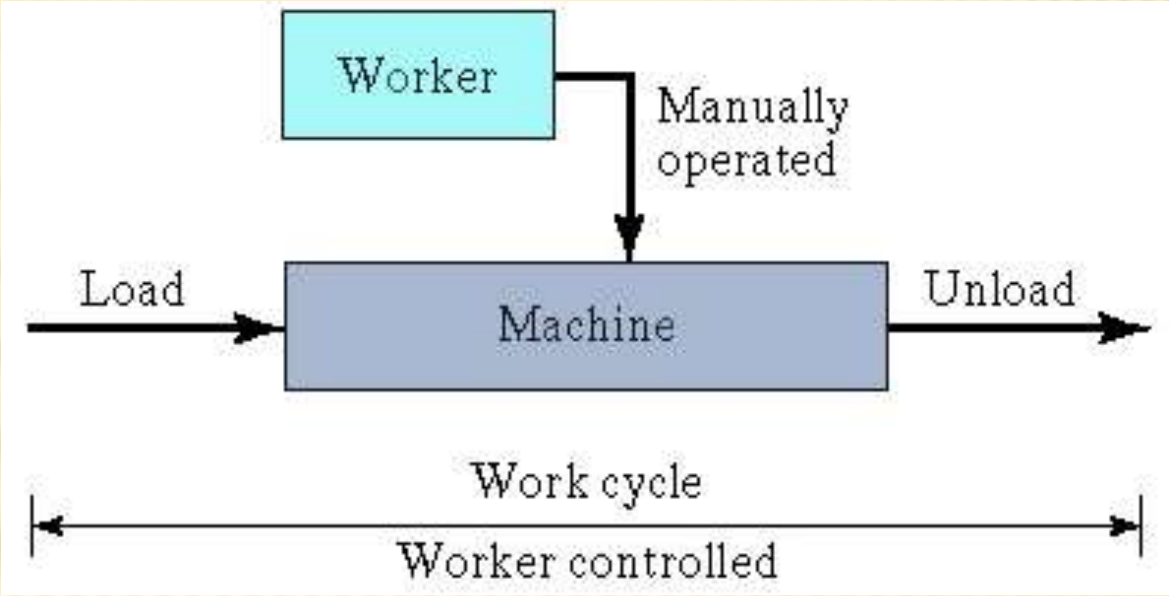
EXAMPLES OF MANUFACTURING SYSTEMS

- Single-station cells
- Machine clusters
- Manual assembly lines
- Automated transfer lines
- Automated assembly systems
- Machine cells (cellular manufacturing)
- Flexible manufacturing systems

PRODUCTION MACHINES

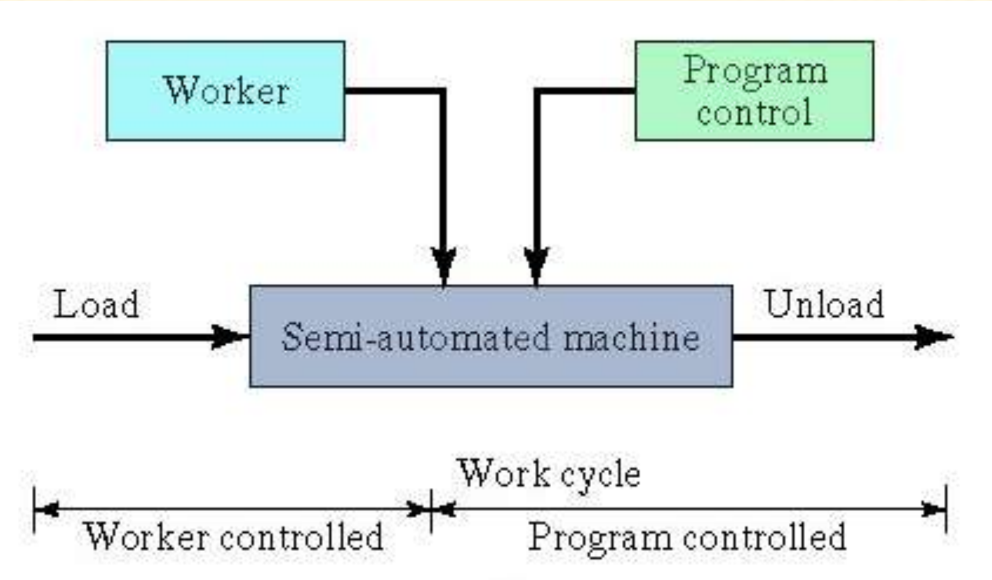
- In virtually all modern manufacturing systems, most of the actual processing or assembly work is accomplished by machines or with the aid of tools
- Classification of production machines:
  1. Manually operated machines are controlled or supervised by a human worker
  2. Semi-automated machines perform a portion of the work cycle under some form of program control, and a worker tends the machine the rest of the cycle
  3. Fully automated machines operate for extended periods of time with no human attention

MANUALLY OPERATED MACHINE



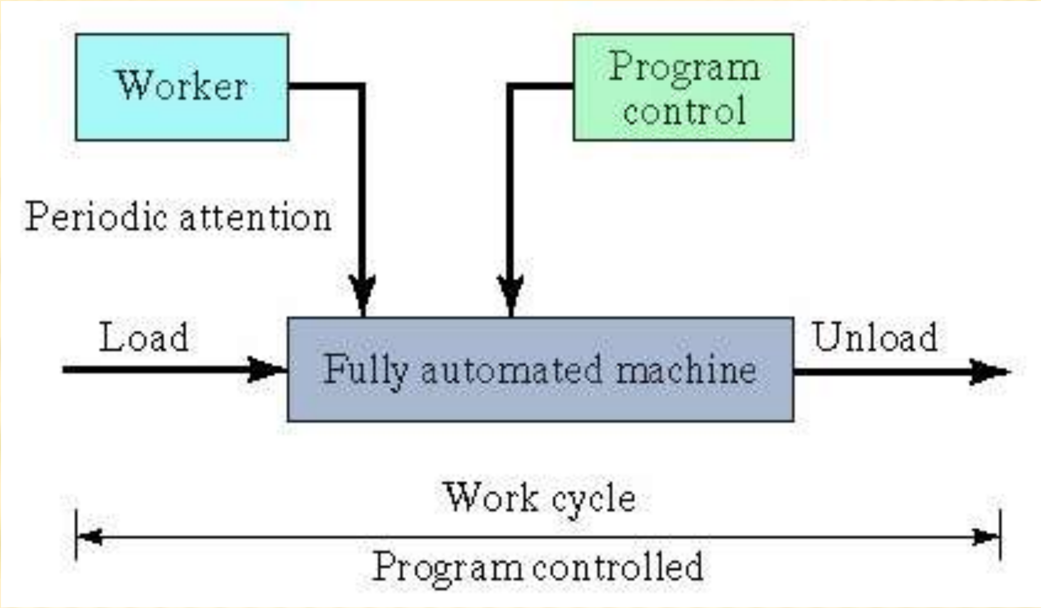
Manually operated machines are controlled or supervised by a human worker. The machine provides the power for the operation and the worker provides the control. The entire work cycle is operator controlled.

SEMI-AUTOMATED MACHINE



A semi-automated machine performs a portion of the work cycle under some form of program control, and a worker tends to the machine for the remainder of the cycle. Typical worker tasks include loading and unloading parts

FULLY-AUTOMATED MACHINE



Machine operates for extended periods (longer than one work cycle) without worker attention (periodic tending may be needed).

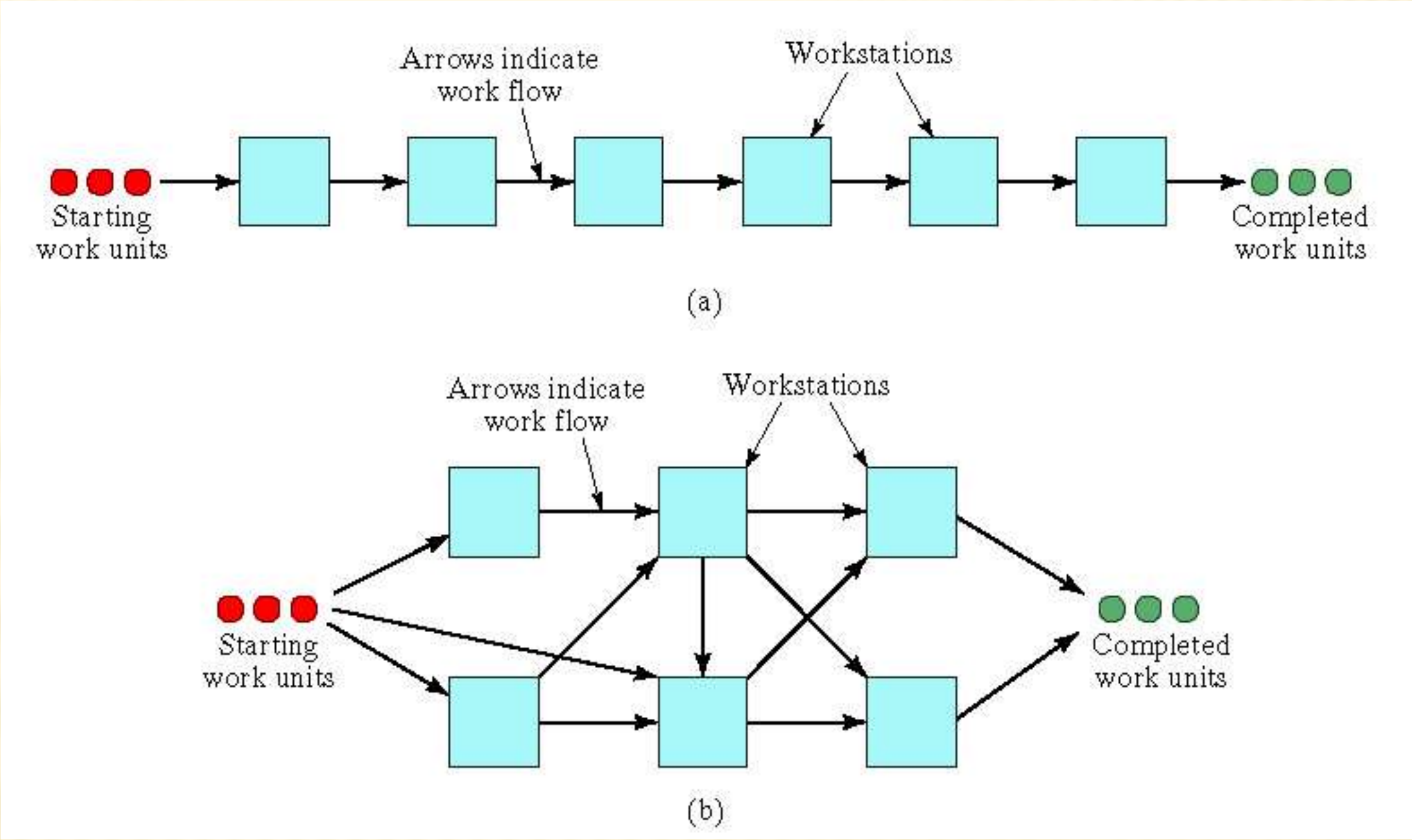
MATERIAL HANDLING SYSTEM

- In most manufacturing systems that process or assemble discrete parts and products, the following material handling functions must be provided:
  1. Loading work units at each station
  2. Positioning work units at each station
  3. Unloading work units at each station
  4. Transporting work units between stations in multi-station systems
  5. Temporary storage of work units

WORK TRANSPORT BETWEEN STATIONS

- Two general categories of work transport in multi-station manufacturing systems:
  1. Fixed routing
     - Work units always flow through the same sequence of workstations
     - Most production lines exemplify this category
  2. Variable routing
     - Work units are moved through a variety of different station sequences
     - Most job shops exemplify this category

(A) FIXED ROUTING AND (B) VARIABLE ROUTING



AUTOMATION AND MANNING LEVELS

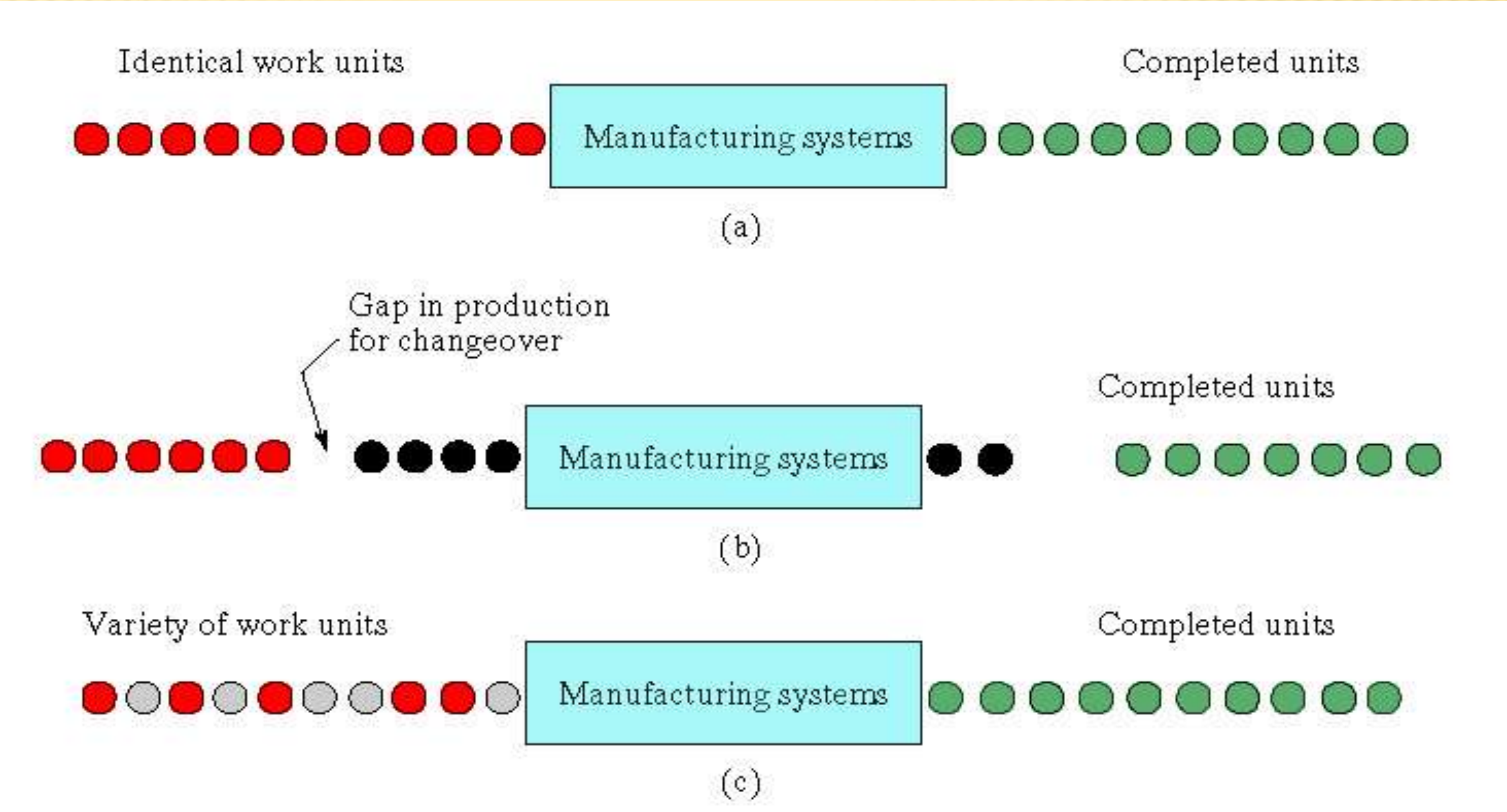
- Level of workstation automation
  - Manually operated
  - Semi-automated
  - Fully automated
- Manning level M_i = *proportion of time worker is in attendance at station i*
  - $M_i = 1$ means that one worker must be at the station continuously
  - $M_i \geq 1$ indicates manual operations
  - $M_i < 1$ usually denotes some form of automation

AUTOMATION IN THE CLASSIFICATION SCHEME:

- Type IM: *single - station manned cell* $n=1, w=1$
- Type IA: *single station automated cell* $M<1$
- Type IIM: *multi station manual system with variable routing*
- Type IIA: *multi station automated system with variable routing* $n>1, w=0, M<1$
- Type IIH: *Multi station hybrid system with variable routing*
- Type IIIM: *Multi station manual system with fixed routing* $n>1, w\geq 1$
- Type IIIA: *Multi station automated system with fixed routing* $n>1, w=0, M<1$
- type IIIH: *Multi station hybrid system with fixed routing* $n>1$

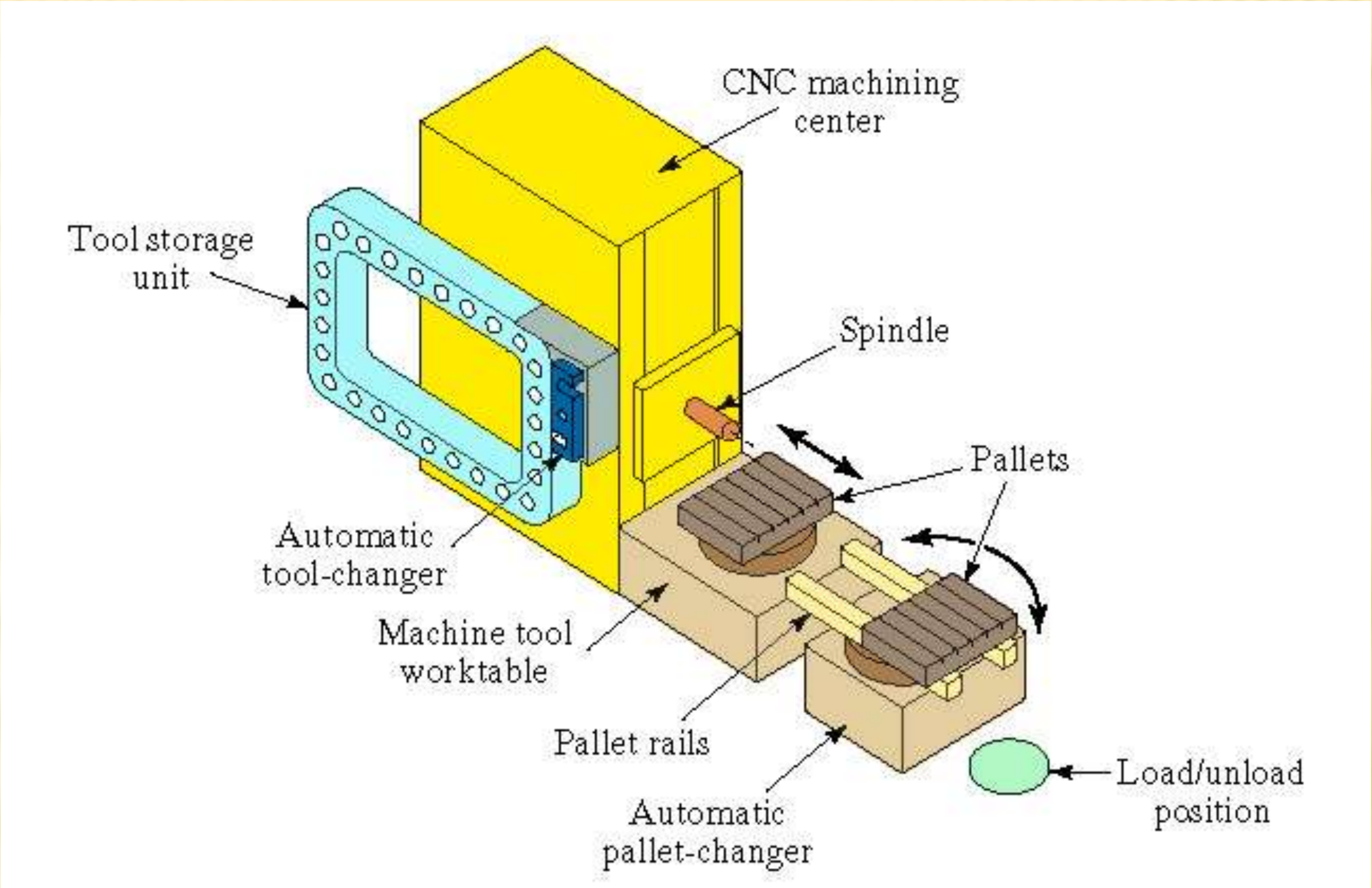
  $w\geq 1$ for some stations, $w=0$ for some stations,

THREE CASES OF PRODUCT VARIETY IN MANUFACTURING SYSTEMS



(a) Single-model case, (b) batch model case, and (c) mixed-model case

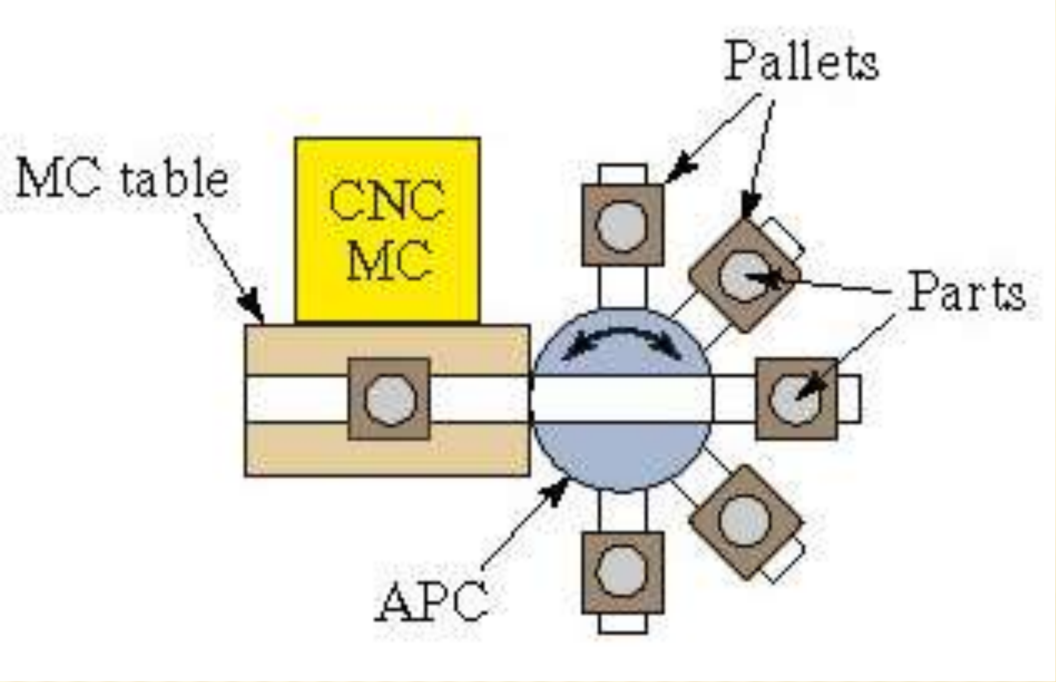
CNC MACHINING CENTER WITH AUTOMATIC PALLET CHANGER - STORES ONE PART



STORAGE CAPACITIES GREATER THAN ONE

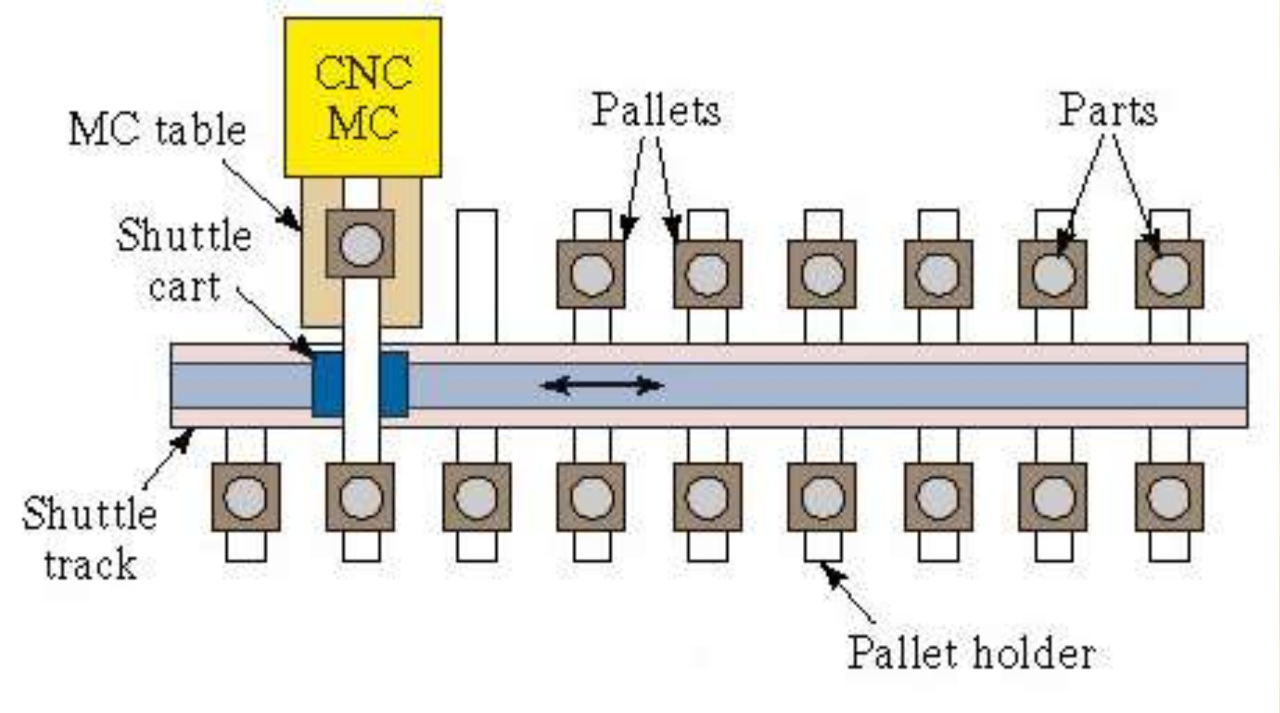
- Machining centers:
  - Various designs of parts storage unit interfaced to automatic pallet changer (or other automated transfer mechanism)
- Turning centers:
  - Industrial robot interface with parts carousel
- Plastic molding or extrusion:
  - Hopper contains sufficient molding compound for unattended operation
- Sheet metal stamping:
  - Starting material is sheet metal coil

STORAGE CAPACITIES GREATER THAN ONE



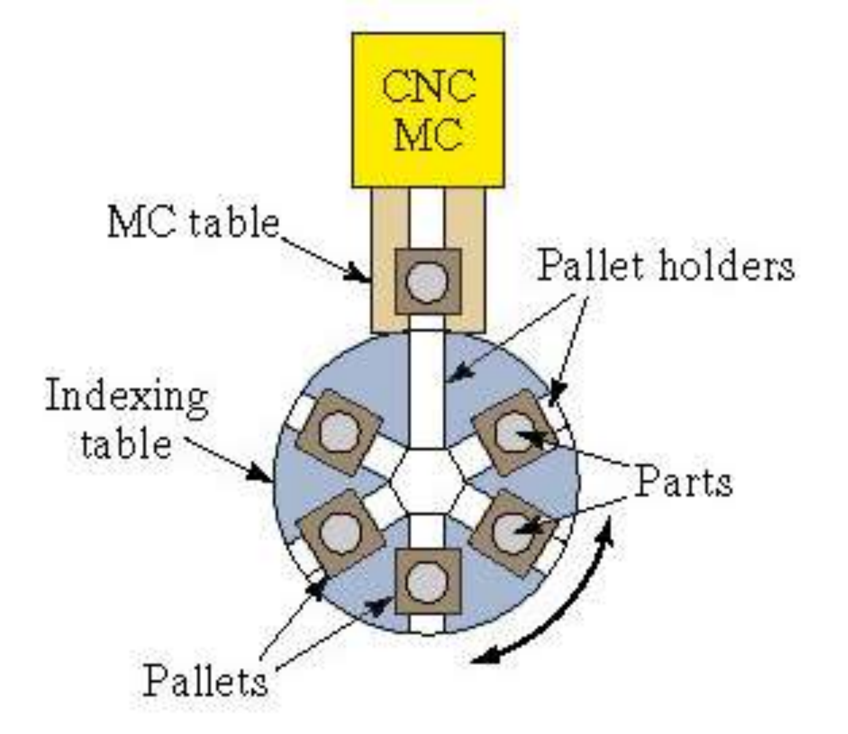
Machining center and automatic pallet changer with pallet holders arranged radially; parts storage capacity = 5

STORAGE CAPACITIES GREATER THAN ONE



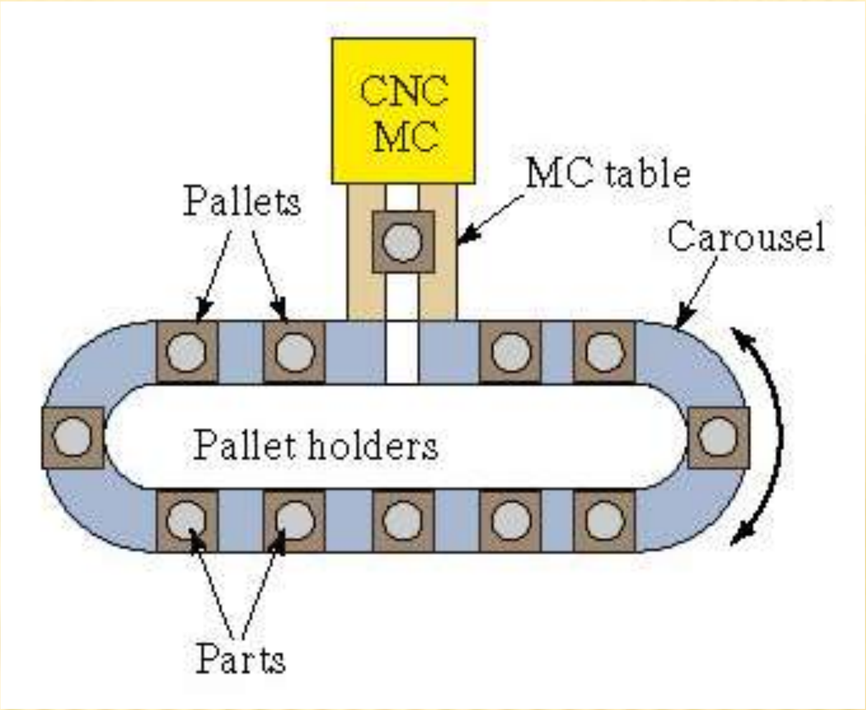
Machining center and in-line shuttle cart system with pallet holders along its length; parts storage capacity = 16

STORAGE CAPACITIES GREATER THAN ONE



Machining center with pallets held on indexing table; parts storage capacity = 6

STORAGE CAPACITIES GREATER THAN ONE



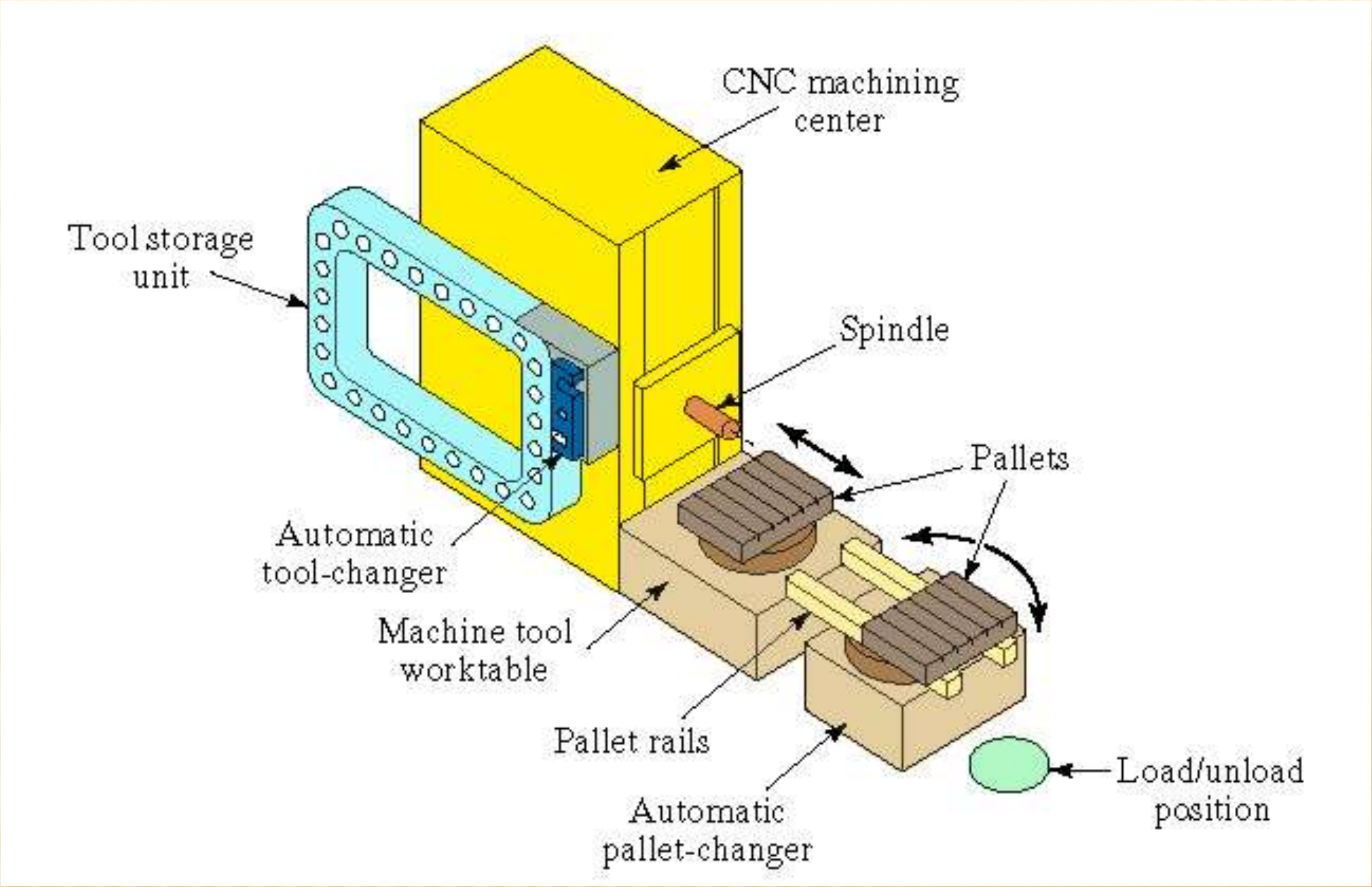
Machining center and parts storage carousel with parts loaded onto pallets; parts storage capacity = 12

CNC MACHINING CENTER

"Machine tool capable of performing multiple operations that use rotating tools on a workpart in one setup under NC control"

- Typical operations: milling, drilling, and related operations
- Typical features to reduce nonproductive time:
  - Automatic tool changer
  - Automatic workpart positioning
  - Automatic pallet changer

CNC HORIZONTAL MACHINING CENTER

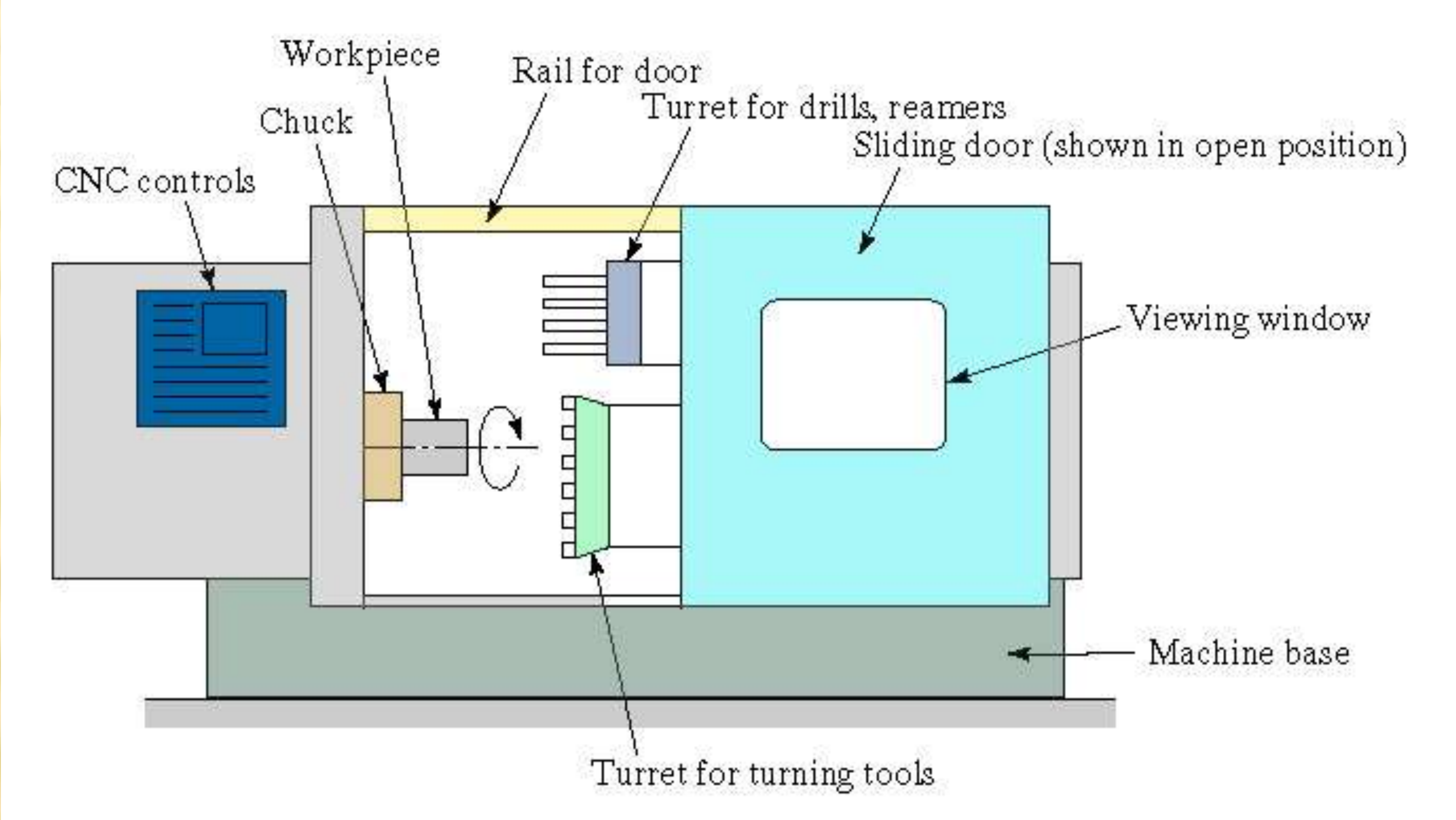


CNC TURNING CENTER

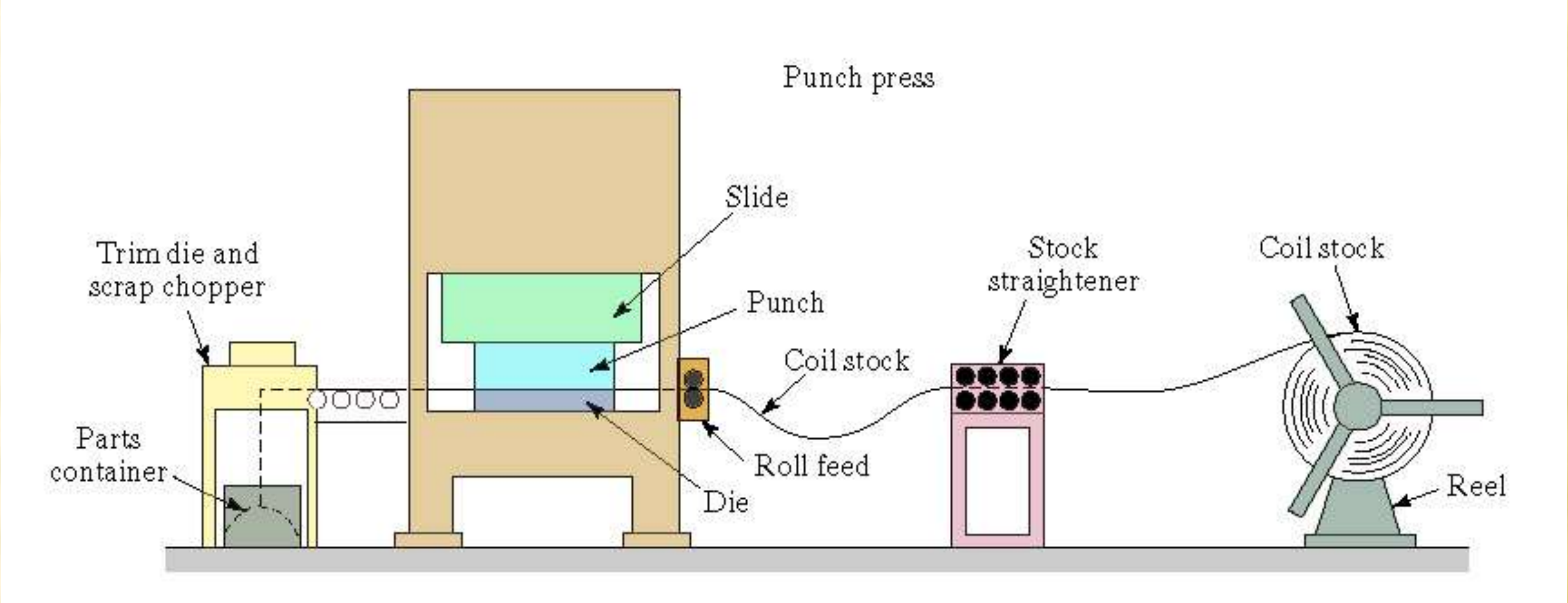
"Machine tool capable of performing multiple operations on a rotating workpart in one setup under NC control"

- Typical operations:
  - Turning and related operations, e.g., contour turning
  - Drilling and related operations along workpart axis of rotation

CNC TURNING CENTER



AUTOMATED STAMPING PRESS



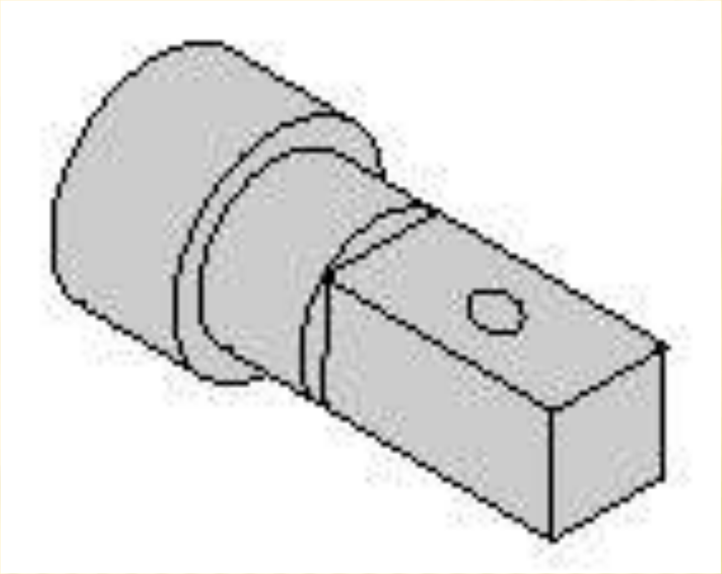
Stamping press on automatic cycle producing stampings from sheet metal coil

CNC MILL-TURN CENTER

"Machine tool capable of performing multiple operations either with single point turning tools or rotating cutters in one setup under NC control"

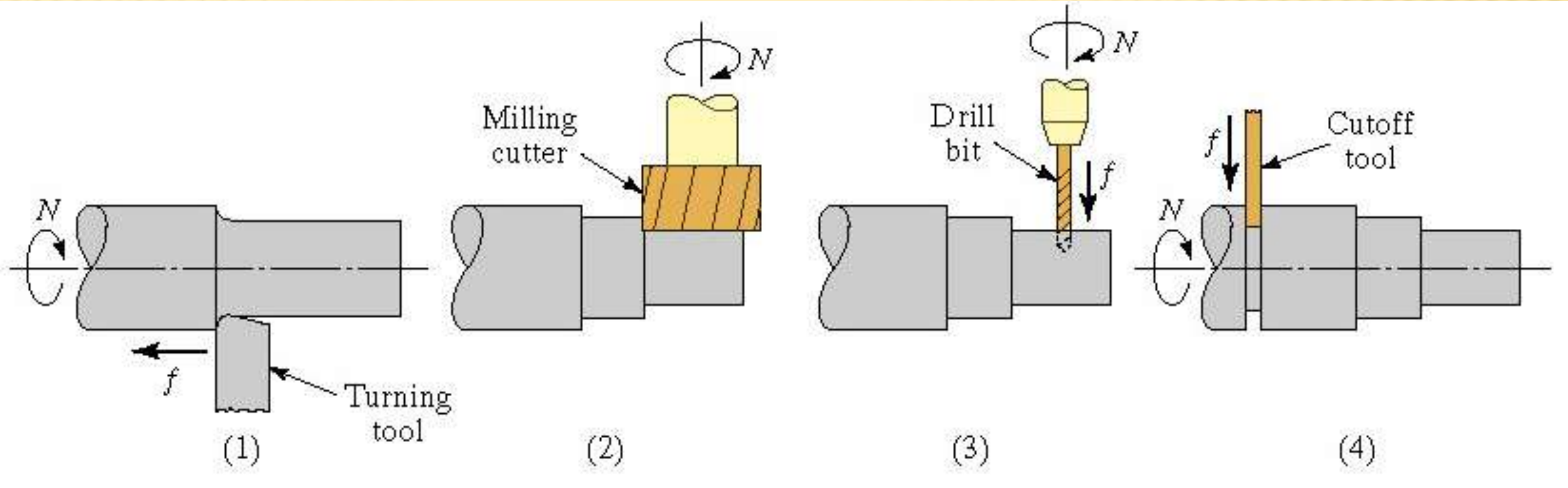
- Typical operations:
  - Turning, milling, drilling and related operations
- Enabling feature:
  - Capability to control position of c-axis in addition to *x*- and *z*-axis control (turning center is limited to *x*- and *z*-axis control)

PART WITH MILL-TURN FEATURES



Example part with turned, milled, and drilled features

SEQUENCE OF OPERATIONS OF A MILL-TURN CENTER FOR EXAMPLE PART



(1) Turn smaller diameter, (2) mill flat with part in programmed angular positions, four positions for square cross section; (3) drill hole with part in programmed angular position, and (4) cutoff of the machined piece

LEAN MANUFACTURING:

- The method to allocate machines to a worker is *fundamentally different in Lean manufacturing.* In LM, the machines are typically arranged in a U-shaped cell, and a worker tends as many workstations as allowed within the Tact time.
- Total service + repositioning time ≤ Takt time *AND*
- Machine + service time ≤ Takt time
- In LM, the machines are not necessarily

UNIT IV
INDUTRIAL APPLICATIONS


CONVEYCO

UNIT IV

ASSIGNMET

Unit-IV

1.

a). What are the principles of material handling system?

b). Describe the use of Material Handling Equipment in Machine Tools.

2. Explain the various problems encountered in interfacing handling and storage systems with manufacturing units.

3. a)Describe the following automated guided vehicle system with the help of simple sketch:

(i) Driverless automated guided train (ii) Unit load carrier.

b) Enumerate the differences between asynchronous conveyors and continuous motion conveyors.

4. Explain the importance of automated work-in-process storage systems. [6]

b) Discuss the automated Storage/Retrieval Systems (AS/RS) controls, and the special features and applications of AS/RS.

5. a) Explain the role of AS/RS in material handling systems. [8]

b) With neat sketch explain about fork lift truck.

UNIT IV

SHORT 'Q' & TUTORIAL

UNIT-IV

1. What is a material-handling system?

A material-handling system can be simply defined as an integrated system involving such activities as handling, storing, and controlling of materials.
 The word material has very broad meaning, covering all kinds of raw materials, work in process, subassemblies, and finished assemblies.
 The primary objective of using a material handling system is to ensure that the material in the right amount is safely delivered to the desired destination at the right time and at minimum cost.
 The material handling system is properly designed not only to ensure the minimum cost and compatibility with other manufacturing equipment but also to meet safety concerns.

2.What are the three parts of the material handling system?

These include:

- Automated storage and retrieval systems.
- Automatic guided vehicles (AGVs)
- Automatic identification and data collection.
- Casters and wheels.
- Controls.
- Conveyors.
- Dock equipment.
- Ergonomics

2. What is the function of a materials handling system?

Material Handling is the **movement**, **storage**, control and **protection** of materials, goods and products throughout the process of manufacturing, **distribution**, consumption and disposal. The focus is on the methods, mechanical equipment, systems and related controls used to achieve these functions.

4. What are the Principles of Material Handling ?

1. Orientation principle: study the system relationships thoroughly prior to preliminary planning in order to identify existing methods and problems, physical and economic constraints, and to establish future requirements and goals.
2. Planning principle: establish a plan to include basic requirements, desirable options, and consideration of contingencies for all MH and storage activities.
3. System principle: integrate the handling and storage activities that are economically viable into a coordinated system of operation including receiving, inspection, storage, production, assembly, packaging, warehousing, shipping, and transportation.
4. Unit load principle: handle product in as large a unit load as practical.
5. Space utilization principle
6. Standardization principle

5. What are the different types of Material Handling Equipment and explain briefly?

1. Industrial trucks include hand trucks such as two-wheeled, four-wheeled, hand lift, and forklift and powered trucks such as forklift, tractor-trailer trains, industrial crane trucks, and side loaders.
2. Conveyors such as belt, chute, roller, wheel, slat, chain, bucket, trolley, tow, screw, vibrating, and pneumatic.
3. Monorails, hoists, and cranes such as bridge, gantry, tower, and stacker. Automated guided vehicle systems such as unit load carriers, towing, pallet trucks, fork trucks, and assembly line.
4. Automated storage and retrieval systems (AS/RS) such as unit load, mini-load, person-on-board, deep lane, and storage carousel systems.

6. What is automated guided vehicle system?

An automated guided vehicle system is a battery-powered driver-less vehicle with Programming capabilities for destination, path selection, and positioning.

The AGVS belongs to a class of highly flexible, intelligent, and versatile material handling systems used to transport materials from various loading locations to various unloading locations throughout the facility.

7. Why an AS/RS?

- An AS/RS is highly space efficient. Space now occupied by raw stock, work in process, or finished parts and assemblies can be released for valuable manufacturing space.
- Increased storage capacity to meet long-range plans.
- Improved inventory management and control.
- Quick response time to locate, store, and retrieve items.
- Reduced shortages of inventory items due to real-time information and control.
- Reduced labor costs due to automation.
- Improved stock rotation.
-

8. What are the different Type of AS/RS and explain briefly?

1. Unit load AS/RS: is used to store and retrieve loads that are palletized or stored in standard-size containers.

2. Mini-load AS/RS: is designed to handle small loads such as individual parts, tools, and supplies.

The system is suitable for use where there is a limit on the amount of space that can be utilized and where the volume is too low for a full-scale unit load system and tool high for a manual system.

3. Person-on-board AS/RS: allows storage of items in less than unit load quantities.

4. Deep-lane AS/RS: is another variation on the unit load system. The items are stored in multi-deep storage with up to 10 items per row rather than single or double deep. This leads to a high density of stored items.

5. Automated item retrieval system

9. What are the Design parameters should be consider for an AS/RS?

1. Determining load sizes
2. Determining the dimensions of an individual storage space

3. Determining the number of storage spaces considering
    - Dedicated storage
    - Randomized storage
4. Determining the system throughput and number of S/R machines
    - Speed of S/R machine
    - Mix of single- and dual-cycle transaction
    - Percent utilization of the storage racks
    - Arrangement of stored items
    - AS/RS control system speed
    - Efficiency

10. What are the Functions of storage systems ?

Receiving, identification and sorting, dispatching to storage, placing in storage, storage, retrieving from storage, order accumulation, packing, shipping, and record keeping for raw materials, purchased parts, work in process, finished product, pallets, fixtures, tools, spare parts, rework and scrap, office supplies, and so forth have traditionally been considered the functions of storage systems.

 An AS/RS attempts to achieve these functions by automating most of these procedures in a cost-effective and efficient manner.

UNIT V
FUNDAMENTALS OF INDUSTRIAL CONTROLS

Objective:

- To know product families often consists of workstations comprising CNC machine tools.

Outcome:

- Student gets exposure on portable power tools.

Fundamentals of Industrial controls: Review of control theory, logic controls, sensors and actuators, Data communication and LAN in manufacturing.
Business process Re-engineering: Introduction to BPE logistics, ERP, Software configuration of BPE.

UNIT-V

Fundamentals of Industrial controls:

Logic Control Systems

To begin the discussion of industrial logic control systems, consider the simple pneumatic system shown in Figure LC-1. The pneumatic cylinder moves in a linear dimension until it reaches the limit switch at the extended end. The cylinder is controlled with a simple two position, four-way solenoid valve as shown. The solenoid valve shown is activated by an electrical current passing through the solenoid coil. This type of simple ON/OFF programming has traditionally been done by relay control systems.

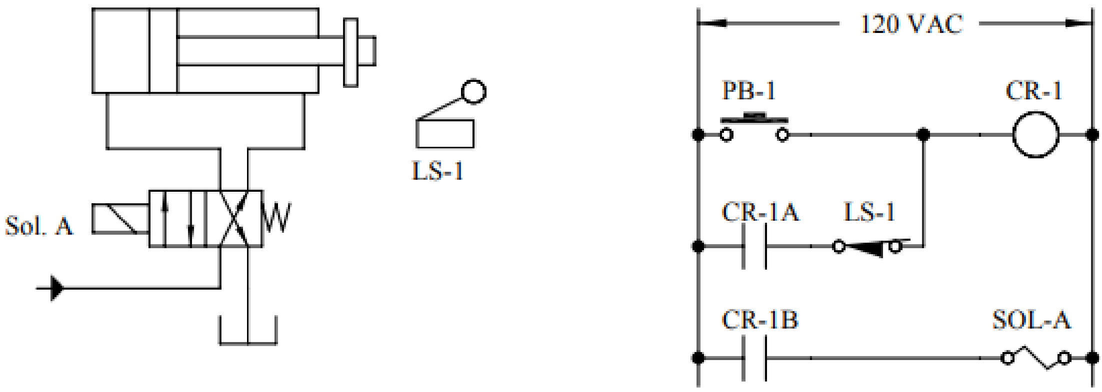


Figure LC-1: Simple pneumatic and logic control system

A relay control system for the simple system of Figure LC-1 is also shown. This schematic diagram represents a type of programming frequently referred to as "ladder logic" by industrial electricians. The two parts of a relay are both shown in this diagram. Electrical relays (Figure LC-2) have a control circuit and one or more sets of outputs. The coil of the relay forms part of an electromagnet which activates a set of contacts (contacts similar to "points" in an pre-70's auto). Electrical current passing through the coil of the relay (the "control relay") closes one of these sets of contacts (CR-1B) which allows current to flow through the pneumatic valve solenoid, SOL-A. Another set of contacts, CR-1A in Figure LC-1, is used to "hold" the contacts closed once they have been energized, by providing an alternate path for electrical current through the control relay. A momentary contact push-button PB-1 (normally open or N.O.) is provided for initiating motion. When PB-1 is pressed, current flows through the actuating circuit of relay CR-1, which closes the output contacts (CR-1A and CR-1B). When PB-1 is released, these contacts remain closed due to electrical current path through the closed relay contacts CR-1A and the normally closed limit switch LS-1. Relay CR-1 remains energized until the limit switch LS-1 activated by the cylinder. Oncethis limit switch is activated, the current flow through the control relay CR-1 is interrupted, and the contacts CR-1A and CR-1B both open. The solenoid SOL-A is de-energized, therefore the spring shifts the solenoid back to the right position, which causes the cylinder to retract. The circuit is inactive until a subsequent pressing of the push-button PB-1. Figure LC-3 shows the most common components of ladder logic diagrams. Input elements include limit switches, momentary contact push-buttons, pressure switches, manual switches, and relay contacts. Typical outputs include solenoid coils, control relay coils, pilot lights, and annunciators (or horns). Note that each of the inputs is available in both normally open (NO) and normally closed (NC) configurations. This distinction is easily explained by observing the limit switch configurations. A normally closed limit switch will carry current if it is not activated (the "normal" state). If a normally closed limit switch is pressed, then it no longer will carry current. A normally open limit switch is the opposite - it will not carry current inactivated, it must be pressed to allow current to flow through it.

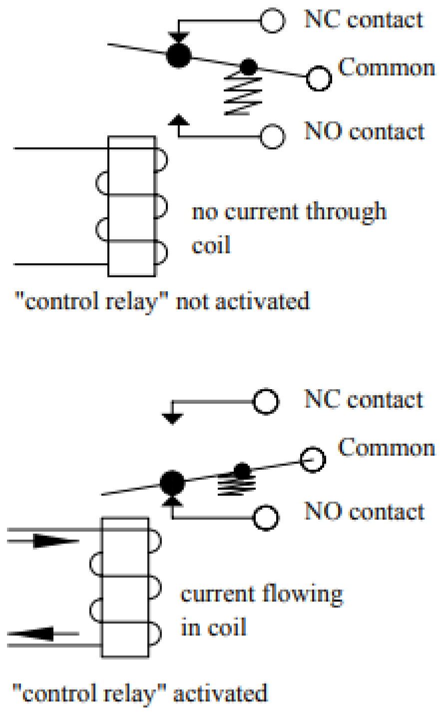


Figure LC-2: Control relay with NO and NC contacts

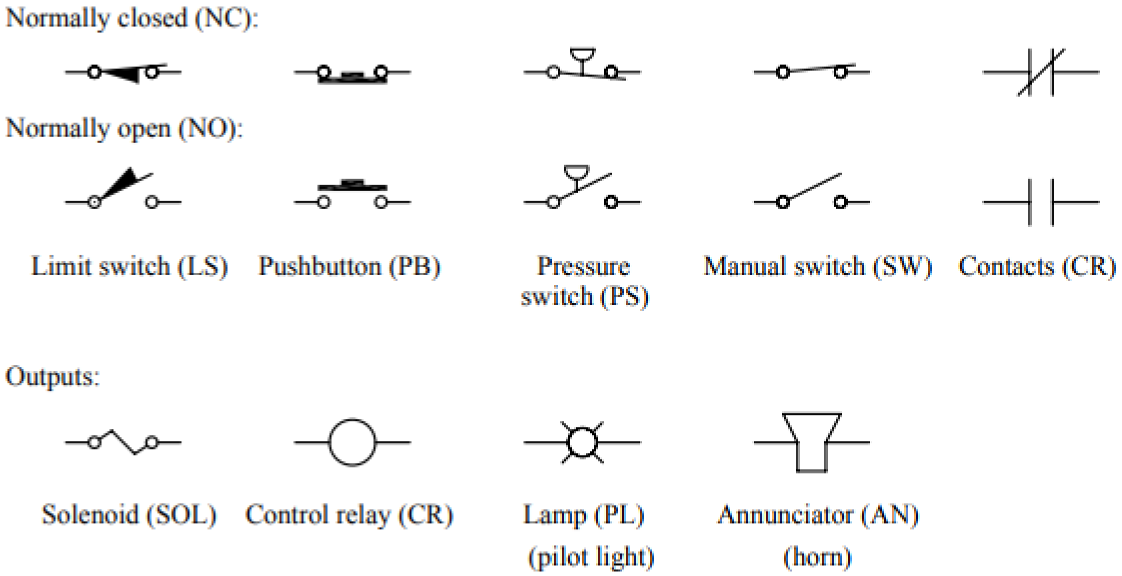


Figure LC-3: Ladder logic schematic elements

Sensors

Sensor is a device that when exposed to a physical phenomenon (temperature, displacement, force, etc.) produces a proportional output signal (electrical, mechanical, magnetic, etc.). The term transducer is often used synonymously with sensors. However, ideally, a sensor is a device that responds to a change in the physical phenomenon. On the other hand, a transducer is a device that converts one form of energy into another form of energy. Sensors are transducers when they sense one form of energy input and output in a different form of energy. For example, a thermocouple responds to a temperature change (thermal energy) and outputs a proportional change in electromotive force (electrical energy). Therefore, a thermocouple can be called a sensor and or transducer.

Classification of Sensors

There are several classifications of sensors made by different authors and experts. Some are very simple and some are very complex. The following classification of sensors may already be used by an expert in the subject but this is a very simple classification of sensors.

In the first classification of the sensors, they are divided in to Active and Passive. Active Sensors are those which require an external excitation signal or a power signal.

Passive Sensors, on the other hand, do not require any external power signal and directly generates output response.

The other type of classification is based on the means of detection used in the sensor. Some of the means of detection are Electric, Biological, Chemical, Radioactive etc.

The next classification is based on conversion phenomenon i.e. the input and the output. Some of the common conversion phenomena are Photoelectric, Thermoelectric, Electrochemical, Electromagnetic, Thermo optic, etc.

The final classifications of the sensors are Analog and Digital Sensors. Analog Sensors produce an analog output i.e. a continuous output signal with respect to the quantity being measured.

Digital Sensors, in contrast to Analog Sensors, work with discrete or digital data. The data in digital sensors, which is used for conversion and transmission, is digital in nature.

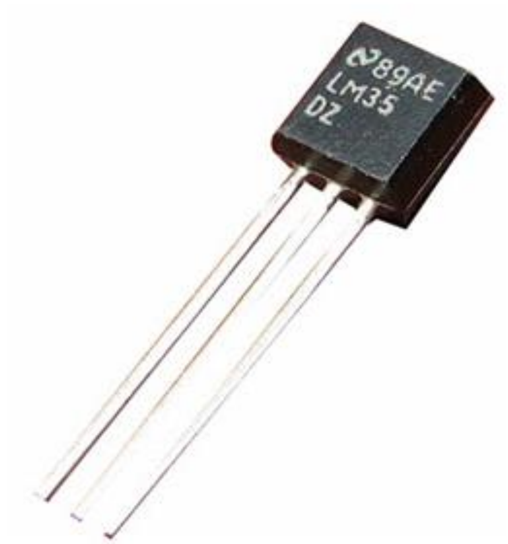
Different Types of Sensors

The following is a list of different types of sensors that are commonly used in various applications. All these sensors are used for measuring one of the physical properties like Temperature, Resistance, Capacitance, Conduction, Heat Transfer etc.

- Temperature Sensor
- Proximity Sensor
- Accelerometer
- IR Sensor (Infrared Sensor)
- Pressure Sensor
- Light Sensor
- Ultrasonic Sensor
- Smoke, Gas and Alcohol Sensor
- Touch Sensor
- Color Sensor
- Humidity Sensor
- Tilt Sensor
- Flow and Level Sensor

Temperature Sensor

One of the most common and most popular sensor is the Temperature Sensor. A Temperature Sensor, as the name suggests, senses the temperature i.e. it measures the changes in the temperature.



LM35 - Temperature Sensor IC

10KΩ NTC Thermistor

In a Temperature Sensor, the changes in the Temperature correspond to change in its physical property like resistance or voltage.

There are different types of Temperature Sensors like Temperature Sensor ICs (like LM35), Thermistors, Thermocouples, RTD (Resistive Temperature Devices), etc.

Temperature Sensors are used everywhere like computers, mobile phones, automobiles, air conditioning systems, industries etc.

A simple project using LM35 (Celsius Scale Temperature Sensor) is implemented in this project: **TEMPERATURE CONTROLLED SYSTEM**.

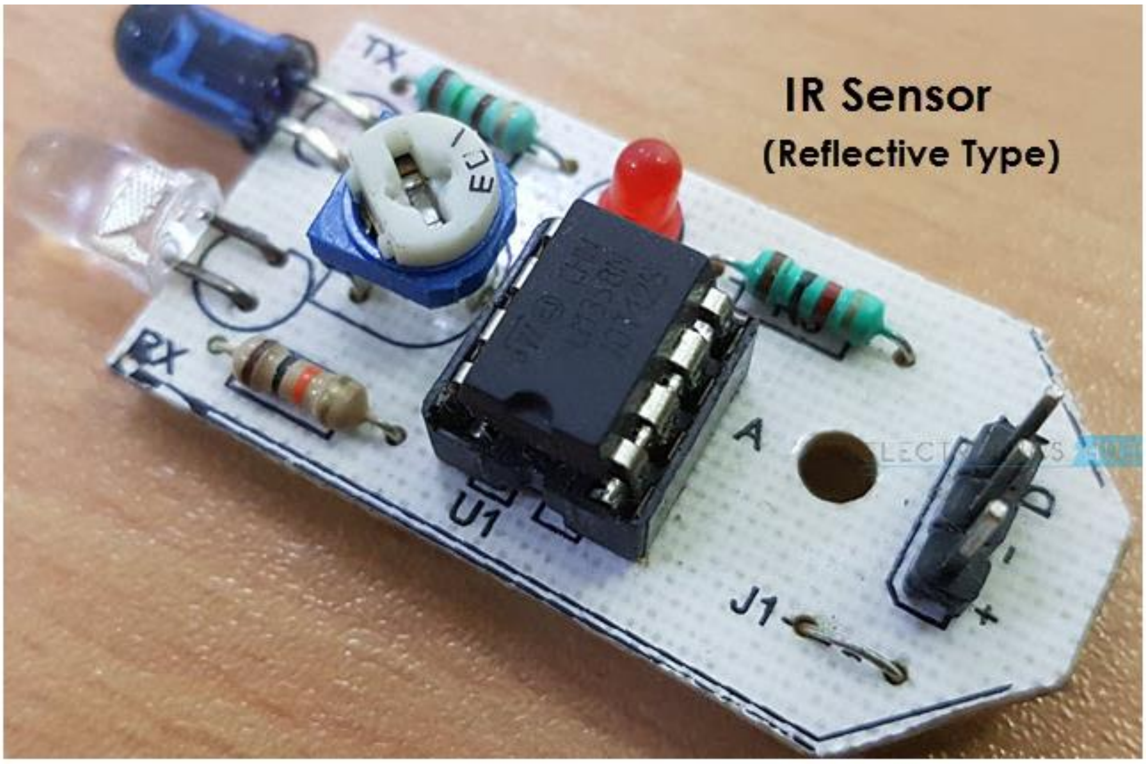
Proximity Sensors

A Proximity Sensor is a non-contact type sensor that detects the presence of an object. Proximity Sensors can be implemented using different techniques like Optical (like Infrared or Laser), Ultrasonic, Hall Effect, Capacitive, etc.

Some of the applications of Proximity Sensors are Mobile Phones, Cars (Parking Sensors), industries (object alignment), Ground Proximity in Aircrafts, etc.
Proximity Sensor in Reverse Parking is implemented in this Project: **REVERSE PARKING SENSOR CIRCUIT**.

Infrared Sensor (IR Sensor)

IR Sensors or Infrared Sensor are light based sensor that are used in various applications like Proximity and Object Detection. IR Sensors are used as proximity sensors in almost all mobile phones.



There are two types of Infrared or IR Sensors: Transmissive Type and Reflective Type. In Transmissive Type IR Sensor, the IR Transmitter (usually an IR LED) and the IR Detector (usually a Photo Diode) are positioned facing each other so that when an object passes between them, the sensor detects the object.

The other type of IR Sensor is a Reflective Type IR Sensor. In this, the transmitter and the detector are positioned adjacent to each other facing the object. When an object comes in front of the sensor, the sensor detects the object.

Different applications where IR Sensor is implemented are Mobile Phones, Robots, Industrial assembly, automobiles etc.

A small project, where IR Sensors are used to turn on street lights: **STREET LIGHTS USING IR SENSORS**.

Ultrasonic Sensor

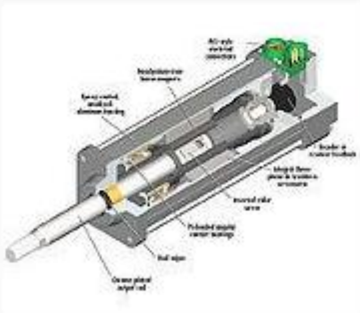
An Ultrasonic Sensor is a non-contact type device that can be used to measure distance as well as velocity of an object. An Ultrasonic Sensor works based on the properties of the sound waves with frequency greater than that of the human audible range.

Using the time of flight of the sound wave, an Ultrasonic Sensor can measure the distance of the object (similar to SONAR). The Doppler Shift property of the sound wave is used to measure the velocity of an object.

Arduino based Range Finder is a simple project using Ultrasonic Sensor: **PORTABLE ULTRASONIC RANGE METER**.

TYPES OF THE ACTUATORS


Actuators


Actuators

Actuator is something that converts energy into motion. It also can be used to apply a force. An actuator typically is a mechanical device that takes energy — usually energy that is created by air, electricity or liquid — and converts it into some kind of motion. That motion can be in virtually any form, such as blocking, clamping or ejecting. An actuator is the mechanism by which an agent acts upon an environment. The agent can be either an artificial intelligence agent or any other autonomous being (human, other animal, etc.). Actuators typically are used in manufacturing or industrial applications and might be used in devices such as motors, pumps, switches and valves.

Energy Sources

Perhaps the most common type of actuator is powered by air and is called a pneumatic cylinder or air cylinder. This type of actuator is an air-tight cylinder, typically made from metal that uses the stored energy of compressed air to move a piston when the air is released or uncompressed. These actuators are most commonly used in manufacturing and assembly processes. Grippers, which are used in robotics, use actuators that are driven by compressed air to work much like human fingers. An actuator also can be powered by electricity or hydraulics. Much like there are air cylinders, there also are electric cylinders and hydraulic cylinders in which the cylinder converts electricity or hydraulics into motion. Hydraulic cylinders, which use liquids, are often found in certain types of vehicles.

Electrical Actuators

Electrical Actuators

Electrical Actuators

Electrical Actuator is an electromechanical device that converts electrical energy into mechanical energy. Most electric actuators operate through the interaction of magnetic fields and current-carrying conductors to generate force. The reverse process, producing electrical energy from mechanical energy, is done by generators such as an alternator or a dynamo; some electric actuators can also be used as generators, for example, a traction motor on a vehicle may perform both tasks. Electric actuators and generators are commonly referred to as electric machines.

Applications

Electric actuators are found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives. They may be powered by direct current, e.g., a battery powered portable device or motor vehicle, or by alternating current from a central electrical distribution grid or inverter. Small actuators may be found in electric wristwatches. Medium-size motors of highly standardized dimensions and characteristics provide convenient mechanical power for industrial uses.

The very largest electric actuators are used for propulsion of ships, pipeline compressors, and water pumps with ratings in the millions of watts. Electric actuators may be classified by the source of electric power, by their internal construction, by their application, or by the type of motion they give.

Fail Safe Actuators

Fail Safe Actuators

Fail Safe Actuator is for larger valves with higher torque requirements, requiring reliable fail safe operation utilizing a unique in-built air reservoir giving fail safe action without the torque losses inherent of spring designs. By using the time proven air accumulator system, and modern design techniques, produces air chamber modules with all the pneumatic circuitry safety protected within. Fail safe actuators maintains the highest seen air supply pressure within the chamber modules, to be released upon control demand.
This design also prevents closure creeping when air supply pressures drop, which occurs with all spring return designs. Torque output is constant in the powered stroke with only a small drop off on the fail stoke. The available torques are proportional to the air supply pressure. Spring changes for various air supply pressures need not be made.
The fail safe actuator operates as a double acting actuator in both directions until there is a loss of supply pressure. When this loss occurs, the compressed air stored in the chambers powers the actuator to close the valve. This makes the fail safe actuator series suitable for use in ON/OFF and modulating control situations while still providing the fail safe requirement.
Applications

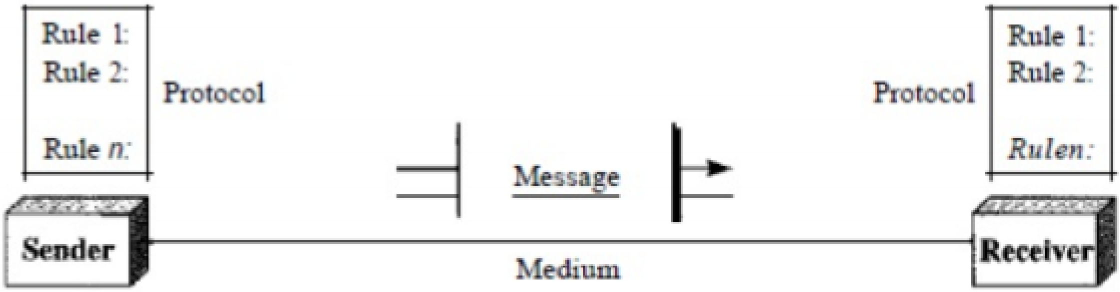
- Wellhead
- Flow line
- Header
- Pipeline system
- Casing relief blow down valve.

DATA COMMUNICATIONS

Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable. For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs). The effectiveness of a data communications system depends on four fundamental characteristics: delivery, accuracy, timeliness, and jitter.
1. Delivery. The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.
2. Accuracy. The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.
3. Timeliness. The system must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called real-time transmission.
4. Jitter. Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.

Components:

A data communications system has five components.



1. Message. The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
2. Sender. The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
3. Receiver. The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
4. Transmission medium. The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves
5. Protocol. A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices.

Local Area Network (LAN):

LAN is usually privately owned and links the devices in a single office, building or campus of up to few kilometers in size. These are used to share resources (may be hardware or software resources) and to exchange information. LANs are distinguished from other kinds of networks by three categories: their size, transmission technology and topology.

LANs are restricted in size, which means that their worst-case transmission time is bounded and known in advance. Hence this is more reliable as compared to MAN and WAN. Knowing this bound makes it possible to use certain kinds of design that would not otherwise be possible. It also simplifies network management.

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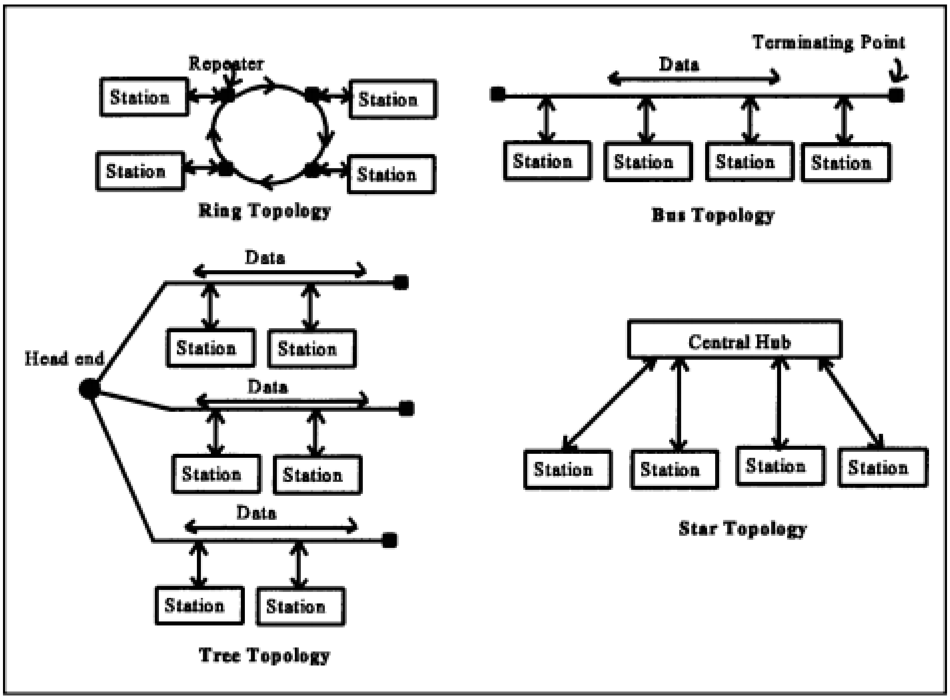


Local Area Network Topologies

Business process re-engineering (**BPR**):

Business process re-engineering (**BPR**) is a business management strategy, originally pioneered in the early 1990s, focusing on the analysis and design of workflows and business processes within an organization. BPR aimed to help organizations fundamentally rethink how they do their work in order to dramatically improve customer service, cut operational costs, and become world-class competitors.

BPR seeks to help companies radically restructure their organizations by focusing on the ground-up design of their business processes. According to early BPR proponent Thomas Davenport (1990), a business process is a set of logically related tasks performed to achieve a defined business outcome. Re-engineering emphasized a holistic focus on business objectives and how processes related to them, encouraging full-scale recreation of processes rather than iterative optimization of sub-processes.

Introduction to Logistics

Logistics is the management of the flow of goods, information and resources between the point of origin and the point of consumption. It is a business concept that evolved during the 1950s due to the increasing complexity of supplying businesses with materials and transporting products in an increasingly globalized supply chain. The complexity led to a call for experts in the process who are called logisticians.

Logistics can be defined as "having the right item in the right place, at the right time, in the right quantity, at the right price and in the right condition, for the right customer".

There are two fundamentally different forms of logistics: one optimizes a steady flow of materials through a network of transport links and storage areas, while the other coordinates an effective sequence of resources in order to carry out a project.

Work in logistics involves the integration of information, transportation, inventory, warehousing, material handling, packaging, human resources and sometimes security. The goal is to manage the life cycle of a project from birth to completion. For example, a logistician would have to ensure that the supply chains work so that raw materials and/or parts arrive at a factory or on site in time and in the correct order. It would be veryinefficient and wasteful if the roof tiles were delivered before the foundations have been dug and the walls built on a construction site, or, if large quantities of paper were delivered to a printer who had nowhere clean and dry to store it. These are very simple examples of an extremely complex and detailed process.

The main functions of a qualified logistician include inventory management, purchasing, transportation, warehousing, consultation and organizing and planning of these activities. Logisticians combine a professional knowledge of each of these functions to coordinate resources in an organization.

***Enterprise resource planning* (*ERP*):**

Enterprise resource planning (*ERP*) is business process management software that allows an organization to use a system of integrated applications to manage the business and automate many back office functions related to technology, services and human resources.

The need for enterprise resource planning (ERP) software grew with big business' mandate for a centralized solution to manage all information system requirements. An ERP may consist of many different business modules, including:

- Manufacturing
- Human Resources/Payroll
- Sales
- Inventory
- Supply Chain/Partners
- Finance and Accounting
- CRM

In short, an ERP solution allows each department or business domain to be managed centrally while operating independently. Advantages include interoperability of data, increased communication and increased data reliability through the use of a single database.

ERP also enhances the quality of enterprise-wide decision making. For example, a customized order may move from the sales department to inventory control, then on to invoicing to finance and manufacturing. By using an ERP, this type of process is an efficient and continuous series of events that allows for easy individual order tracking.

1. Business Process Engine (BPE):

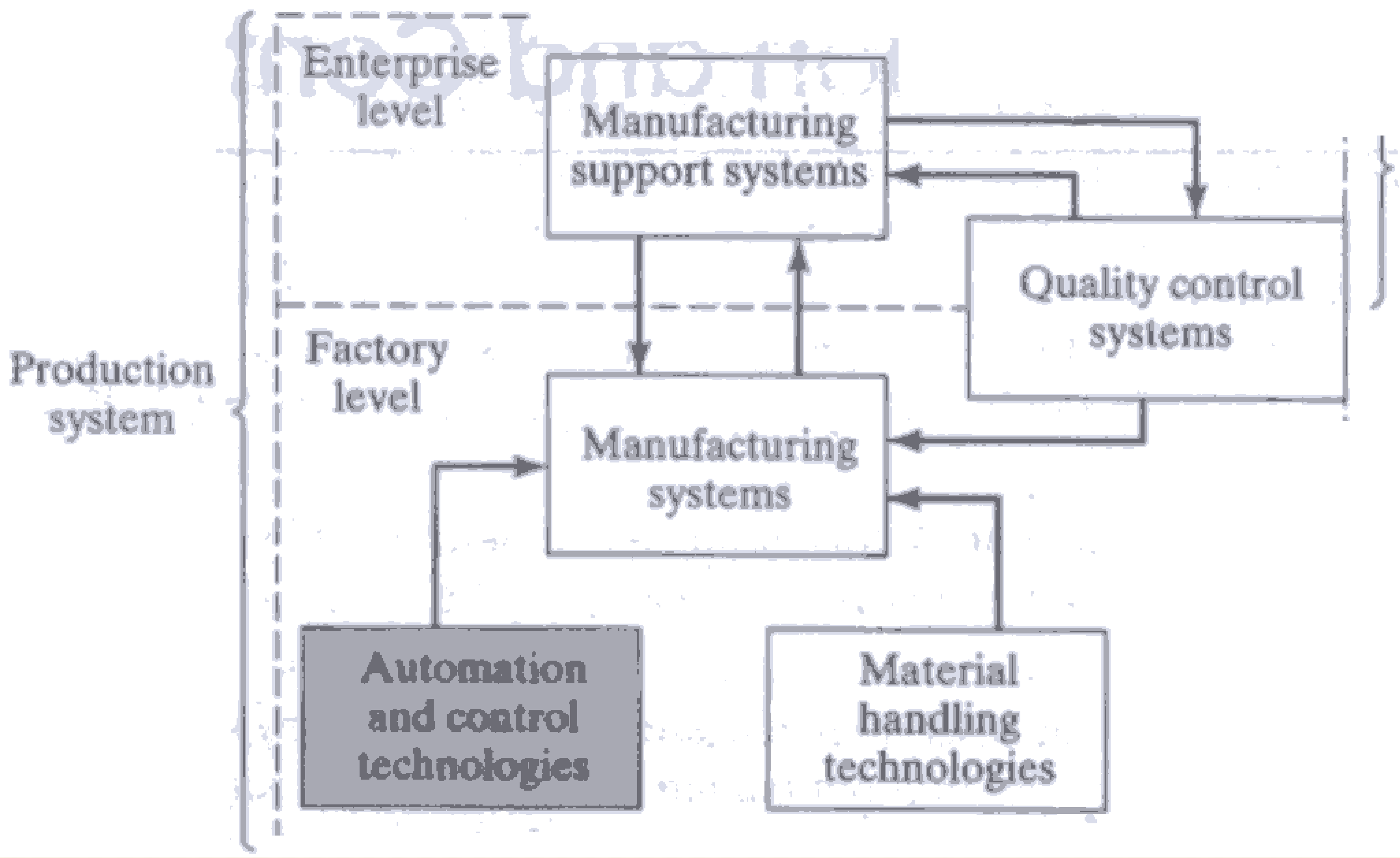
A business process engine (BPE) is a software framework that enables the execution and maintenance of process workflows. It provides business process interaction and communication between different data/process sources spread across one or more IT applications and services.

A BPE is a business process management (BPM) solution component used to oversee the technical architecture of business process integration, interlinking and interprocessing. BPE works with all of the different application infrastructure layers, including front end, middleware, backend and external business applications. It facilitates the integration of their processes, inter and intra system communication, process data routing, data transformation and merging. A BPE dynamically monitors and adjusts changes applied to data, as well as associated processes and process workflows.

A BPE also may be used to create new business processes, business rules and deployment capability for all connected applications without disruption or downtime.

UNIT V
POWER POINT PRESENTATION SLIDES

AUTOMATION AND CONTROL TECHNOLOGIES IN THE PRODUCTION SYSTEM



COMPONENTS OF MANUFACTURING SYSTEM

- Production machines, tools, fixtures and other related hardware
- Material handling system
- Computer system to coordinate and control the above components
- Human workers

1. PRODUCTION MACHINES

The machines can be classified as

(1) Manually operated: Directed by human workers

(2) Semi-automated:performs a portion of the work cycle under some form of program control, and a human worker tends to the machine for the remainder of the cycle, by loading and unloading it or performing some other task each cycle.

(3) Fully automated:has a capacity to operate for extended periods of time with no human attention.

2. MATERIAL HANDLING SYSTEM

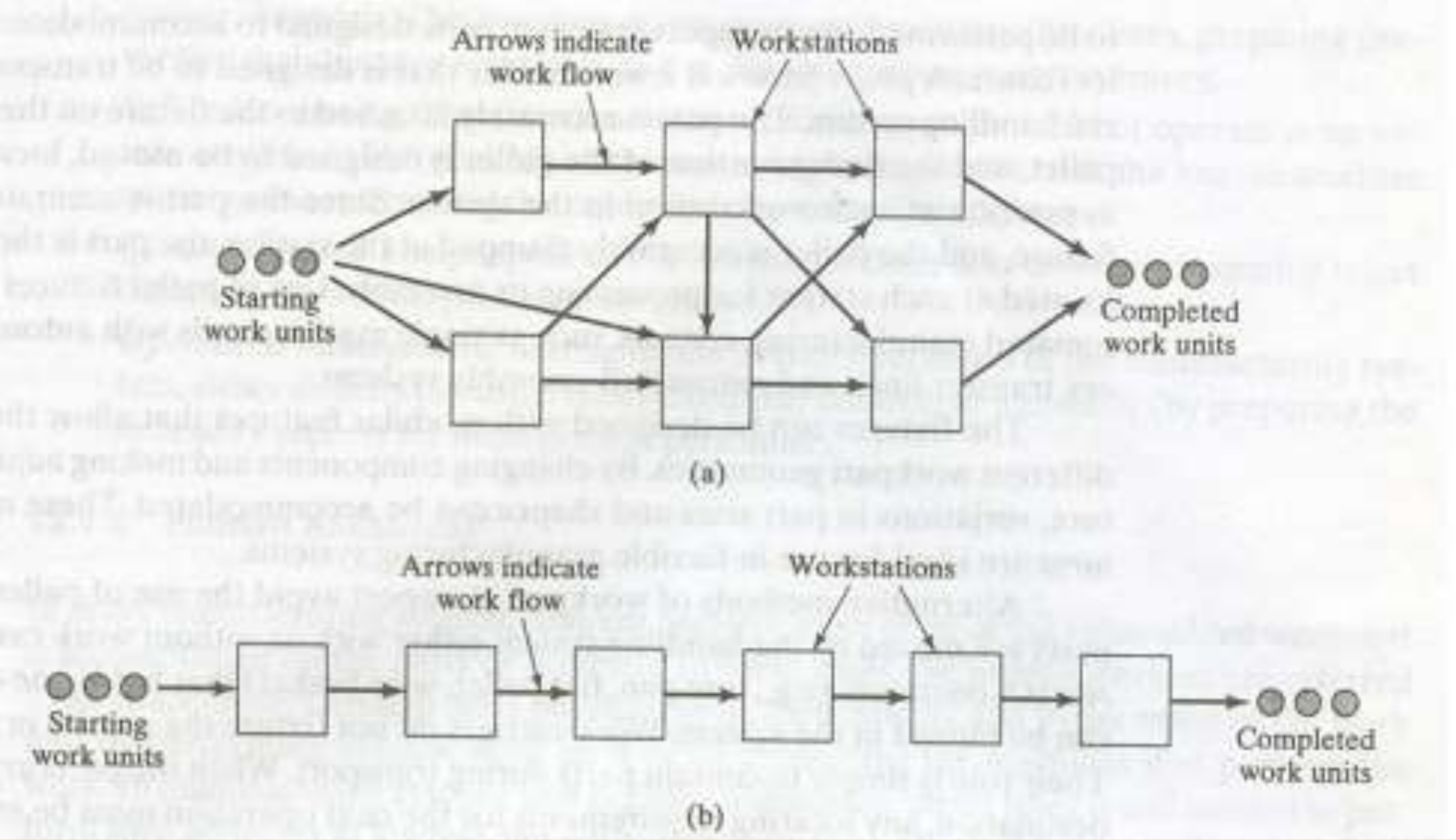
(1) *loading* and *unloading* work units

(2) *positioning* the work units at each station.

(3) *transporting* work units between stations

(4) Temporary storage function

TYPES OF ROUTING IN MULTIPLE STATION MANUFACTURING SYSTEMS



(a) Variable routing (b) Fixed routing

Common Material Transport Equipment Used for Variable and Fixed Routing in Multiple Station Manufacturing Systems

Type of Part Routing	Material Handling Equipment*
Variable routing	Automated guided vehicle system Power-and-free overhead conveyor Monorail system Cart-on-track conveyor
Fixed routing	Powered roller conveyor Belt conveyor Drag chain conveyor Overhead trolley conveyor Rotary indexing mechanisms Walking beam transfer equipment

3. COMPUTER CONTROL SYSTEM

Communicate instructions to workers. In manually operated workstations that perform different tasks on different work units, processing or assembly instructions for the specific work unit must be communicated to the operator.

Download part programs to computer-controlled machines (e.g-, CNC machine tools).

Material handling system control. This function is concerned with controlling the material handling system and coordinating its activities with those of the workstations.

Schedule production. Certain production scheduling functions are accomplished at the site of the manufacturing system.

Failure diagnosis. This involves diagnosing equipment malfunctions, preparing preventive maintenance schedules, and maintaining spare parts inventory.

Safety Monitoring. This function ensures that the system does not operate in an unsafe condition. The goal of safety monitoring is to protect both the human workers manning the system and the equipment comprising the system.

Quality Control. The purpose of this control function is to detect and possibly reject defective work units produced by the system.

Operations management. Managing the overall operations of the manufacturing

4. HUMAN RESOURCES

In many manufacturing systems, humans perform some or all of the value-added work that is accomplished on the parts or products. In these cases, the human workers are referred to as *Direct labor*

In manufacturing systems that are fully automated, direct labor is still needed to perform such activities as loading and unloading parts to and from the system, changing tools, resharpening tools, and similar functions.

Human workers are also needed for automated manufacturing systems to manage or support the system as computer programmers, computer operators, part programmers for CNC machine tools

CLASSIFICATION OF MANUFACTURING SYSTEMS

(1) Types of operations performed,
(2) Number of workstations and system layout,
(3) Level of automation, and
(4) Part or product variety

Factors in Manufacturing Systems Classification Scheme

Factor	*Alternatives*
Types of operations performed	Processing operations versus assembly operations Type of processing or assembly operation
Number of workstations and system layout	One station versus more than one station For more than one station, variable routing versus fixed routing
Level of automation	Manual or semi-automated workstations that require full-time operator attention versus fully automated that require only periodic worker attention
Part or product variety	All work units identical versus variations in work units that require differences in processing

1. TYPES OF OPERATIONS PERFORMED

1. Processing operations on individual units
2. Assembly operations to combine the individual parts in to assembled entities

2.NUMBER OF WORK STATIONS AND SYSTEM LAYOUT

Type I *Single station.* This is the simplest case, consisting of one workstation (n = 1), usually including a production machine that can be manually operated, semi-automated, or fully automated.

Type II *Multiple stations with variable routing.* This manufacturing system consists of two or more stations (n > 1) that are designed and arranged to accommodate the processing or assembly of different part or product styles.

Type III *Multiple stations with fixed routing.* This system has two or more workstations (n > 1) , which are laid out as a production line.

3. LEVEL OF AUTOMATION

Manning level of a work station (M_i) is proportion of time that a worker is in attendance at the station. If $M_i = 1$ for station I, it means that one worker must be at the station continuously.

The average manning level of multi station is equal

$$M = \frac{w_u + \sum_{i=1}^{n} w_i}{n} = \frac{w}{n}$$

M_i = average manning level
W_u = number of utility workers assigned to the systems
W_i = number of workers assigned to I
W= total number of workers assigned to the system

AUTOMATION IN THE CLASSIFICATION SCHEME

Type I M *Single station manned cell.* The basic case is one machine and one worker (*n* = *l*,*w* = 1).The machine is manually operated or semi-automated,and the worker must be in continuous attendance at the machine.

Type I A *Single station automated cell.* This is a fully automated machine capable of unattended operation (*M* < 1) for extended periods of time (longer than one machine cycle). A worker must periodically load and unload the machine or otherwise service it.

Type II M *Multi-station manual system with variable routing.* This has multiple stations that are manually operated or semi-automated. The layout and work transport system allow for various routes to be followed by the parts or products made by the system. Work transport between stations is either manual or mechanized.

Type II A *Multi-station automated system with variable routing*. This is the same as the previous system; except the stations are fully automated (*n* > 1, *w;* = 0, I *M* < 1). Work transport is also fully automated.

AUTOMATION IN THE CLASSIFICATION SCHEME CONT……

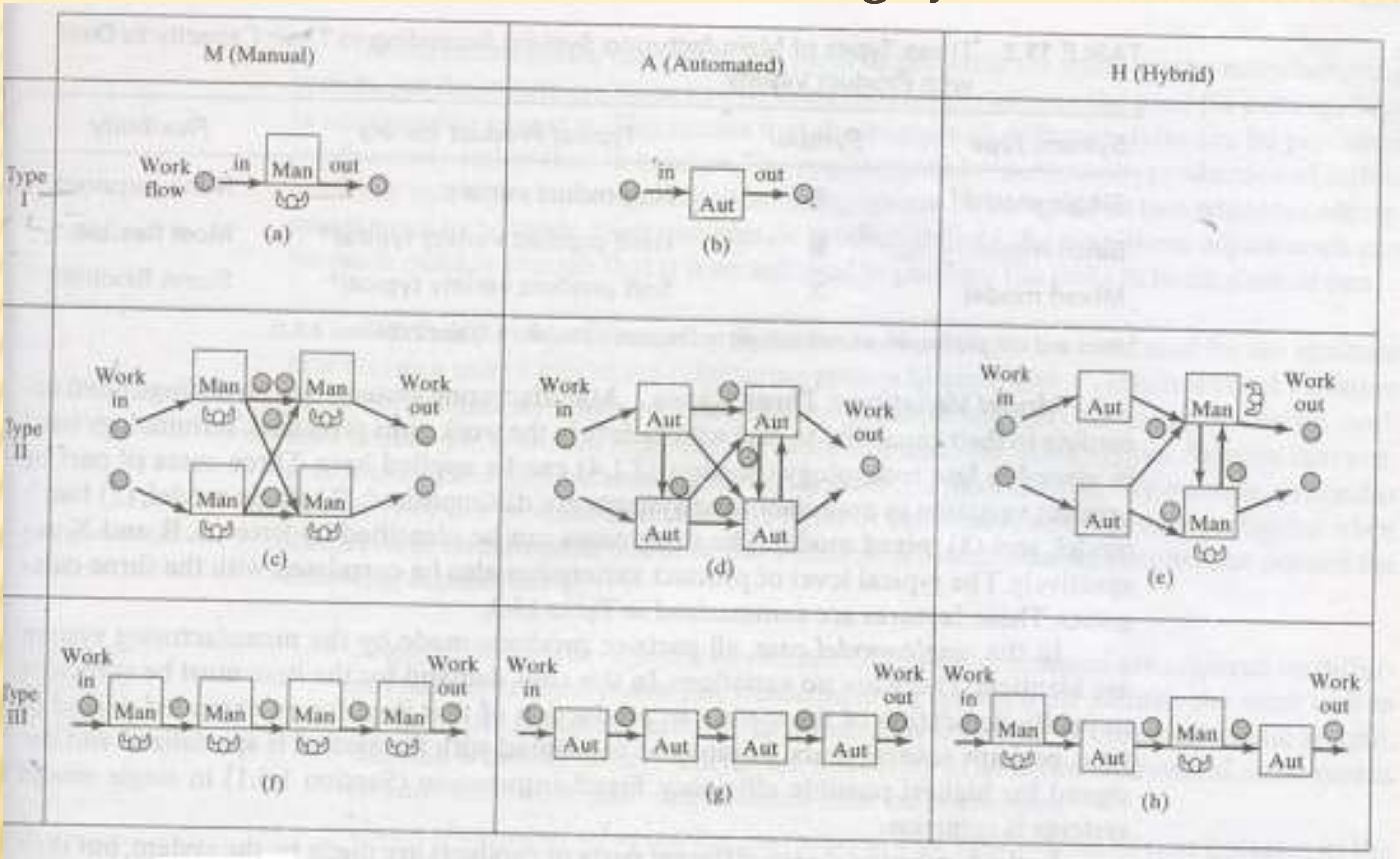
Type II H *Multi-station hybrid system with variable routing.* This manufacturing system contains both manned and automated stations. Work transport is manual, automated, or a mixture (hybrid).

Type III M *Multi-station manual system with faxed routing*. This manufacturing system consists of two or more stations (n > 1), with one or more workers at each station (w>=1). The operations are sequential, thus necessitating a fixed rout- ing, usually laid out as a production line. Work transport between stations is either manual or mechanized.

Type III A *Multi-station automated system with fixed routing.* This system consists of two or more automated stations (n > 1, w_i> = 0, M < 1) arranged as a production line or similar configuration. Work transport is fully automated.

Type III H *Multi-station hybrid system with fixed routing*. This system includes both manned and automated stations (n > 1, w_i> = 1 for some stations, w_i = 0 for other stations, M > 0). Work transport is manual, automated, or a mixture (hybrid).

Classification of Manufacturing Systems



(a) single station manned cell, (b) single station automated cell, (c) multi-station manual system with variable routing, (d) multi-station automated system with variable routing, (e) multi-station hybrid system with variable routing, (f) multi-station manual system with serial operations, (g) multi-station automated system with serial operations, and (h) multi-station hybrid system with serial operations.

Key: Man = manned station, Aut = automated station.

4. PART OR PRODUCT VARIETY

Examples of possible variations that a manufacturing system may have to cope with include:

- variations in type and/or color of plastic of molded parts in injection molding
- variations in electronic components placed on a standard size printed circuit board
- variations in the size of printed circuit boards handled by a component place
- variations in geometry of machined parts
- variations in parts and options in an assembled product on a final assembly line

MODEL VARIATIONS

TABLE 13.3 Three Types of Manufacturing System According to Their Capacity to Deal with Product Variety

System Type	*Symbol*	*Typical Product Variety*	*Flexibility*
Single model	S	No product variety	None required
Batch model	B	Hard product variety typical*	Most flexible
Mixed model	X	Soft product variety typical*	Some flexibility

* Hard and soft product variety are defined in Chapters 1 (Section 1.1) and 2 (Section 2.3.1).

1. Single model: All parts or products made by the manufacturing systems are identical
2. Batch model: different parts or products made by the system, but they are made in different batches because a changeover in physical setup and/or equipment programming is required between models
3. Mixed model case: , different parts or products are made by the manufacturing system, but the system is able to handle these differences without the need for a changeover in setup and/or program.

FLEXIBILITY IN MANUFACTURING SYSTEMS

Identification of the different work units. Different operations are required on different part or product styles. The manufacturing system must identify the work unit to perform the correct operation. In a manually operated or semi-automatic system, this task is usually an easy one for the worker(s). In an automated system, some means of automatic work unit identification must be engineered.

Quick changeover of operating instructions. The instructions, or part program in the case of computer-controlled production machines, must correspond to the correct operation for the given part. In the case of a manually operated system, this gener- ally means workers who (1) are skilled in the variety of operations needed to process or assemble the different work unit styles, and (2) know which operations to perform on each work unit style. In semi-automatic and fully automated systems, it means that the required part programs are readily available to the control unit.

Quick changeover of physical setup. Flexibility in manufacturing means that the dif- ferent work units are not produced in batches. For different work unit styles to be pro- duced with no time lost between one unit and the next, the flexible manufacturing system must be capable of making any necessary changes in fixturing and tooling in a very short time. (The changeover time should correspond approximately to the time required to exchange the completed work unit for the next unit to be processed.)

RECONFIGURABLE MANUFACTURING SYSTEMS

Ease of mobility. Machine tools and other production machines designed with a three- point base that allows them be readily lifted and moved by a crane or forklift truck. The three-point base facilitates leveling of the machine after moving.

Modular design of system components. This permits hardware components from dif- ferent machine builders to be connected together.

Open architecture in computer controls. This permits data interchange between soft- ware packages from different vendors.

CNC workstations. Even though the production machines in the system are dedicat- ed to one product, they are nevertheless computer numerical controlled to allow jor upgrades in software, engineering changes in the part currently produced, and changeover of the equipment when the production run finally ends

UNIT V

INDUTRIAL APPLICATIONS

Industry 4.0 Fundamentals (I4F)

Course 1

Introduction to Mechatronics

38 Lessons

Topics Include:

- Introduction to Industry 4.0
- Safety
- Hand Tools
- Measurement
- Print Reading
- Precision Measurement
- Mechanical Drives
- Fluid Power
- AC/DC Electricity
- Electrical Relay Control
- Robotics Programming
- Electronic Sensors

Course 2

Introduction to Industrial Control Systems

33 Lessons

Topics Include:

- Industry 4.0 Principles
- Mechanical Drives
- Hydraulics Fluid Power
- Pneumatics
- Robotics Programming
- Electrical Relay Control
- Electronic Sensors
- Ethernet Network Communications
- Programmable Controllers
- CNC Programming
- Mechatronic Systems

Course 3

Robot Operation & Programming

Topics Include:

- Robotic Safety & Components
- Frames
- Program Development
- Inputs, Outputs, and Macros

And More!

Certified Production Technician

Topics Include:

- Safety
- Quality Practices & Measurement
- Manufacturing Processes & Production
- Maintenance Awareness

And More!

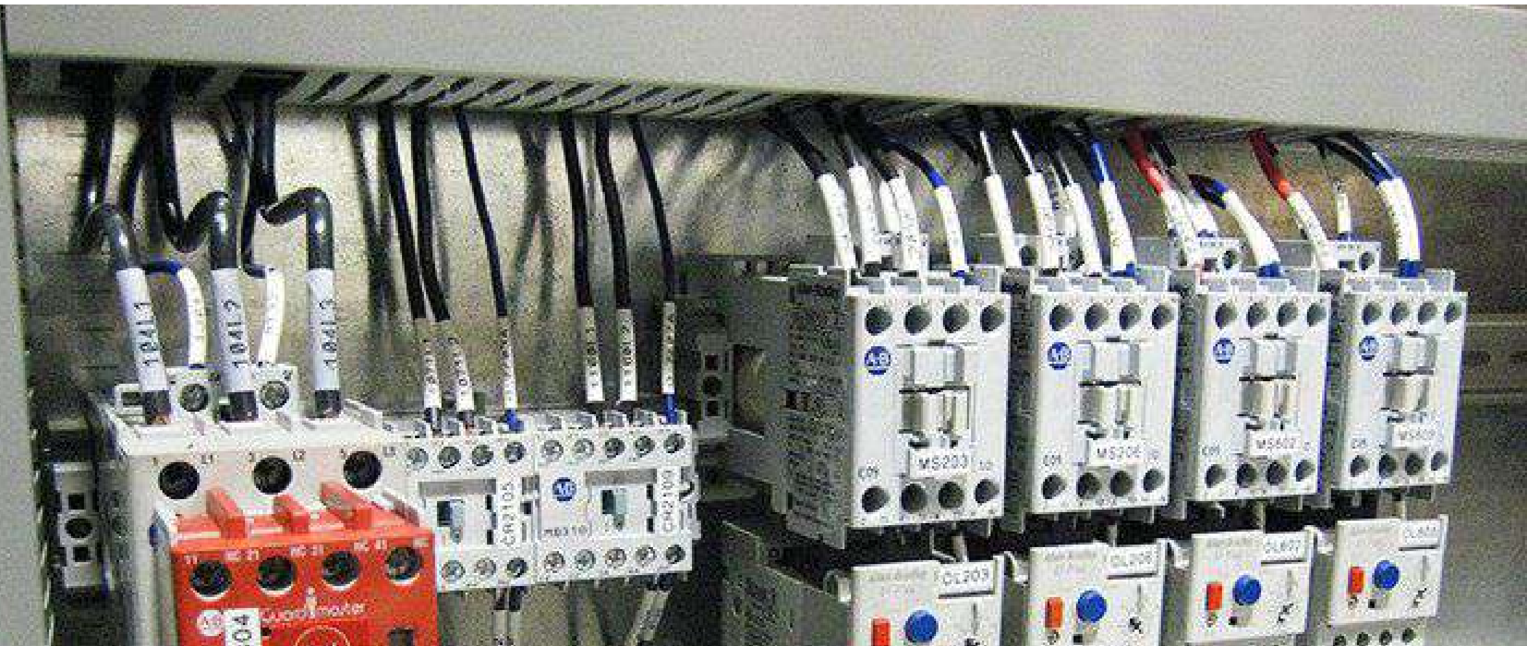
Course 4

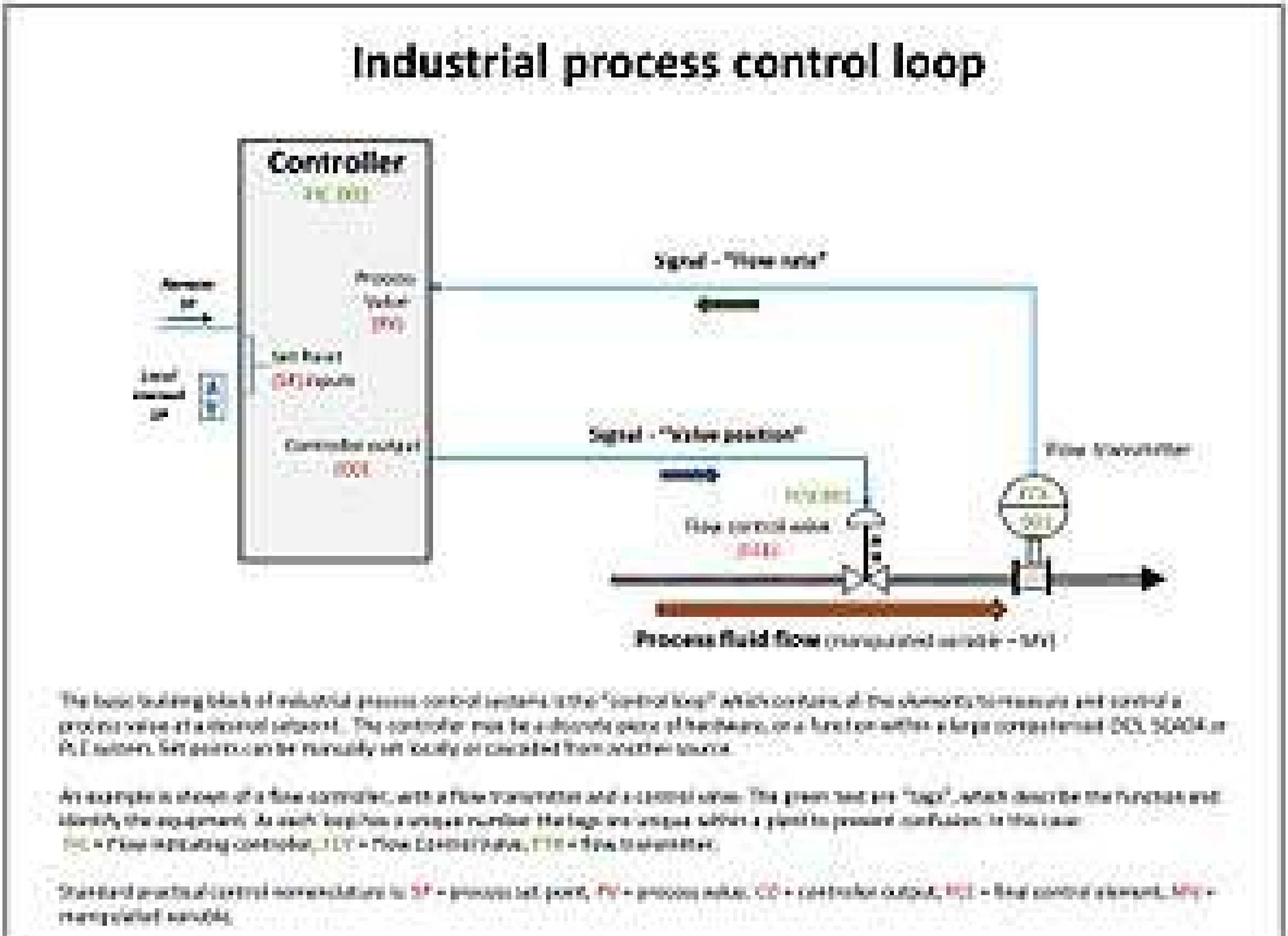
Introduction to Industrial Internet of Things

28 Lessons

Topics Include:

- Advanced Programmable Controllers
- Data Analytics 1
- Variable Frequency Drives
- Bar Code Production Identification
- Mechatronics: Motors & Conveyors
- Ethernet Network 2
- RFID Product Identification
- Smart Sensors
- Programmable Controllers
- System Optimization
- Mechatronics: Communication & ASRS
- PLC Troubleshooting


SC1304
MS203
MS206
OL203


Industrial process control loop
Controller
Signal - "Flow rate"
Signal - "Valve position"
Process fluid flow

UNIT V

ASSIGNMET

Unit-V

1.

a). Explain the situations where adaptive control can be beneficially applied?

b). What are the limitations of adaptive control?

2.

a). Explain how various parameters such as cutting force, temperatures are controlled using adoptive control concept.

b). Explain the process of adaptive control constraint (ACC).

3. Explain about Sensors and Actuators

4. Data communication and LAN manufacturing

5. Explain Business Process Re-engineering

UNIT V

SHORT 'Q' & TUTORIAL

UNIT-V

1. What is a Sensor?

It is a device that converts signals from one energy domain to electrical domain. The definition of the Sensor can be understood if we take an example in to consideration. The simplest example of a sensor is an LDR or a Light Dependent Resistor. It is a device, whose resistance varies according to intensity of light it is subjected to. When the light falling on an LDR is more, its resistance becomes very less and when the light is less, well, the resistance of the LDR becomes very high.

2. What are the Different Types of Sensors?

The following is a list of different types of sensors that are commonly used in various applications. All these sensors are used for measuring one of the physical properties like Temperature, Resistance, Capacitance, Conduction, Heat Transfer etc.

- Temperature Sensor
- Proximity Sensor
- Accelerometer
- IR Sensor (Infrared Sensor)
- Pressure Sensor
- Light Sensor
- Ultrasonic Sensor
- Smoke, Gas and Alcohol Sensor
- Touch Sensor
- Color Sensor
- Humidity Sensor
- Tilt Sensor
- Flow and Level Sensor

1. What is an actuator and classify the types of actuators?

An actuator is a component of a machine that is responsible for moving and controlling a mechanism or system, for example by opening a valve. In simple terms, it is a "mover".

An actuator requires a control signal and a source of energy. The control signal is relatively low energy and may be electric voltage or current, pneumatic or hydraulic pressure, or even human power. Its main energy source may be an electric current, hydraulic fluid pressure, or pneumatic pressure. When it receives a control signal, an actuator responds by converting the signal's

4. What is LAN in manufacturing?

A local area network (**LAN**) is a computer network that interconnects computers within a limited area such as a residence, school, laboratory, university campus or office building. Ethernet and Wi-Fi are the two most common technologies in use for local area networks.

5. What do you mean by data communication?

Data communications (DC) is the process of using computing and communication technologies to transfer data from one place to another, and vice versa. It enables the movement of electronic or digital data between two or more nodes, regardless of geographical location, technological medium or data contents.

6. What do you mean by logistics?

Logistics management is the part of supply chain management that plans, implements, and controls the efficient, effective forward, and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customer's requirements.

PREVIOUS QUESTION PAPERS

1. a) Draw the general structure of a hydraulic circuit and explain the important components involved in it. [7]
   b) Describe the function and working of the single station automated machine tool. [4]
   c) Explain the following automation strategies:
   (i) Plant Operation Control (ii) Process Control and Optimization. [4]

2. a) Draw the neat sketches of the Rachet and Pawl mechanism and discuss briefly. [6]
   b) Explain briefly Chain Drive Conveyor System. [5]
   c) What are the different types of control function that are required in an automated flow line? [4]

3. a) The following data apply to a 10-station in-line transfer machine:
   P = 0.015 (all stations have an equal probability of failure)
   T_c = 0.4 min
   T_d = 4.0 min
   Using the lower-bound approach, compute the following for the transfer machine: (i) the frequency of line stops, (ii) the average production rate (iii) the line efficiency. [7]
   b) Discuss the efficiency of automated flow lines with storage buffer. [4]
   c) What is 'Upper-bound approach' used in the analysis of transfer lines? [4]

4. a) What is precedence diagram in the line balancing and explain briefly. [5]
   b) Explain the importance in solving line balancing problems by using Ranked Positional Weights Method. [6]
   c) What are the different manual methods for solving the line balancing problems? Briefly discuss any one method. [4]

5. a) What are the important categories of Automated Guided Vehicle Systems? Discuss them briefly with the help of neat sketches. [7]
   b) Discuss the important factors to be considered in material handling system design. [4]
   c) Explain the applications of Automated Guided Vehicles. [4]

6. a) Define ‘work-in-process’. [3]
   b) Briefly describe the Pickup and deposit stations of an AS/RS: [6]
   c) Describe the Aisle transfer cars of an AS/RS system. [6]

7. a) What are the various operation parameters that can be measured in milling operation to use them in adaptive control systems? [6]
   b) Draw the block diagram of Adaptive Control with Optimization system for drilling process. [5]
   c) What are the advantages of using adaptive control systems in turning operation? [4]

8. a) Explain the different types of CMM controls. [6]
   b) Name the different types of contact inspection techniques and explain any one technique. [5]
   c) What are the applications of machine vision system? [4]

1. a) What are the important pneumatic components used in automated system? [5]
   b) Explain the following automation strategies:
      (i) Combined Operations (ii) On-line inspection [5]
   c) Describe the function and working of the following automated machine tools:
      (i) Transfer Machine (ii) Single Station Machine. [5]

2. a) Illustrate the working of walking beam transfer system with the help of neat sketches. [7]
   b) Discuss the advantages and limitations of using buffer storage capacity zones in automated flow lines. [4]
   c) Draw the neat sketches of the Over and Under type chain drive mechanism. [4]

3. a) What are the various basic approaches used in the analysis of transfer lines without storage? [4]
   b) Discuss the efficiency of automated flow lines with storage buffer. [4]
   c) In a 15 station transfer line, the probability that a station break down will occur for a given work part is equal to 0.015. This probability is the same for all 15 stations. Determine the frequency of line stops per cycle on this flow line using the upper bound approach and also calculate the production rate. [7]

4. a) What is ranked positional weight value? [4]

b) Discuss the Inventory Buffers between stations for improving the performance of the line balance. [5]

c) What are the various possible ways that should be considered by the designer for improving the operation of the line? [6]

5. a) Discuss the important factors to be considered in material handling system design. [5]

b) Discuss the important features of conveyors and their applications. [5]

c) Discuss the safety issues for the AGVS to operate efficiently. [5]

6. a) What are the advantages of Automated Storage Systems? [5]

b) Explain the Storage/Retrieval mechanism of an AS/RS. [5]

c) Discuss the use of automated work-in-process storage systems. [5]

7. a) Name the different types of adaptive control systems and distinguish between them. [4]

b) List out the various operation parameters that can be measured in turning operation to use in adaptive control systems. [6]

c) Draw the block diagram of a typical computerized Adaptive Control with Constraints system for grinding process. [5]

8. a) List out the different applications of CMM. [6]

b) Define accuracy, precision and sensitivity of an automated inspection system. [3]

c) Explain the image processing and analysis in the operation of machine vision. [6]

1.a) What are the important mechanical feeding devices used in automated systems? [4]

b) What are the important pneumatic components used in automated system? [4]

c) Describe the function and working of the transfer machine type of automated machine tool. [7]

2.a) What are the important considerations that are to be taken into during design and fabrication of automated flow lines? [5]

b) Draw the neat sketches of the Rachet and Pawl mechanism and discuss briefly. [5]

c) Explain the use of buffer storage zones in automated flow lines. [5]

3.a) What is ‘Lower-bound approach’ used in the analysis of transfer lines? [4]

b) What is the Partial Automation used in automated flow lines? [4]

c) An eight-station rotary indexing machine operates with an ideal cycle time of 45 s. The frequency of line stop occurrences is 0.08 stops/cycle on the average. When a stop occurs, it takes an average of 3 min to make repairs. Determine the following:

(i) Average production time

(ii) Average production rate

(iii) Line efficiency

(iv) Proportion of downtime [7]

4.a) Explain how the methods analysis will improve the line balance. [5]
b) Discuss the Dividing work elements for improving the performance of the line balance. [6]
c) Enumerate the differences between flexible assembly lines and manual assembly lines. [4]

5.a) What are the various material handling equipments used in manufacturing industries? [4]
b) Describe the unit load carrier AGV with the help of simple sketch. [7]
c) List out the traffic control issues for the AGVS to operate efficiently. [4]
[5]

6.a) Discuss how to overcome the problems that are encountered in interfacing AS/RS units to the manufacturing function.
b) Describe the load identification station feature of an AS/RS. [5]
c) Explain the Storage modules of an AS/RS. [5]

7.a) What are the applications of adaptive control system in various machining operations? [4]
b) List out the variable parameters that can be measured in grinding process to use in adaptive control system. [6]
c) Draw the block diagram of a typical computerized Adaptive Control with Constraints system for milling process. [5]

8.a) What are the various advantages of using CMM? [5]
b) Write the step by step inspection procedure to be performed. [5]
c) What is image acquisition and digitization in the operation of machine vision? [5]
Describe the function and working of the following automated machine tools:
(i) Transfer Machine (ii) Single Station Machine. [6]
b) Describe the function and working of the rotary indexing automated machine tool. [5]
c) Draw the simple block diagram of pneumatic circuit and label the parts. [4]

2.a) Explain the reasons for the use of buffer storage zones in automated flow lines. [4]
b) Discuss the common reasons for line stoppages in automated flow lines [4]
c) Explain briefly cam mechanism for material transfer with the help of neat sketch. [7]

3.a) In a 10 station transfer line, the probability that a station break down will occur for a given work part is equal to 0.02. This probability is the same for all 10 stations. Determine the frequency of line stops per cycle on this flow line using the lower bound approach and also calculate the production rate. [7]
b) Discuss briefly about the Buffer stock effectiveness used in automated flow line. [4]
c) Discuss the efficiency of automated flow lines without storage buffer. [4]

4.a) Explain the steps used in solving the line balancing problem by using Largest-Candidate Rule method. [6]

b) Explain how the parallel stations will improve the line balance. [4]

c) Define cycle time in the line balancing and explain briefly. [5]

5.a) Explain the paint strips technology used in Automated Vehicle Systems for vehicle guidance. [5]

b) Explain the advantages of implementing various principles of material handling. [5]

c) Describe the Driverless Automated Guided Train System. [5]

6.a) Briefly describe the Storage structure of an AS/RS. [5]

b) Discuss the different applications of AS/RS technology. [5]

c) Describe the Fully/Empty bin detectors of an AS/RS. [5]

7.a) List out the differences between ACO and ACC types of adaptive control. [4]

b) Explain the variables in the Adaptive Control with Optimization system for drilling process. [6]

c) Draw the block diagram of a typical computerized Adaptive Control with Constraints system for milling process. [5]

8.a) List out the various components of CMM. [4]

b) What are the advantages of non-contact inspection techniques? [5]

c) What are the basic functions of machine vision system? [6]

Code No: **R42034** **R10** **Set No. 1**

IV B.Tech II Semester Regular/Supplementary Examinations, April- 2015

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

*****

1. a) Discuss the following automation strategies:
   i) Combined Operations ii) On-line inspection
   iii) Plant Operation Control iv) Process Control and Optimization

   b) Describe the function and working of the following automated machine tools:
   i) Transfer Machine ii) Single Station machine

2. a) Illustrate the working of walking beam transfer system with the help of neat sketches.

   b) Explain the differences between intermittent transfer mechanism and power-and-free transfer mechanism.

3. A proposal has been made to replace one of the current manual stations with an automatic work head on a 10-station transfer line. The current system has six automatic work heads and four manual stations. The current cycle time is 30 s. The bottleneck station is the manual station that is the candidate for replacement. The proposed automatic station would allow the cycle time to be reduced to 24 s. The new station costs at Rs.25/min. Other cost data for the existing line:
   Co = Rs.15/min; Cas = Rs.10/min; Cat = Rs.10/min. Breakdowns occur at each of the six automatic workstations with a probability p =0.01. The average downtime per breakdown is 3 min. It is estimated that the value of p for the new automatic station would be p = 0.02. The average downtime for the line would be unaffected. Material for the product costs Rs.50/unit. Tooling costs can be neglected (Ct = 0). Which is the best method among the new automated station and the current manual station based on the cost per unit?

Code No: **R42034** **R10** **Set No. 2**

IV B.Tech II Semester Regular/Supplementary Examinations, April- 2015

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

4. a) Explain the importance in solving line balancing problems by using Ranked Positional Weights Method.
   b) Discuss the following ways for improving the performance of the line balance:
      i). Dividing work elements
      ii). Pre assembly of components
      iii). Inventory Buffers between stations

5. a) Explain the applications of Automated Guided Vehicles.
   b) What are the important categories of Automated Guided Vehicle Systems? Discuss them briefly with the help of neat sketches

6. a) Describe the Aisle transfer cars of an AS/RS system.
   b) What are the various operation parameters that can be measured in milling operation to use them in adaptive control systems.

7. a) Draw the block diagram of Adaptive Control with Optimization system for grinding operation and explain each block in detail.
   b) Explain the variables in the Adaptive Control with Optimization system for drilling process.

8. a) Define accuracy, precision and sensitivity of an automated inspection system.
   b) What are the basic functions of machine vision system?

Code No: **R42034** **R10** **Set No. 3**

IV B.Tech II Semester Regular/Supplementary Examinations, April- 2015

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
*****

1. a) Explain the following types of Automation:
   i) Programmable Automation ii) Fixed Automation
   b) Describe the function and working of the single station automated machine tool.

2. a) Illustrate the working of walking beam transfer system with the help of neat sketches.
   b) Explain the use of buffer storage zones in automated flow lines.

3. a) Discuss the analysis of the performance of a partially automated flow line without buffer storage.
   b) In a 10 station transfer line, the probability that a station break down will occur for a given work part is equal to 0.02. This probability is the same for all 10 stations. Determine the frequency of line stops per cycle on this flow line using the lower bound approach and also calculate the production rate.

4. a) What are the various assembly systems used in industry to accomplish the assembly processes.
   b) What are the various possible ways that should be considered by the designer for improving the operation of the line?

5. a) Explain the advantages of implementing various principles of material handling.
   b) What are the important categories of Automated Guided Vehicle Systems? Discuss them briefly with the help of neat sketches

6. a) What are the various operation parameters that can be measured in milling operation to use them in adaptive control systems.
   b) Briefly describe the Pickup and deposit stations of an AS/RS.

7. a) Draw the block diagram of Adaptive Control with Optimization system for milling and explain each block in detail.
   b) Explain the variables in the Adaptive Control with Optimization system for drilling process.

8. a) Explain the image processing and analysis in the operation of machine vision.
   b) What are the advantages of non-contact inspection techniques?

Code No: **R42034** **R10** **Set No. 4**

IV B.Tech II Semester Regular/Supplementary Examinations, April- 2015

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
*****

1. a) Draw the general structure of a hydraulic circuit and explain the important components involved in it.
   b) What are the important pneumatic components used in automated system? Describe briefly.

2. a) Draw the neat sketch of Rack and Pinion mechanism for rotary indexing table and explain its working.
   b) Explain briefly cam mechanism for material transfer with the help of neat sketch.

3. a) Discuss the analysis of the performance of a partially automated flow line without buffer storage.
   b) What are the reasons for the implementation of automated flow lines in the production units? Explain briefly.

4. a) Discuss the Dividing work elements for improving the performance of the line balance.
   b) Explain the steps used in solving the line balancing problem by using Largest Candidate Rule method.

5. a) Discuss the important factors to be considered in material handling system design.
   b) Describe the following conveyors used in material transport systems:
      i) In-floor tow-line conveyor ii) Overhead trolley conveyor.

6. a) Discuss how to overcome the problems that are encountered in interfacing AS/RS units to the manufacturing function.
   b) "The work-in-process storage systems are a systematic method for managing work-in-process in batch production factories"-Explain the reasons.

7. a) List out the various operation parameters that can be measured in turning operation to use in adaptive control systems.
   b) What are the applications of adaptive control system in various machining operations?

8. a) What are the various advantages of using CMM?
   b) What are the advantages of non-contact inspection techniques?

Code No: **R42034** **R10** **Set No. 4**

IV B.Tech II Semester Regular/Supplementary Examinations, April- 2015

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
*****

1. a) What are the important pneumatic components used in automated system?
   b) Discuss the common reasons for line stoppages in automated flow lines

2. a) Explain briefly cam mechanism for material transfer with the help of neat sketch
   b) A Geneva mechanism with a six-slotted driven member is used in a dial-type assembly machine. The longest assembly operation takes exactly one second to complete, so the driven member must be in a stopped (dwell) position for this length of time.
      i). At what rotation speed must the driver be turned to accomplish this one second dwell?
      ii). How much time will be required to index the dial to the next position?
      iii). Determine the ideal production rate of the assembly machine if each index of the dial produces a completed work part.

3. a) What is the Partial Automation used in automated flow lines?
   b) An eight-station rotary indexing machine operates with an ideal cycle time of 45 s. The frequency of line stop occurrences is 0.08 stops/cycle on the average. When a stop occurs, it takes an average of 3 min to make repairs. Determine the following:
      i) Average production time ii) Average production rate
      iii) Line efficiency iv) Proportion of downtime

4. a) What are the different manual methods for solving the line balancing problems? Briefly discuss any one method.
   b) Enumerate the differences between flexible assembly lines and manual assembly lines.

5. a) Describe the following Automated Guided Vehicle System with the help of simple sketch:
      i) Driverless Automated Guided Train ii) Unit Load Carrier.
   b) Explain the applications of Automated Guided Vehicles

6. a) Explain the following components of an AS/RS:
      i) Storage/Retrieval machine ii) Storage modules.
   b) Discuss the use of automated work-in-process storage systems

7. a) List out the differences between ACO and ACC types of adaptive control
   b) List out the variable parameters that can be measured in grinding process to use in adaptive control system

8. a) Write the step by step inspection procedure to be performed.
   b) What is image acquisition and digitization in the operation of machine vision?

Code No: **R42034** **R10** **Set No. 1**

IV B.Tech II Semester Regular/Supplementary Examinations, April/May - 2016

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

*****

1 a) What are the various types of automation? Explain them. [8]

b) What are the various pneumatic and hydraulic components used in automated industry. [7]

2 a) What are the various types of automatic loading methods used in practice and explain mechanical feeding method? [8]

b) What are the various functions involved in automation and how can they reduce cost of production? [7]

3 a) What are the various factors influence manufacturing lead time (MLT) and explain the methods to reduce transfer time? [8]

b) b) What are the objectives of use of flow lines in automation and explain various types of flow lines and their advantages? [7]

4 a) How the transfer lines are analysed in continuous and intermittent transfer machines? [8]

b) What is manual single station assembly and `manual assembly line'? Enumerate the differences between them [7]

5 a) A manual production flow line is arranged with six stations and a conveyor system is used to move parts along the line. The belt speed is 1.8 m/min and the spacing of raw workparts along the line is one for every 1.35 m. The total line length is 13.5 m, hence each station length equals 2.25 m. Determine the following [8]

i) Feed rate. ii) Tolerance time. iii) Theoretical cycle time.

b) Explain the applications of automated strong and retrieval system. [7]

6 a) Explain the various problems encountered in interfacing handling and storage systems with manufacturing units. [8]

b) What are the special features of AS/RS components? Discuss briefly. [7]

7 a) With the help of a neat block diagram, discuss the Adaptive Control with Optimization for drilling process to obtain the optimal process parameters [8]

b) Discuss the application of Adaptive Control in Machining operations. [7]

8 a) Explain the constructional features of coordinate measuring machine. [8]

b) Discuss the basic functions of machine vision system. [7]

Code No: **R42034** **R10** **Set No. 2**

IV B.Tech II Semester Regular/Supplementary Examinations, April/May - 2016

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
*****

1 a) Enumerate the principles of automation in manufacturing industry [8]
b) Enumerate the importance reasons for adopting automation by the companies with respect Indian scenario. [7]

2 a) What are the different methods of work part transport? Explain them. [8]
b) Explain rotary transfer mechanism. [7]

3 a) Compare manual and automated methods of production in terms direct labour material and over head costs. [8]
b) With a block diagram, explain various levels of automation. [7]

4 a) What is line balancing and explain largest candidate rule is adopted in Line-balancing of operations. [8]
b) What is manual single station assembly and `manual assembly line'? Enumerate the differences between them. [7]

5 A 16-station transfer line can be divided into two stages by installing a storage buffer between station 8 and 9. The probability of failure at any station is p = 0.01. The ideal cycle time is 1.0 min, and the downtime per line stop is 10.0 min.These values are both the one stage and two stage configurations. The downtime should be considered constant, and the upper bound approach should be used in the analysis. The cost of installing the storage buffer is a function of its capacity. This cost function is Cb = Rs0.6 b/hr, where b is the buffer capacity. However, the buffer can only be constructed to store increments of 10. The cost to operate the line itself is Rs120 / hr. Ignore material and tooling cost. Based on cost per unit of production, determine the buffer capacity 'b' that will minimize unit production cost.. [16]

6 a) Discuss the features of parts classification and coding systems. [8]
b) With the help of a line diagram explain the layout of a machine cell with semi integrated handling. [7]

7 a) What is the objective of Adaptive Control with Constraints? Draw the block diagram of a typical computerized Adaptive Control with Constraints system for drilling operation and explain in detail [8]
b) Explain the three phases involved in shop floor control system. [7]

8 a) Explain the constructional features of coordinate measuring machine. [8]
b) Discuss the basic functions of machine vision system. [7]

Code No: **R42034** **R10** **Set No. 3**

IV B.Tech II Semester Regular/Supplementary Examinations, April/May - 2016

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

****

1 a) Discuss the important categories of machine tool control strategies [8]

b) What are the basic elements of an automated system? Explain. [7]

2 a) List out the requirements of a plant layout for automation. [8]

b) What are the three basic control functions used in automated flow lines? Explain their features. [7]

3 a) Define the following:
i) Average production time. ii) Line efficiency iii) Cost per work piece [8]

b) Draw the neat sketches of the following mechanisms and discuss briefly
i) Rachet and Pawl mechanism. ii) `Over and Under' type chain drive mechanism [7]

4 a) Briefly explain ranked position weights method of line balancing with suitable example. [8]

b) Explain the following methods of AGUS.
i) Frequency select method. ii) Path switch select method [7]

5 A 16-station transfer line can be divided into two stages by installing a storage buffer between station 8 and 9. The probability of failure at any station is p =0.01. The ideal cycle time is 1.0 min, and the downtime per line stop is 10.0 min.These values are both the one stage and two stage configurations. The downtime should be considered constant, and the upper bound approach should be used in the analysis. The cost of installing the storage buffer is a function of its capacity. This cost function is Cb = Rs0.6 b/hr, where b is the buffer capacity. However, the buffer can only be constructed to store increments of 10. The cost to operate the line itself is Rs120 / hr. Ignore material and tooling cost. Based on cost per unit of production, determine the buffer capacity 'b' that will minimize unit production cost. [16]

6 a) Explain various reasons for using the storage buffers on the automated production lines [8]

b) Discuss the features of parts classification and coding systems. [7]

7 a) What is the objective of Adaptive Control with Constraints? Draw the block diagram of a typical computerized Adaptive Control with Constraints system for drilling operation and explain in detail [8]

b) Explain the three phases involved in shop floor control system [7]

8 a) Discuss the features of generative computer aided process planning [8]

b) Write about coordinate measuring machine and its types and benefits. [7]

Code No: **R42034** **R10** **Set No. 4**

IV B.Tech II Semester Regular/Supplementary Examinations, April/May - 2016

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

*****

1 a) What are the different types of automation? Discuss them briefly. [8]

b) What are the various types of automated systems used in practice and explain their relative merits and applications [7]

2 a) Explain the fundamentals of automated production lines. [8]

b) Explain the reasons for the use of storage buffers in automation [7]

3 a) Discuss the working of Geneva mechanism used in rotational indexing motion [8]

b) In a 10-station transfer line, the probability breakdown will occur for a given work part is equal to 0.01. This probability is the same for all 10 stations. Determine the frequency of line stops per cycle on this flow line using the upper-bound approach. [7]

4 a) How the transfer lines are analyzed in continuous and intermittent transfer machines [8]

b) List out the characteristics of automated assembly systems. [7]

5 a) Explain the design principles of automated guided vehicle system. [8]

b) Explain the applications of automated strong and retrieval system. [7]

6 a) What are the benefits of automated production lines. [8]

b) Explain various reasons for using the storage buffers on the automated production lines. [7]

7 a) With the help of a neat block diagram, discuss the Adaptive Control with Optimization for drilling process to obtain the optimal process parameters [8]

b) Discuss the application of Adaptive Control in Machining operations [7]

8 a) Explain the constructional features of coordinate measuring machine [8]

b) Discuss the basic functions of machine vision system. [7]

Code No: **RT41039** **R13** **Set No. 1**

IV B.Tech I Semester Regular Examinations, November - 2016

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B
*****

PART–A ***(22 Marks)***

1. a) List out the advantages of automation. [4]
   b) What are two reasons for the existence of partially automated production lines? [4]
   c) Name some line balancing methods. [3]
   d) Define Monorail and conveyer. [4]
   e) List out the advantages of Adaptive control. [4]
   f) What is inspection? [3]

PART–B ***(3x16 = 48 Marks)***

2. a) What is automation? Discuss various types of automation. [8]
   b) List various mechanical feeding devices. Explain any one with neat sketch. [8]

3. a) Discuss the various control functions of an automated transfer line. [8]
   b) A Geneva with six slots is used to operate the work table of a dial-indexing machine. The slowest workstation on the dial-indexing machine has an operation time of 2.5 sec, so the table must be in a dwell position for this length of time.
      i) At what rotational speed must the driven member of the Geneva mechanism be turned to provide this dwell time? [8]
      ii) What is the indexing time each cycle?

4. A six-station automatic assembly line has an ideal cycle time of 12 sec. Downtime occurs for two reasons. First, mechanical and electrical failures cause line stops that occur with a frequency of once per 50 cycles. Average downtime for these causes is 3 min. Second, defective components also result in downtime. The fraction defect rate of each of the six components added to the base part at the six stations is 2%. The probability that a defective component will cause a station jam is 0.5 for all stations. Downtime per occurrence for defective parts is 2 min. Determine
   i) yield of assemblies that are free of defective components,
   ii) proportion of assemblies that contain at least one defective component,
   iii) average production rate of good product, and
   iv) uptime efficiency. [16]

5. a) Explain any two material handling equipment with neat sketches. [8]
   b) Briefly describe the basic components of AS/RS. [8]

6. a) What do you mean by adaptive control? Explain two types of adaptive control. [8]
   b) List out the various operation parameters that can be measured in turning operation to use in adaptive control systems. [8]

7. a) Differentiate contact and non-contact inspection. [8]
   b) Explain the working of Co-ordinate Measuring Machine with neat sketch. [8]

Code No: **RT41039** **R13** **Set No. 2**

IV B.Tech I Semester Regular Examinations, November - 2016

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

*****

PART–A ***(22 Marks)***

1. a) Explain about flexible automation. [4]

   b) Name three reasons for including a storage buffer in an automated production line? [4]

   c) What are the four automated assembly system configurations? [3]

   d) Name various types material handling equipment. [4]

   e) Define adaptive control constraints. [4]

   f) Write the functions of CMM [3]

PART–B ***(3x16 = 48 Marks)***

2. a) List six basic components required in a hydraulic fluid system and state their essential functions. [8]

   b) Discuss various types of automation strategies mentioning their importance. [8]

3. a) Explain about geneva Mechanism. [8]

   b) A ten-station transfer machine has an ideal cycle time of 30 sec. The frequency of line stops is 0.075 stops per cycle. When a line stop occurs, the average downtime is 4.0 min. Determine
      (i) average production rate in pc/hr,
      (ii) line efficiency, and
      (iii) proportion downtime [8]

4. The following table defines the precedence relationships and element terms for new model toy.
   i) Construct the precedence diagram for this job
   ii) If the ideal cycle time = 1.1min. repositioning time 0.1 min and up time proportion is assumed to be 1.0, what is the theoretical minimum number of work station required to minimize the balance delay under the assumption that there will be one worker per station?
   iii) Using Ranked Positional Weights method, assign work elements to stations compute balance delay.

Work Element No.	T_e (Min)	Immediate Predecessor
1	0.5	--
2	0.3	1
3	0.8	1
4	0.2	2
5	0.1	2
6	0.6	3
7	0.4	4,5
8	0.5	3,5
9	0.3	7,8
10	0.6	6,9

[16]

5. a) Discuss the applications of AS/RS. [8]
   b) An automated guided vehicle system has an average travel distance per delivery = 200 m and an average empty travel distance = 150 m. Load and unload times are each 24 s and the speed of the AGV = 1 m/s. Traffic factor = 0.9. How many vehicles are needed to satisfy a delivery requirement of 30 deliveries/hour? Assume that availability = 0.95. [8]

6. What is the objective of Adaptive Control with Constraints? Draw the block diagram of a typical computerized Adaptive Control with Constraints system for drilling operation and explain in detail. [16]

7. a) Explain the working of machine vision with neat sketch. [8]
   b) Discuss briefly about the construction of Coordinate measuring machine. [8]

IV B.Tech I Semester Regular Examinations, November - 2016

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

*****

PART–A ***(22 Marks)***

1. a) Differentiate between fixed automation and Programmable automation. [4]
   b) Explain about upper bound approach. [3]
   c) Trace out the importance of precedence diagram in the line balancing. [4]
   d) Name the four traditional (non-automated) methods for storing materials. [3]
   e) State the principal difference between adaptive control system and conventional closed loop control system. [4]
   f) What is the difference between off-line inspection and on-line inspection? [4]

PART–B ***(3x16 = 48 Marks)***

2. a) Define the following terms used in mass production.
      (i) flexible automation
      (ii) Production rate
      (iii) Plant capacity [8]
   b) What are the important pneumatic components used in automated system? Describe briefly. [8]

3. a) Mention the objectives of automated flow line and discuss about in-line and rotary type configuration lines. [8]
   b) Explain the analysis of transfer lines without storage. [8]

4. a) Define the following performance measures related to line balancing
      i) Line efficiency
      ii) Balancing efficiency
      iii) Repositioning efficiency [8]
   b) Explain the largest candidate rule. [8]

5. a) An overhead trolley conveyor is configured as a continuous closed loop. The delivery loop has a length of 120 m and the return loop = 80 m. All parts loaded at the load station are unloaded at the unload station. Each hook on the conveyor can hold one part and the hooks are separated by 4 m. Conveyor speed = 1.25 m/s. Determine
   i) maximum number of parts in the conveyor system,
   ii) parts flow rate; and
   iii) maximum loading and unloading times that are compatible with the operation of the conveyor system? [8]

   b) Write the function of following material handling equipment.
   i) Industrial trucks
   ii) Pallet trucks
   iii) Roller conveyer [8]

6. a) Differentiate between ACO and ACC types of adaptive control. [8]

   b) Explain the adaptive control for grinding operation with block diagram. [8]

7. Explain different types of CMM with neat sketch. [16]

Code No: **RT41039**

R13

Set No. 4

IV B.Tech I Semester Regular Examinations, November - 2016

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B
*****

PART–A ***(22 Marks)***

1. a) List out the components in Pneumatic system. [3]
   b) What is a dial-indexing machine? [4]
   c) What is precedence diagram? Give the significance of precedence diagram. [4]
   d) What are the four basic components of nearly all automated storage/retrieval systems? [4]
   e) Define Adaptive control. [3]
   f) What are the four steps in a typical inspection procedure? [4]

PART–B ***(3x16 = 48 Marks)***

2. List out various mechanical feeding devices. Explain any two with neat sketch [16]

3. a) With neat diagrams explain the functioning of various types of Transfer Mechanisms. [8]
   b) Calculate the line efficiency for a transfer line with one storage buffer. The line has10 workstations, each with a probability of breakdown of 0.02. The cycle time of the line is 1 min. and each time a breakdown occurs, it takes exactly 5 min. to make repairs. The line is to be divided into two stages by a storage bank so that each stage will consist of five stations. Compute the efficiency of the two-stage line for various buffer capacities. [8]

Code No: **RT41039** **R13** **Set No. 4**

4. A manual assembly is to be designed to make a small consumer product. The work element, their times, and precedence constraints are given in the table below. A worker will operate the line for 400 min/day and must produce 300 products/day. A mechanized belt moving at a speed of 1.25 /min will transport the products between stations. Because of the variability in the time required to perform the assembly operations, it has been determined that the tolerance time should be 1.5 times the cycle of the line.

   i) Determine the ideal minimum number of workers on the line
   ii) Use kilbridge and wester method to balance the line
   iii) Compute the balance delay.

Element	T_e (min)	Preceded by
1	0.4	--
2	0.7	1
3	0.5	1
4	0.8	2
5	1.0	2,3
6	0.2	3
7	0.3	4
8	0.9	4,9
9	0.3	5,6
10	0.5	7,8

[16]

5. a) Discuss in detail the various steps involved in design of automated guided vehicle system. [8]
   b) Explain the various problems encountered in interfacing handling and storage systems with manufacturing units. [8]

6 Draw the block diagram of a typical computerized Adaptive Control with Constraints system for milling process. Explain in detail. [16]

7. Write short notes on following:
   i) Contact inspection Vs Non contact inspection [6]
   ii) Construction of CMM [5]
   iii) Types of illumination in Machine vision [5]

Code No: **R42034** **R10** **Set No. 1**

IV B.Tech II Semester Supplementary Examinations, April/May - 2017

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time : 3 hours **Max. Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks
*****

1 a) What are the different types of automation? Discuss them briefly. [8]
b) What are the important mechanical feeding devices used in automated systems? Discuss them briefly. [7]

2 a) Explain the differences between intermittent transfer mechanism and continuous transfer mechanism. [8]
b) Give the reasons for including a storage buffer in an automated production line? [7]

3 a) What are the three problem areas that must be considered in the analysis and design of an automated production line? [7]
b) Briefly discuss the following related to the efficiency of an automated flow lines:
i) Efficiency of line without storage buffer
ii) Efficiency of line with storage buffer [8]

4 a) Explain the following terms in line balancing:
i) Minimum rational work element
ii) Total work content
iii) Work Station Process Time [7]
b) Discuss any four methods that should be considered by the designer of a flow line for improving the efficiency of the assembly line. [8]

5 a) What are the three important categories of Automated Guided Vehicle Systems? [7]
b) Discuss briefly the AGVS guidance systems and explain the applications of AGVS. [8]

6 a) Explain the configuration and control features of carousel storage systems. [8]
b) Discuss the problems encountered in the control of AS/RS operation. [7]

7 a) What is the objective of Adaptive Control with Constraints? Draw the block diagram of a typical computerized Adaptive Control with Constraints system for any machining operation and explain in detail. [12]
b) What are the limitations of Adaptive Control systems? [3]

8 a) Differentiate between contact and non-contact inspection methods mentioning their advantages & applications. [8]
b) Describe the types of Coordinate Measuring Machines with neat sketches. [7]

Code No: **RT41039** **R13** **Set No.1**

IV B.Tech I Semester Supplementary Examinations, March - 2017

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

***** **PART–A** ***(22 Marks)***

1. a) What do you mean by actuator? [3]
   b) What are the functions of buffer storage? [4]
   c) How a flexible assembly line works? [3]
   d) List out the functions of material handling system. [4]
   e) State the advantages of adaptive control system. [4]
   f) Differentiate contact and non-contact inspection. [4]

PART–B ***(3x16 = 48 Marks)***

2. a) Explain any one mechanical feeding device with neat sketch. [8]
   b) Draw a neat sketch of pneumatic system and explain its components. [8]

3. a) In a 10 station transfer line, the probability that a station break down will occur for a given work part is equal to 0.01. This probability is the same for all 10 stations. Determine the frequency of line stops per cycle on this flow line using the upper bound approach and also calculate the production rate. [8]
   b) Explain the analysis of transfer lines with no internal parts storage. [8]

4. a) Enumerate the importance Ranked positional Weights method over other methods. [8]
   b) What is assembly line balancing, discuss in detail? [8]

5. a) Explain the applications of Automated Guided Vehicles. [8]
   b) With neat diagrams explain the functioning of various types of Transfer Mechanisms. [8]

6. a) Explain with neat block diagram typical configuration of Adaptive control Machining system. [8]
   b) Describe adaptive control with constraint for turning with a neat sketch. [8]

7. a) Discuss briefly about the construction of Coordinate measuring machine. [8]
   b) With neat sketch, explain the illumination techniques in Machine vision. [8]

Code No: **RT41039** **R13** **Set No. 1**

IV B.Tech I Semester Regular/Supplementary Examinations, October/November - 2017

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

*****

PART–A *(22 Marks)*

1. a) List the merits and demerits of the automations in production systems. [4]
   b) In a 10-station transfer line, the probability that a station breakdown will occur for a given work part is equal to 0.01. This probability is the same for all 10 stations. Determine the frequency of line stops per cycle on this flow line using the upper-bound approach. [3]
   c) Define (i) Minimum rotational work elements (ii) precedence constraints. [4]
   d) What are the technologies used for vehicle guidance in AGVs [4]
   e) What is meant by adaptive control constraint (ACC) [4]
   f) Define Inspection. [3]

PART–B *(3x16 = 48 Marks)*

2. a) Explain ten strategies for automation and process improvement [8]
   b) Write about fixed automation and programmable automation. [8]

3. a) A 2 station transfer line has an ideal
4. cycle time of Tc = 1.2 mins. The probability of station breakdown per cycle is equal for all stations & P =0.005 breakdowns / cycle. For each of the upper bound & lower bound determine: i) frequency of line stops per cycle ii) average actual production rate iii) line efficiency [8]
   b) Explain any four reasons, why storage buffers are used on automated production lines? [8]

4 A manual assembly line is to be designed to make a small consumer product. The work elements, their times, and the precedence constraints are as follows :

Element	Time (min)	Preceded by:	Element	Time (min)	Preceded by :
2	0.7	1	7	0.3	4
3	0.5	1	8	0.9	4,9
4	0.8	2	9	0.3	5,6
5	1.0	2,3	10	0.5	7,8

The workers will operate the line for 400 min per day and must produce 300 products per day. A mechanized belt, moving at a speed of 4.0 ft/min, will transport the products between workstations. Because of the variability in the time required to perform the assembly operations, it has been determined that the tolerance time should be equal to 1.5 times the cycle time of the line.
(i) Determine the ideal number of workstations on the line.
(ii) Use the ranked positional weights method to balance the line.
(iii) Compute the balance delay for your solution in part (ii). [16]

5. a) Explain the importance of automated work-in-process storage systems. [6]
   b) Discuss the automated Storage/Retrieval Systems (AS/RS) controls, and the special features and applications of AS/RS. [10]

6. a) What is adaptive control, and what are the major functions of adaptive control? [8]
   b) Discuss the effect of various constraints such as cutting force, temperature, vibration, and acoustic emission on adaptive control. [8]

7. a) Describe experimental procedure for machine vision. [8]
   b) List some of the applications of CMM. [8]

Code No: **RT41039** **R13** **Set No. 2**

IV B.Tech I Semester Regular/Supplementary Examinations, October/November - 2017

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

*****

PART–A *(22 Marks)*

1. a) What are the basic components of automated systems? [4]
   b) Define transfer lines. [4]
   c) Why storage buffers are used in automated production lines? [4]
   d) List two applications of cranes and hoists. [4]
   e) Name the different types of adaptive control systems. [3]
   f) List out the various components of CMM [3]

PART–B *(3x16 = 48 Marks)*

2. a) Summarize feeding devices and tool changing devices. [8]
   b) Discuss some of the reasons used to justify automation system. [8]

3. a) Make use of the given data and compute, a) Production rate b) Line efficiency and c) Cost per unit piece produced on the line. For a 20-station transfer line, it will operate at a production rate of 50 pieces per hour at 100% efficiency, probability of station breakdown per cycle is equal to p = 0.005 breakdowns/cycle for all stations. Average down time per line stop is 8 minutes. Machining cost is Rs.3 per component. The line operates at a cost of Rs.75/hr. One cutting tool per station lasts for 50 parts and average cost per tool is Rs.2 per cutting edge. [8]
   b) Why are continuous work transport systems uncommon on automated production lines? [8]

4. a) Discuss the different types of assembly systems. [8]
   b) Explain the other ways to improve line balancing in flexible assembly lines. [8]

5. a) Explain the role of AS/RS in material handling systems. [8]
   b) With neat sketch explain about fork lift truck. [8]

6. a) What are the advantages of adaptive control systems? [8]
   b) Explain a typical adaptive control machining system. [8]

7. a) Explain the functions of a machine vision system. [8]
   b) Explain any three CMM mechanical configurations. [8]

Code No: **RT41039** **R13** **Set No. 3**

IV B.Tech I Semester Regular/Supplementary Examinations, October/November - 2017

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

*****

PART–A *(22 Marks)*

1. a) Define automation. [3]
   b) Distinguish between upper bound and lower bound approach. [4]
   c) List out the advantages of kilbridge wester method. [3]
   d) List three major categories of work transport systems in production lines. [4]
   e) What is adaptive control optimization? [4]
   f) What are the functions of machine vision? [4]

PART–B *(3x16 = 48 Marks)*

2. a) Distinguish between automated production system and CIM. [6]
   b) Define automated machine tool? Classify actuators. What is the difference between hydraulic and pneumatic actuators? [10]

3. a) Explain the three general methods of transporting the work pieces on automated flow lines. [8]
   b) An eight station rotary indexing machine operates with an ideal cycle time of 20 sec. The frequency of line stop occurrences is 0.06 stop / cycle on the average. When a stop occurs it takes an average of 3 min to make repairs. Determine the following: (i) Average production time (ii) Line efficiency (iii) Proportion of downtime (iv) Average production rate. [8]

4. a) Explain any one method of line balancing with an example. [8]
   b) Write short note on flexible assembly lines. [8]

5. a) An overhead trolley conveyor is configured as a continuous closed loop. It has a delivery loop length of 75 m and return loop length 60 m. Each hook on the conveyor can hold one part, and the hooks are separated by 4.5 m. The speed of the conveyor is 40m/min. Determine the total number of parts in the conveyor system, and the parts flow rate. [8]
   b) Discuss the different types of AGV’s and their applications. [8]

6. Draw & Explain the block diagram of an Adaptive Control optimization system for milling process. [16]

7. a) Summarize Machine vision applications in manufacturing. [8]
   b) What are the various methods of automated inspection? Explain. [8]

1. a) Write are the Benefits of industrial automation? [4]
   b) What is a buffer storage? [3]
   c) What is the importance of line balancing? [4]
   d) Define material handling. [4]
   e) Where to use adaptive control systems. [4]
   f) What are the components of CMM? [3]

PART–B *(3x16 = 48 Marks)*

2. a) Explain the different types of production automation. Show, by suitable graph, three types of production automation as a function of production volume and product variety. [8]
   b) Write about hopper, feed track and parts feeder. [8]

3. a) Explain the two principal reasons for the use of buffer storage zones. Show by means of a diagram the case of two processing lines separated by a storage buffer. [8]
   b) Draw the neat sketches of any two transfer mechanisms and discuss briefly. [8]

4. A proposal has been submitted to replace a group of assembly workers, each working individually, with an assembly line. The following table gives the individual work elements.

Element	T_c(min)	Immediate predecessors
1	1.0	-
2	0.5	-
3	0.8	1,2
4	0.63	2
5	1.2	3
6	0.2	3,4
7	0.5	4
8	1.5	5,6,7

The demand rate for this job is 1600 units/week (assume 40 h/week) and the current number of operators required to meet this demand is eight using the individual manual workers.

(a) Construct the precedence diagram from the data provided on work elements.
(b) Use the largest-candidate rule to assign work elements to stations. What is the balance delay for the solution? [16]

5. a) Discuss the design of material handling systems. [8]
   b) Describe briefly traffic control patterns used in AGVs traffic management. [8]

6. a) What is the role of adaptive control in industry? [8]
   b) Draw the block diagram of Adaptive Control with Constraint system for turning operation. [8]

7. Explain the following inspection techniques:
   (i) Electrical field technique
   (ii) Radiation technique
   (iii) Ultrasonic inspection technique [16]

Code No: **R42034** **R10** **Set No. 1**

IV B.Tech II Semester Supplementary Examinations, April - 2018

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

****

1 a) Define `Fixed Automation’ and `Flexible Automation’. Enumerate the differences between them. [8]

b) Explain any one mechanical feeding device with neat sketch. [7]

2 a) Draw the neat sketches of the Rachet and Pawl mechanism and discuss briefly. [8]

b) What is a buffer storage? Explain the two principle reasons for the use of buffer storage zones. Show by means of a diagram, the case of two processing lines separated by a storage buffer. [7]

3 a) Discuss the efficiency of automated flow lines with storage buffer. [8]

b) Write a short note on partial automation. [7]

4 Consider the following problem of assembly line balancing.

Task	Task Time(Min)	Immediate Predecessor
A	0.9	--
B	0.4	A
C	0.6	B
D	0.2	C
E	0.3	D
F	0.4	E
G	0.7	F
H	1.1	G

Assuming that 55 minutes per hour are productive, compute the cycle time needed to obtain 50 units per hour as the output. Determine

(i) The minimum number workstations required and assign tasks based on largest candidate rule

(ii) Compute line utilization [15]

5 a) Describe the unit load carrier AGV with the help of simple sketch. [8]

b) An overhead trolley conveyor is configured as a continuous closed loop. It has a delivery loop length of 75 m and return loop of 60 m. Each hook on the conveyor can hold one part, and the hooks are separated by 4.5 m. The speed of the conveyor is 40 m/min. Determine the total number of parts in the conveyor system, and the parts flow rate. [7]

6 a) Briefly describe the Storage structure of an AS/RS. [8]
b) Discuss the use of automated work-in-process storage systems. [7]

7 a) Name the different types of adaptive control systems and distinguish between them. [8]
b) Draw the block diagram of Adaptive Control with Optimization system for drilling process. [7]

8 Explain the following:
(i) Any two types of CMM
(ii) Contact vs non contact inspection
(iii) Automated inspection vs manual inspection [15]

Code No: **RT41039** **R13** **Set No. 1**

IV B.Tech I Semester Supplementary Examinations, February/March - 2018

AUTOMATION IN MANUFACTURING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

*****

PART–A *(22 Marks)*

1. a) What is a production system? [3]
   b) What is partial automation? [3]
   c) What are the three major categories used to accomplish assembly of components? [4]
   d) What is the primary objective of a guiding system? [4]
   e) What is the importance of modification function in adaptive control system? [4]
   f) What are the two categories of inspection? [4]

PART–B *(3x16 = 48 Marks)*

2. a) Differentiate fixed and programmable automation. [8]
   b) What are the principles of automation? [8]

3. a) What are the objectives of flow line automation? [8]
   b) What are the design and fabrication considerations in an automated flow lines. [8]

4. a) What are the methods used in industry to accomplish the assembly process? [8]
   b) What are the two ways in which transfer of workpart takes place between workstations? [8]

5. a) What are the principles of material handling system? [12]
   b) What are the components of AS/RS system? [4]

6. a) Explain the principle and structure of adaptive control. [12]
   b) What is the drawback of adaptive control with optimization? [4]

7. a) What is the inspection procedure followed? [8]
   b) What are the components of a basic CMM? [8]

Code No: **RT41039** **R13** **Set No. 1**

IV B.Tech I Semester Regular/Supplementary Examinations, Oct/Nov - 2018
AUTOMATION IN MANUFACTURING
(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B
******* PART–**

A ***(22 Marks)***

1. a) Write the various automation strategies. [3]
   b) What is the significance of buffer storage? [4]
   c) Why assembly lines? [3]
   d) List various conveyor systems. [4]
   e) What is adaptive control system? Why? [4]
   f) What do you know about Off-line Inspection Methods? [4]

PART–B ***(3x16 = 48 Marks)***

2. a) Define Automation. Discuss various levels of automation. [8]
   b) Differentiate between fixed and flexible automation. [8]

3. a) What is Buffer storage? Explain the reasons for the use of Buffer storage zones. [8]
   b) What are the methods of transporting work pieces on flow lines? Explain them. [8]

4. The following data apply to a 10-station in-line transfer machine:
   $P = 0.01$ (all stations have an equal probability of failure)
   $T_c = 0.3$ min
   $T_d = 3.0$ min
   Using the upper-bound approach. Compute the following for the transfer machine:
   (i) F, the frequency of line stops. (ii) R_p, the average production rate.
   (iii) E, the line efficiency. [16]

5. a) Describe the use of Material Handling Equipment in Machine Tools. [8]
   b) Explain the various problems encountered in interfacing handling and storage systems with manufacturing units. [8]

6. a) Explain the situations where adaptive control can be beneficially applied? [8]
   b) What are the limitations of adaptive control? [8]

7. a) Distinguish the contact and Non-contact inspection methods. [8]
   b) Explain different types of CMM. [8]

Code No: **RT41039** **R13** **Set No. 2**

IV B.Tech I Semester Regular/Supplementary Examinations, Oct/Nov - 2018
AUTOMATION IN MANUFACTURING
(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B
*****

PART–A *(22 Marks)*

1. a) List the hydraulic components of automated systems. [4]
   b) What is buffer storage? Write its significance. [4]
   c) What are the different line balancing methods? [4]
   d) What is AS/RS? [3]
   e) List the applications of adaptive control. [4]
   f) Write Inspection vs. Testing. [3]

PART–B *(3x16 = 48 Marks)*

2. a) Discuss various levels of automation. [8]
   b) What are the important pneumatic components used in automated system? Describe briefly. [8]

3. Explain the following linear transfer mechanisms:
   (i) Walking beam system.
   (ii) Powered roller conveyor system. [16]

4. A 30-station transfer line has an ideal cycle time T_c=0.75 min, an average downtime T_d = 6.0 min per line stop occurrence, and a station failure frequency p = 0.01 for all stations. A storage buffer is located between stations 15 and 16 to improve the line efficiency. Using the upper bound approach, determine
   (i) The current line efficiency and production rate.
   (ii) Maximum possible line efficiency and production rate because of storage buffer. [16]

5. a) Describe the following automated guided vehicle system with the help of simple sketch:
   (i) Driverless automated guided train (ii) Unit load carrier. [8]
   b) Enumerate the differences between asynchronous conveyors and continuous motion conveyors. [8]

6. a) Explain how various parameters such as cutting force, temperatures are controlled using adoptive control concept. [8]
   b) Explain the process of adaptive control constraint (ACC). [8]

7. a) What is automated inspection? Discuss its procedure. [8]
   b) Discuss the constructional details of CMM. [8]

Code No: **RT41039** **R13** **Set No. 3**

IV B.Tech I Semester Regular/Supplementary Examinations, Oct/Nov - 2018
AUTOMATION IN MANUFACTURING
(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B
*****

PART–A *(22 Marks)*

1 a) List the pneumatic components of automated systems. [3]
b) Identify the transfer mechanisms used in automated flow lines. [4]
c) What are the different ways of improving line balancing? [4]
d) What are the functions of automated material handling systems? [4]
e) How adaptive control is implemented in machining operations? [4]
f) What are the various inspection attributes? [3]

PART–B *(3x16 = 48 Marks)*

2 a) Explain any one mechanical feeding device with neat sketch. [8]
b) Explain the following types of Automation:
(i) Programmable Automation (ii) Fixed Automation [8]

3 a) What is a transfer line? Explain any two work part transfer methods. [8]
b) Write short note on partial automation. [8]

4 A manual assembly line is to be designed to make a small consumer product. The work elements, their times and precedence constraints are given in the table below. The workers will operate the line for 400 min/day and must produce 300 products per day.
(i) Determine the ideal minimum number of workers on the line.
(ii) Use RPW method to balance the line.

Element	1	2	3	4	5	6	7	8	9	10
T_e(min)	0.4	0.7	0.5	0.8	1.0	0.2	0.3	0.9	0.3	0.5
Preceded by	-	1	1	2	2,3	3	4	4,9	5,6	7,8

[16]

5 a) Explain the advantages of implementing various principles of material handling. [8]
b) Describe the following conveyors used in material transport systems:
(i) In-floor tow-line conveyor (ii) Overhead trolley conveyor. [8]

6 a) What is meant by adaptive control? Explain. [8]
b) Differentiate between adaptive control optimization and adaptive control constraint. [8]

7 a) Write about CMM operation. [8]
b) Describe the action step resulting from Automated Inspection. [8]

Code No: **RT41039** **R13** **Set No. 4**

IV B.Tech I Semester Regular/Supplementary Examinations, Oct/Nov - 2018
AUTOMATION IN MANUFACTURING
(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B

***** **PART–A** ***(22 Marks)***

1. a) What are the various mechanical feeding methods? [4]
   b) List the methods of part transport. [3]
   c) What is the use of assembly lines? [4]
   d) Classify the material handling systems. [4]
   e) List adaptive control components. [3]
   f) Write the various inspection variables. [4]

PART–B ***(3x16 = 48 Marks)***

2. a) Explain the pneumatic and hydraulic components in Automation. [8]
   b) Write about Automation in machine Tools. [8]

3. a) What is an automated flow line? Mention the objectives of the use of flow line automation. [8]
   b) Explain the factors to be considered in designing and building an automated flow line. [8]

4. The following data apply to a 12-station in-line transfer machine:
   $P = 0.01$ (all stations have an equal probability of failure)
   $T_c = 0.3$ min
   $T_d = 3.0$ min
   Using the lower-bound approach, compute the following for the transfer machine:
   (i) F, the frequency of line stops. (ii) R_p, the average production rate.
   (iii) E, the line efficiency.
   What proportion of work parts are removed from the transfer line? [16]

5. a) Discuss the various material characteristics factors which influence the design of the material handling system. [8]
   b) Discuss the following tasks to operate Automated Guided Vehicle Systems efficiently:
   (i) Traffic Control (ii) Vehicle Dispatching. [8]

6. a) Explain the process of adaptive control optimization (ACO). [8]
   b) What are the benefits of adaptive control machining? [8]

7. a) Write about types of inspection methods and equipments. [8]
   b) Describe the Machine Vision operation. [8]

R15

Code No: R15A0344

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

IV B. Tech II Semester Regular Examinations, April/ May 2019

Automation in Manufacturing

(ME)

Roll No										

Time: 3 hours **Max. Marks: 75**

Note: This question paper contains two parts A and B
Part A is compulsory which carriers 25 marks and Answer all questions.
Part B Consists of 5 SECTIONS (One SECTION for each UNIT). Answer FIVE Questions, Choosing ONE Question from each SECTION and each Question carries 10 marks.

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PART-A (25 Marks)

1). a What is industrial automation **[2M]**
b Mention the features of FMS **[3M]**
c Define control function **[2M]**
d What are the features of automated flow lines **[3M]**
e Define assembly system **[2M]**
f What are the benefits of line balancing **[3M]**
g List out the functions of material handling system **[2M]**
h List out types of conveyers **[3M]**
i Mention the advantages of LAN in manufacturing **[2M]**
j What is the function of actuator in automation **[3M]**

PART-B (50 MARKS)

SECTION-I

2 Discuss on mechanical feeding and feeding devices in automation **[10M]**

OR

3 Explain types of automation **[10M]**

SECTION-II

4 Explain methods of work part transfer in automation **[10M]**

OR

5 Discuss analysis of transfer lines with buffer storages **[10M]**

SECTION-III

6 Explain flexible assembly lines and its advantages **[10M]**

OR

7 Discuss on assembly process with examples **[10M]**

SECTION-IV

8 Discuss the importance of AGVS **[10M]**

OR

9 Mention the types of material handling equipment **[10M]**

SECTION-V

10 Explain terms (a) Logic controls (b) Sensors **[10M]**

OR

11 Write short note on Control theory and LAN in Manufacturing **[10M]**

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