ATME College of Engineering

Computer Aided Design & Manufacturing 18ME72

Module-3

Flexible Manufacturing Systems

Mr.Shashidhar .M.K
Assistant Professor,
Dept. of Mechanical Engineering,
ATMECE, Mysuru

GROUP TECHNOLOGY

- **Group technology (G T)** is a manufacturing philosophy that identifies and exploits the underlying **similarities of parts** and manufacturing processes.
- In batch-type manufacturing for multi-products and small-lot-sized production, conventionally each part is treated as unique from design through manufacture However, by grouping similar parts into part families based on either their **design or processes**.
- It is possible to increase the productivity through more effective design rationalization and data retrieval, and manufacturing standardization and rationalization.

OBJECTIVES OF GROUP TECHNOLOGY

- Reduce average lot size
- Increase part variety
- Increase variety of materials
- Achieve close tolerance
- Improve scheduling
- Reduce tooling
- Increase equipment utilization

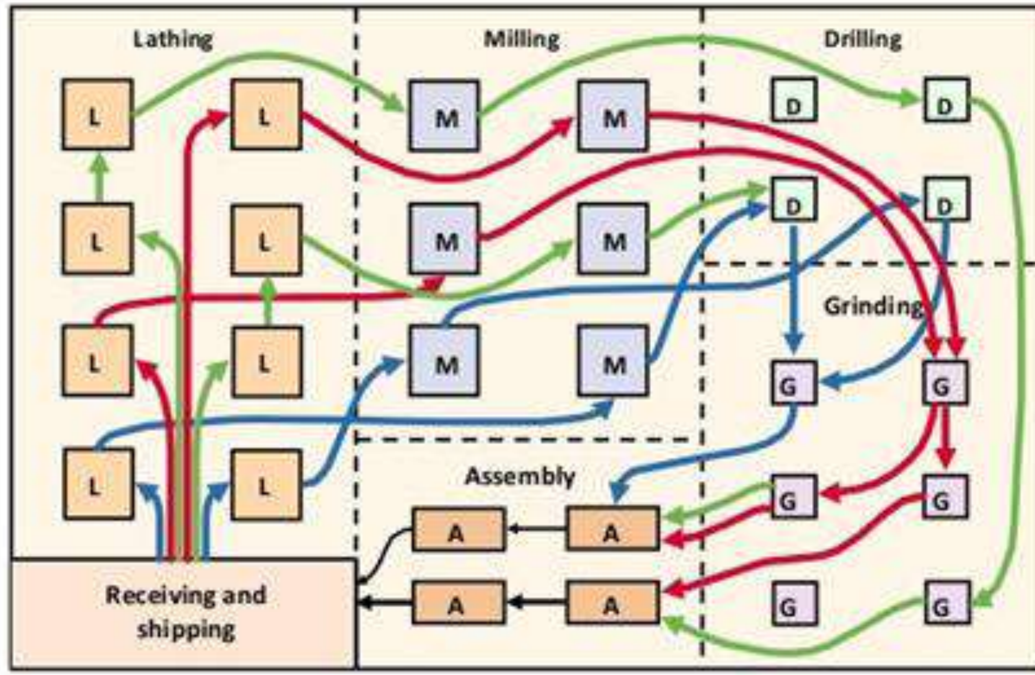
GROUP TECHNOLOGY

The two major tasks that a company must undertake when it implements GT are

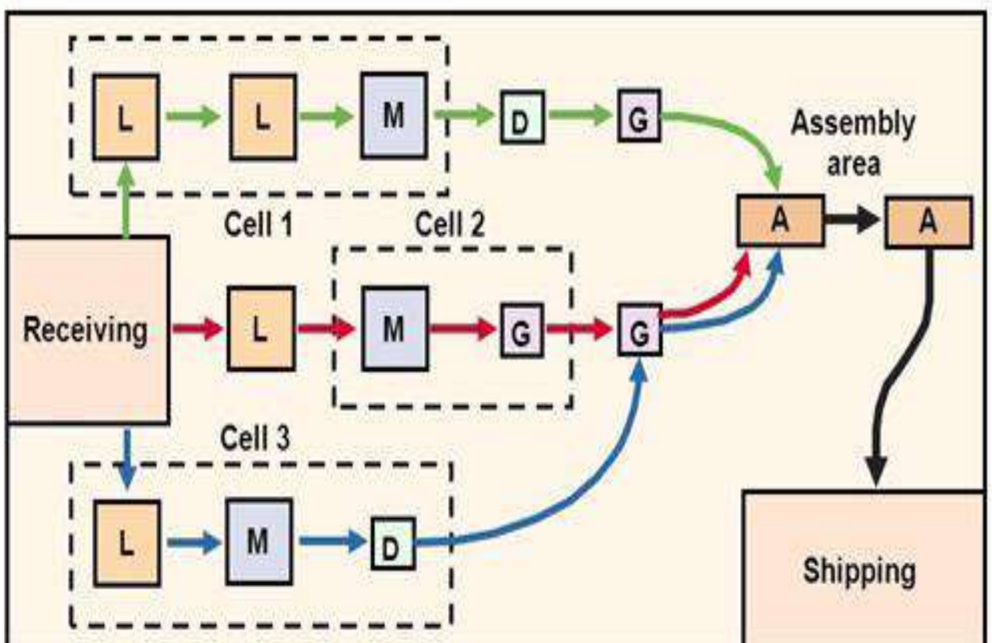
1. **Identifying the part families**. If the plant makes 10,000 different parts, reviewing all of the part drawings and grouping the parts into families is a substantial task that consumes a significant amount of time.
2. **Rearranging production machines into machine cells**. It is time consuming and costly to plan and accomplish this rearrangement and the machines are not producing during the changeover period.

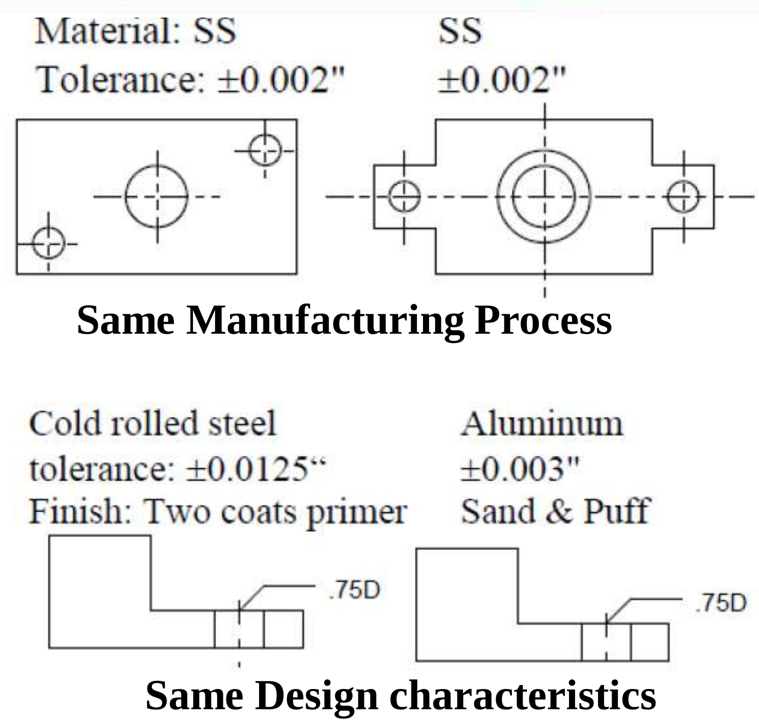
Grouping the production equipment into machine cells, where each cell specializes in the production of a part family is called **Cellular Manufacturing.**

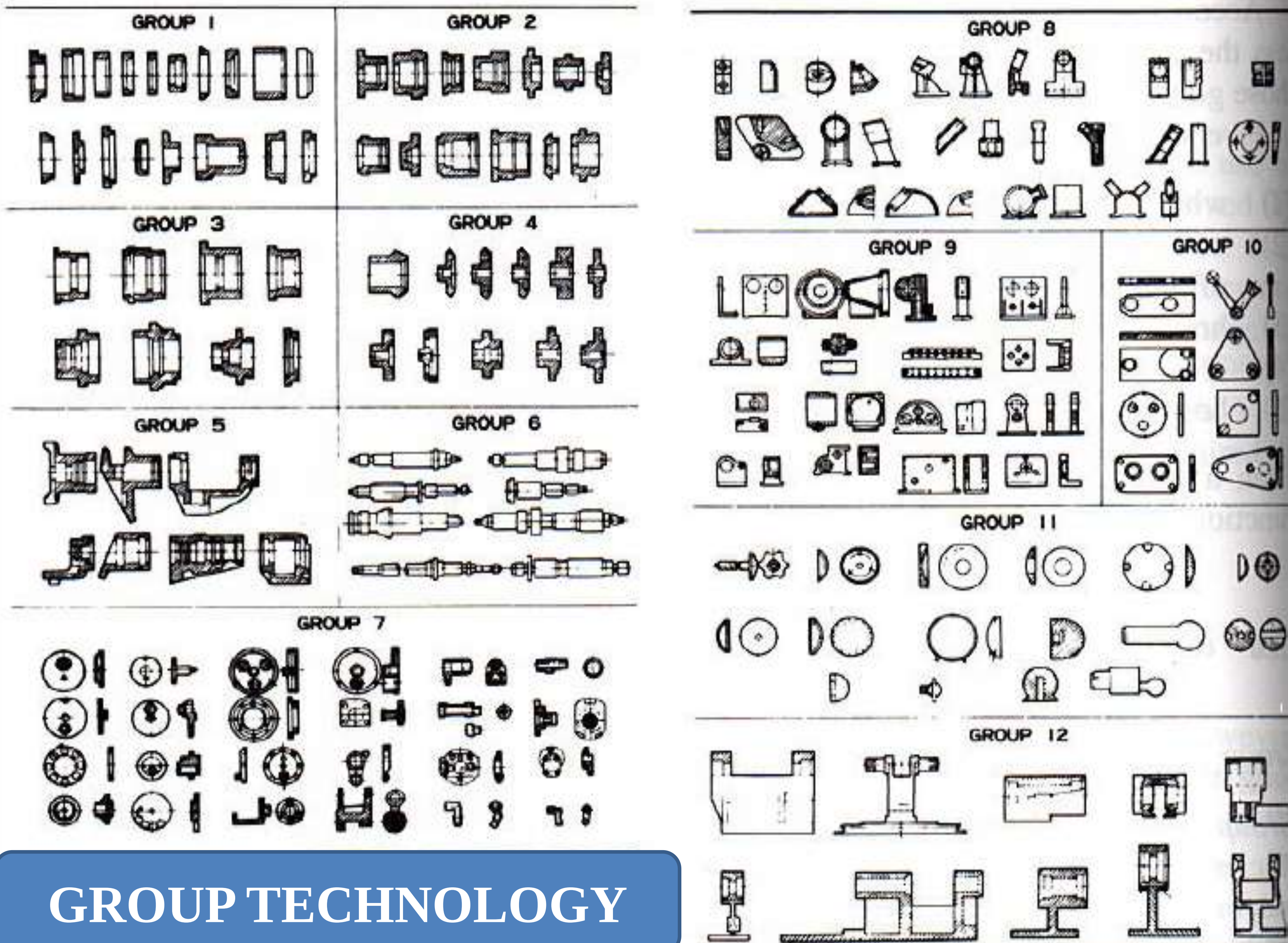
Process Type Plant Layout



Group Technology Layout







GROUP TECHNOLOGY

BENEFITS OF GT

- GT promotes **standardization** of tooling, fixturing and setups.
- Material handling is reduced because parts are moved within a machine cell rather than within the entire factory.
- Process planning and production scheduling are simplified
- Setup times are reduced, resulting in lower manufacturing lead times.
- Work-in-process is reduced.
- Worker satisfaction usually improves when workers collaborate in a GT cell.
- Higher quality work is accomplished using group technology.

Table: Design and Manufacturing Attributes used in Classification and Coding System

Part Design Attributes	Part Manufacturing Attributes
• Basic external shape • Basic internal shape • Rotational or rectangular shape • Length-to-diameter ratio (rotational parts) • Aspect ratio (rectangular parts) • Material type • Part function • Major dimensions • Minor dimensions • Tolerances • Surface finish	• Major processes • Minor operations • Operation sequence • Major dimension • Surface finish • Machine tool • Production cycle time • Batch size • Annual production • Fixtures required • Cutting tools

Examples of Parts Classification and Coding Systems

- Opitz classification system
- The Brisch System (Brisch Birn Inc.)
- CODE (Manufacturing Data Systems Inc.)
- CUTPLAN (Metcut Associates);
- DCLASS (Brigham Young University):
- MultiClass(OIR: Organization for Industrial Research)
- Part Analog System (Lovelace. Lawrence & Co., Inc.).

FLEXIBLE MANUFACTURING SYSTEM

- **Flexible Manufacturing System (FMS)** is a highly automated GT machine cell consisting of a group of processing workstations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by a distributed computer system.

  OR

  A FMS is a group of NC machine tools that can randomly process a group of parts, having automated material handling and central computer control to dynamically balance resource utilization so that the system can adapt automatically to changes in parts production, mixes, and levels of output

- The reason the FMS is called Flexible is that it is capable of processing a variety of different part styles simultaneously at the various workstations, and the mix of part styles and quantities of production can be adjusted in response to changing demand patterns.
- The FMS is most suited for the **mid-variety, mid-volume** production range.

F M S Components

The components of flexible manufacturing system are workstations to process the part, material handling system to transfer the parts from one workstation to another, network of computers of all the equipments to a master computer to control manufacturing activity, human labor for maintenance.

- **Workstations**
  - **Primary equipment:**
    - Work centers:- HMC, VMC, Grinding M/c, etc.
    - Processing Centers: - CMM, Wash M/c, Robot work station etc
  - **Secondary equipment:**
    - Pallet/ fixture, Load / Unload stations, tool setting / commissioning area
  - **Support equipment:**
    - Robots, AGV, Tool stores, Raw material stores, Pallet stores, etc.
- **Material handling systems**
  - Conveyor system, AGV, Robots
- **Network infrastructure and programming language**
  - Bus- LAN- Star – point to point - serial
  - Programming languages and software's
- **Human Resources**

A Typical FMS

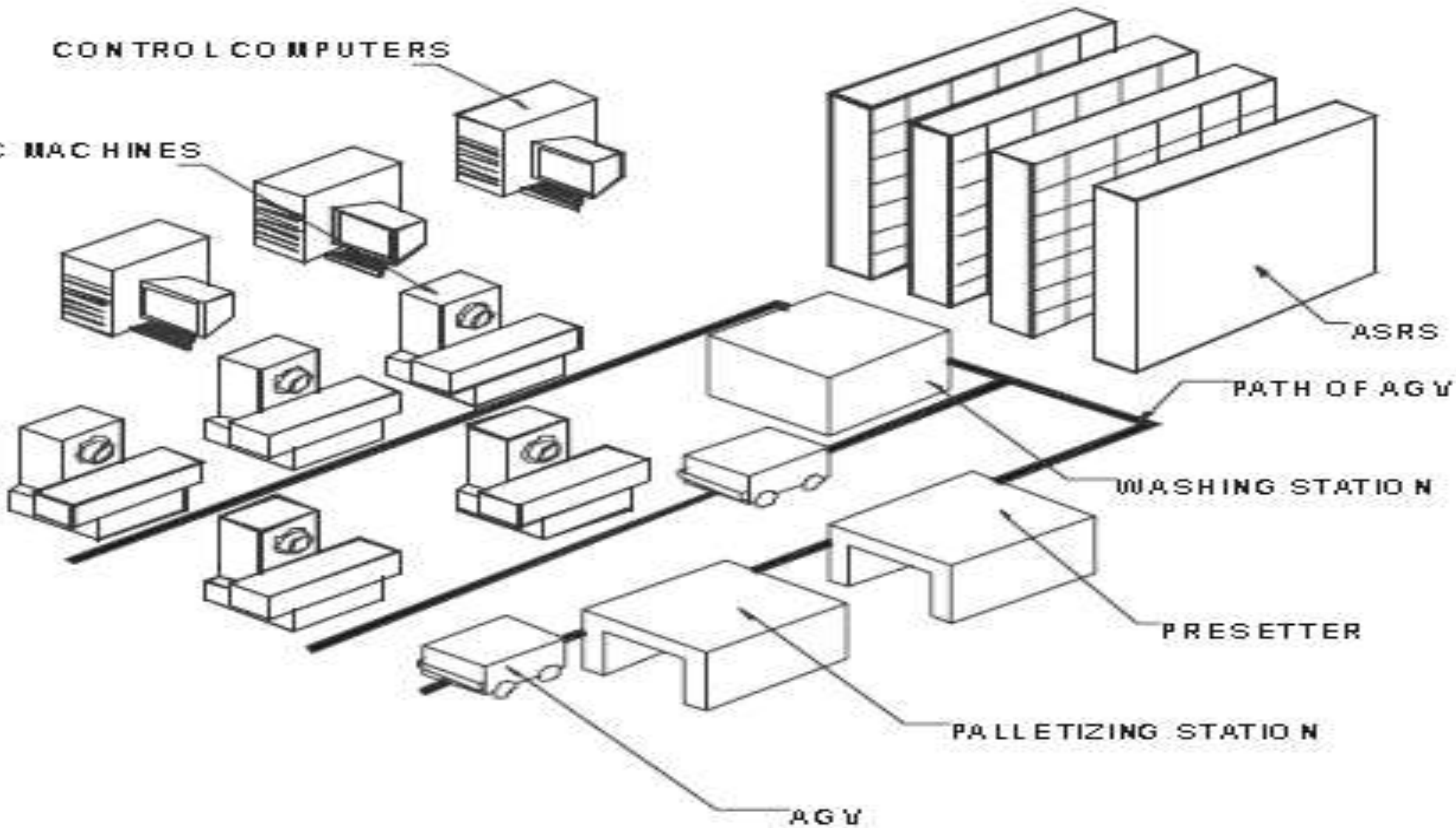
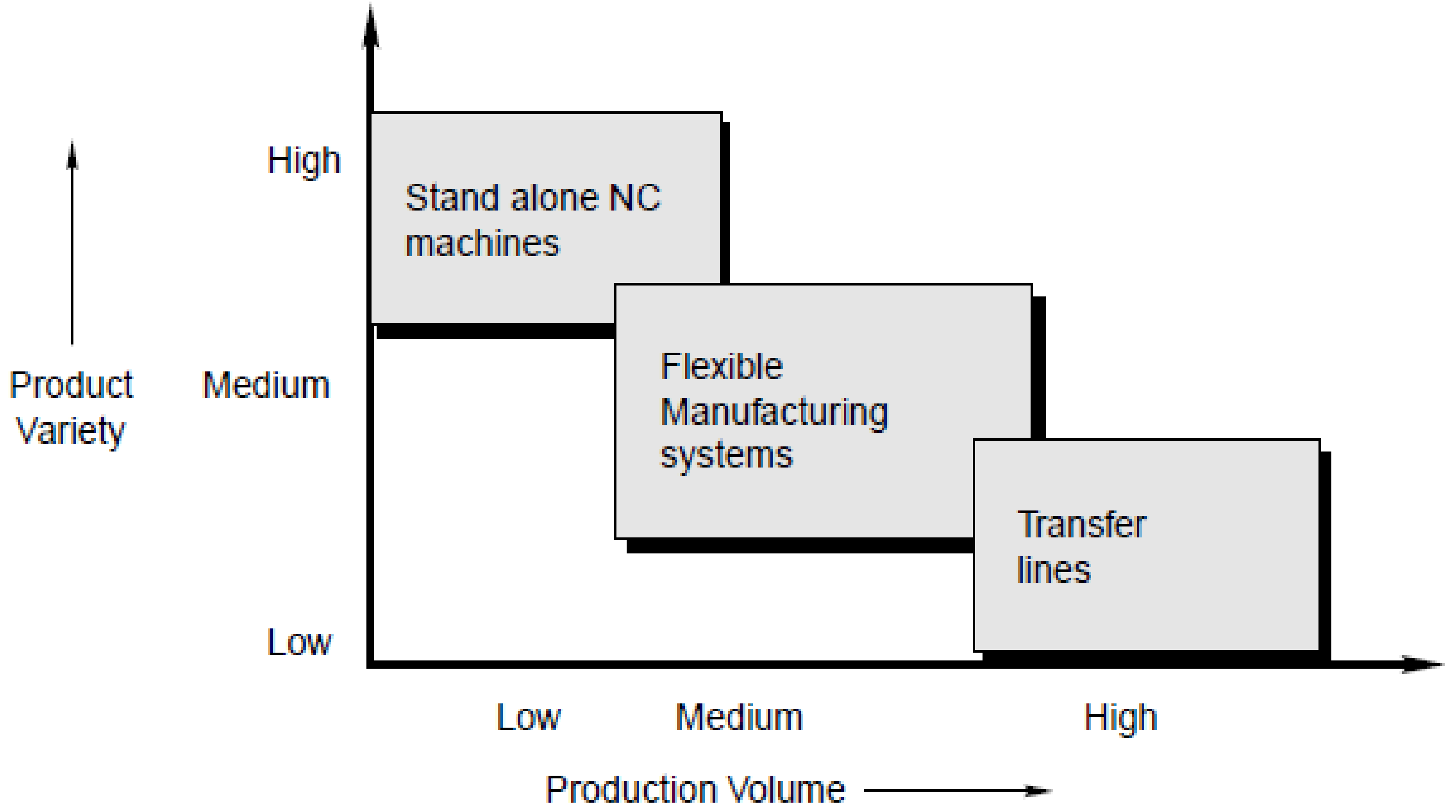


Fig. A Typical FMS

Application of FMS

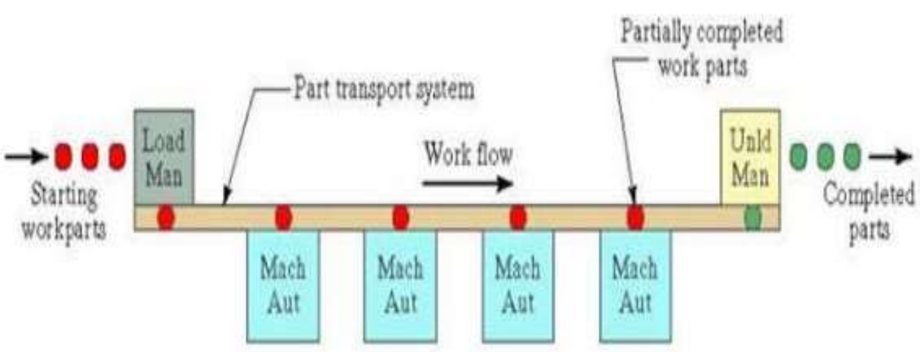


FMS Layouts

The arrangement of material handling system establishes the FMS layout. Typical material handling system used as the primary handling system for FMS layouts are In-line transfer system, Conveyor system, Rail guided vehicle system, Automated guided vehicle system, In- floor tow line carts, Industrial robots. The five categories of FMS layouts are

1. **Progressive or In-Line type Layout**
2. **Loop Type Layout**
3. **Ladder Type Layout**
4. **Open Field Type Layout**
5. **Robot Centered Type Layout**

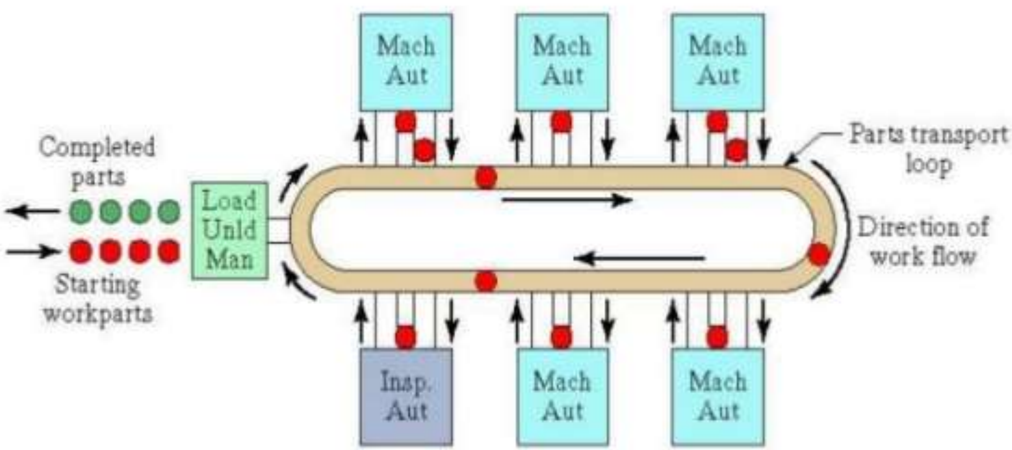
1. PROGESSIVE OR LINE TYPE



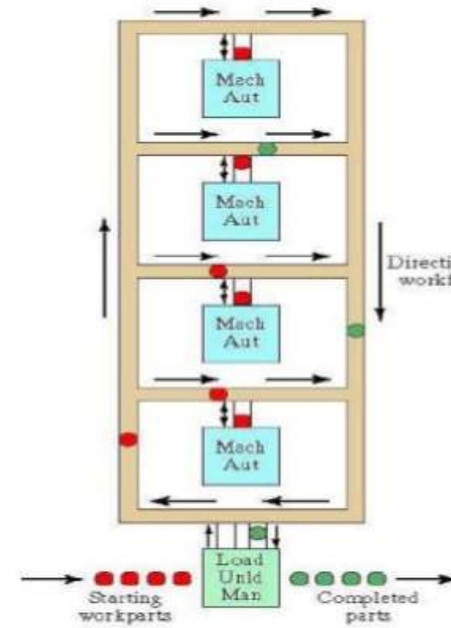
Progressive or In-Line type Layout: In this layout, the workstations and material handling systems are arranged in a straight line. Parts progress from one workstation to another in a well defined sequence. The work part always moves in one direction and there is no back flow. All the work parts follow same routing sequence even though the processing varies at each station.

Loop Type Layout: In the loop layout the workstations are organized in a loop that is served by a part handling system in the same shape. Parts usually flow in one direction around the loop, with the capability to stop and be transferred to any station. A secondary handling system at each station permits the parts to move without obstruction around the loop. Workstations are served by a carousel parts handling system. Load/unload stations are usually located at one end of the loop.

2. LOOP TYPE



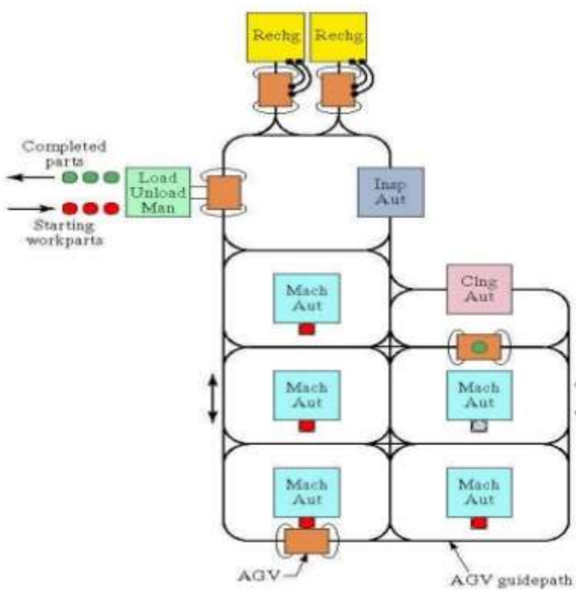
3. LADDER TYPE



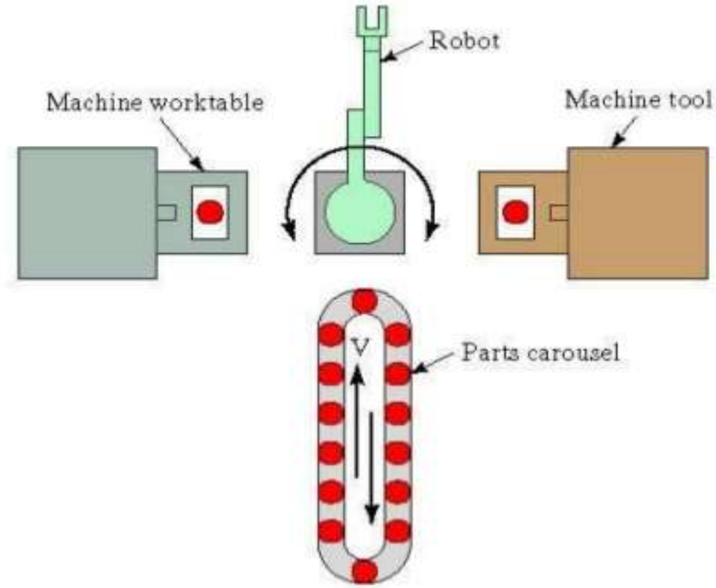
Ladder Type Layout : is a modification of loop layout. It has connections between the two straight sections of the loop, on which workstations are located. This increases the possible ways of getting from one machine to next, and reduces the need for secondary handling systems. Load / unload station is usually placed at one end of the loop. The flexibility of this layout is that the parts can be sent to any machine in any sequence, parts are not limited to particular part families.

Open Field Type: This is the most complex FMS layout. It has multiple loops and ladders and it includes several support stations. Parts move from one station to another with the help of AGV. This layout is generally appropriate for processing a large family of parts.

4. OPEN FIELD TYPE



5. ROBOT CENTERD TYPE



Robot Centered Type: In this type of layout one or more robot is used to transfer material from one workstation to another. The robots are equipped with double grippers that make them well suited for the handling of rotational parts. The robot unloads and loads the part at workstations. It picks up raw material from the conveyor and also deposits the finished part on to the conveyor. These layouts are often used to process cylindrical or disk shaped parts.

Types of Flexibility

- **Machine Flexibility.** It is the capability to adapt a given machine in the system to a wide range of production operations and part styles. The greater the range of operations and part styles the greater will be the machine flexibility. The various factors on which machine flexibility depends are:
  - Setup or changeover time
  - Ease with which part-programs can be downloaded to machines
  - Tool storage capacity of machines
  - Skill and versatility of workers in the systems
- **Production Flexibility.** It is the range of part styles that can be produced on the systems. The range of part styles that can be produced by a manufacturing system at moderate cost and time is determined by the process envelope. It depends on following factors:
  - Machine flexibility of individual stations
  - Range of machine flexibilities of all stations in the system

Types of Flexibility

- **Mix Flexibility.** It is defined as the ability to change the product mix while maintaining the same total production quantity that is, producing the same parts only in different proportions. It is also known as process flexibility. Mix flexibility provides protection against market variability by accommodating changes in product mix due to the use of shared resources. However, high mix variations may result in requirements for a greater number of tools, fixtures, and other resources. Mixed flexibility depends on factors such as:
  - Similarity of parts in the mix
  - Machine flexibility
  - Relative work content times of parts produced
- **Product Flexibility.** It refers to ability to change over to a new set of products economically and quickly in response to the changing market requirements. The change over time includes the time for designing, planning, tooling, and fixturing of new products introduced in the manufacturing line-up. It depends upon following factors:
  - Relatedness of new part design with the existing part family
  - Off-line part program preparation
  - Machine flexibility

Types of Flexibility

- **Routing Flexibility.** It can define as capacity to produce parts on alternative workstation in case of equipment breakdowns, tool failure, and other interruptions at any particular station. It helps in increasing throughput, in the presence of external changes such as product mix, engineering changes, or new product introductions. Following are the factors which decides routing flexibility:
  - Similarity of parts in the mix
  - Similarity of workstations
  - Common tooling
- **Volume Flexibility.** It is the ability of the system to vary the production volumes of different products to accommodate changes in demand while remaining profitable. It can also be termed as **capacity flexibility**. Factors affecting the volume flexibility are:
  - Level of manual labor performing production
  - Amount invested in capital equipment
- **Expansion Flexibility.** It is defined as the ease with which the system can be expanded to foster total production volume. Expansion flexibility depends on following factors:
  - Cost incurred in adding new workstations and trained workers
  - Easiness in expansion of layout
  - Type of part handling system used

Types of FMS

Flexible manufacturing systems can be divided into various types depending upon their features.

1. **Depending upon kinds of operation**
2. **Depending upon number of machines**
3. **Depending upon level of flexibility**

1. DEPENDING UPON KINDS OF OPERATION : Flexible manufacturing system can be distinguished depending upon the kinds of operation they perform:

I. **Processing operation.** Such operation transforms a work material from one state to another moving towards the final desired part or product. It adds value by changing the geometry, properties or appearance of the starting materials.

II. **Assembly operation.** It involves joining of two or more component to create a new entity which is called an assembly/subassembly. Permanent joining processes include welding, brazing, soldering , adhesive bonding, rivets, press fitting, and expansion fits.

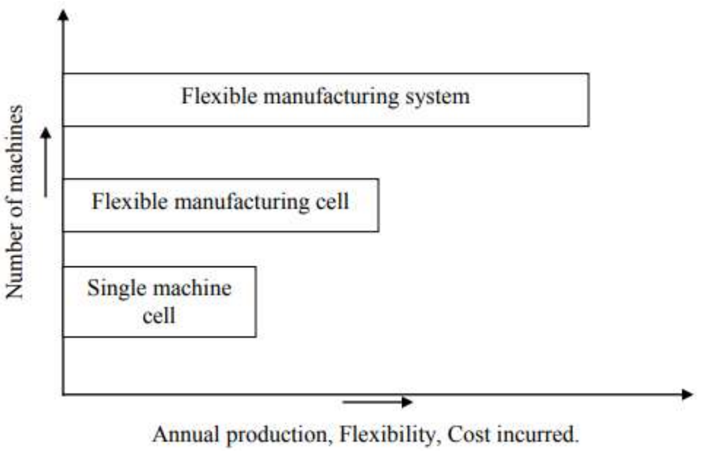
Types of FMS

2. DEPENDING UPON NUMBER OF MACHINES – The following are typical categories of FMS according to the number of machines in the system:

I. single machine cell (SMC). It consist of a fully automated machine capable of unattended operations for a time period longer than one machine cycle. It is capable of processing different part styles, responding to changes in production schedule, and accepting new part introductions. In this case processing is sequential not simultaneous.

II. Flexible manufacturing cell (FMC). It consists of two or three processing workstation and a part handling system. The part handling system is connected to a load/unload station. It is capable of simultaneous production of different parts.

III. A Flexible Manufacturing System (FMS). It has four or more processing work stations (typically CNC machining centers or turning centers) connected mechanically by a common part handling system and automatically by a distributed computer system. It also includes non-processing work stations that support production but do not directly participate in it. e.g. part / pallet washing stations, coordinate measuring machines. These features significantly differentiate it from Flexible manufacturing cell (FMC).

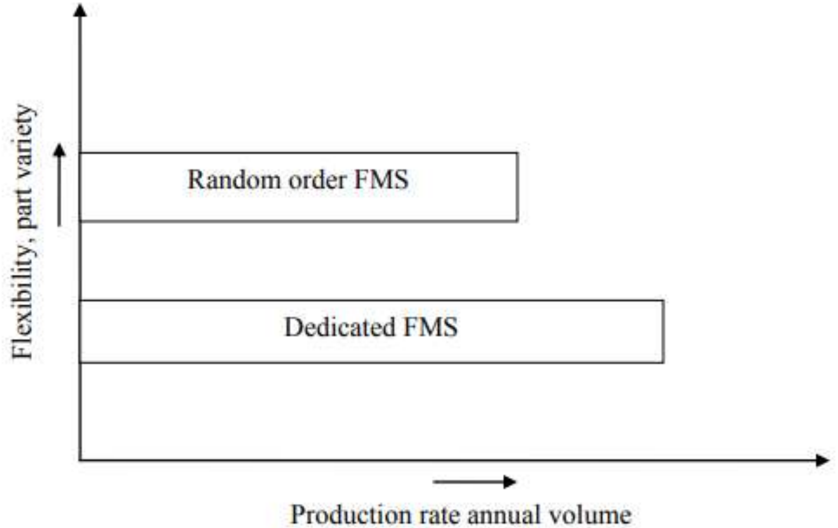


Types of FMS

3. DEPENDING UPON LEVEL OF FLEXIBILITY– Another classification of FMS is made according to the level of flexibility associated with the system. Two categories are distinguished here:

I. Dedicated FMS. It is designed to produce a particular variety of part styles. The product design is considered fixed. So, the system can be designed with a certain amount of process specialization to make the operation more efficient.

II. Random order FMS. It is able to handle the substantial variations in part configurations. To accommodate these variations, a random order FMS must be more flexible than the dedicated FMS. A random order FMS is capable of processing parts that have a higher degree of complexity. Thus, to deal with these kinds of complexity, sophisticated computer control system is used for this FMS type.



Advantages And Disadvantages of FMS Implementation

Advantages

- Faster, lower- cost changes from one part to another which will improve capital utilization
- Lower direct labor cost, due to the reduction in number of workers
- Reduced inventory, due to the planning and programming precision
- Consistent and better quality, due to the automated control
- Lower cost/unit of output, due to the greater productivity using the same number of workers
- Savings from the indirect labor, from reduced errors, rework, repairs and rejects

Disadvantages

- Limited ability to adapt to changes in product or product mix (ex. machines are of limited capacity and the tooling necessary for products, even of the same family, is not always feasible in a given FMS)
- Substantial pre-planning activity
- Expensive, costing millions of dollars
- Technological problems of exact component positioning and precise timing necessary to process a component
- Sophisticated manufacturing systems
- Personnel training cost is high

Comparison of Conventional and Flexible Manufacturing Systems

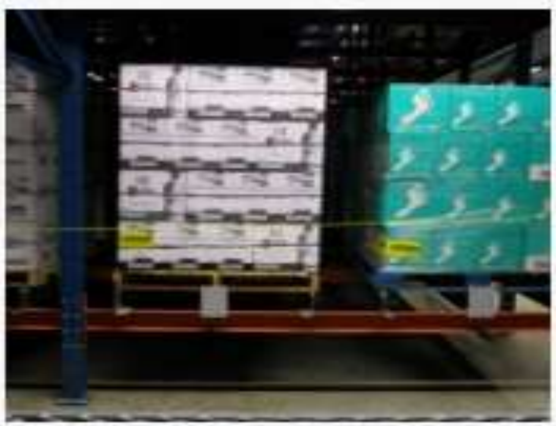
Particulars	FMS System	Conventional System
Flexibility	High	Low
Set-Up	Defined	Varies
Lead Time	Low	High
Engineering Changes	Easier	Equipment & Time constraints
Tooling and Fixcture	Flexible	Rigid
Production Control	Predictable	Unpredictable
Equipment Utilization	Optimized	Low
Scrap	Low	High
Labor	Low	High
WIP	Low	High
Quality	Controlled	Varies
Inspection	Automatic-tie-in	Doesn’t flow
Market Changes	Flexible	Rigid
Equipment Cost	High for short term	Low for Short term

AUTOMATED STORAGE AND RETRIEVAL SYSTEMS(ASRS)

Definition of AS / RS

Automated Storage and Retrieval Systems, commonly referred to as ASRSs, are automated inventory-handling systems desired to replace manual and remote- control handling systems. An automated storage/retrieval system (AS/RS) can be defined as a storage system that performs storage and retrieval operations with speed and accuracy under a defined degree of automation. A wide range of automation is found in commercially available AS/RS.

Automated Storage & Retrieval Systems Gallery:



Why AS/RS?

- Maximizing available storage space in existing structures, avoiding off-site storage and expansions
- Minimizing overall building footprint up to 50% versus conventional warehouses
- Reducing energy costs by 40% in cooler environments
- Reducing labor and product damage costs
- Increasing inventory accuracy and customer service

AS/RS Types

- **Unit load AS/RS:** The unit load AS/RS is typically a large automated system designed to handle unit loads stored on pallets or in other standard containers. The system is computer controlled, and the S/R machines are automated and designed to handle the unit load containers. The unit load system is the generic AS/RS. Other systems described below represent variations of the unit load AS/RS.

- **Deep -lane AS/RS:** The deep-lane AS/RS is a high-density unit load storage system that is appropriate when large quantities of stock are stored, but the number of separate stock types (SKUs) is relatively small. Instead of storing each unit load so that it can he accessed directly from the aisle (as in a conventional unit load system), the deep- lane system stores ten or more loads in a single rack, one load behind the next. Each rack is designed for “flow-through,” with input on one side and output on the other side. Loads are picked from one side of the rack by an S/R-type machine designed for retrieval, and another machine is used on the entry side of the rack for load input.

AS/RS Types

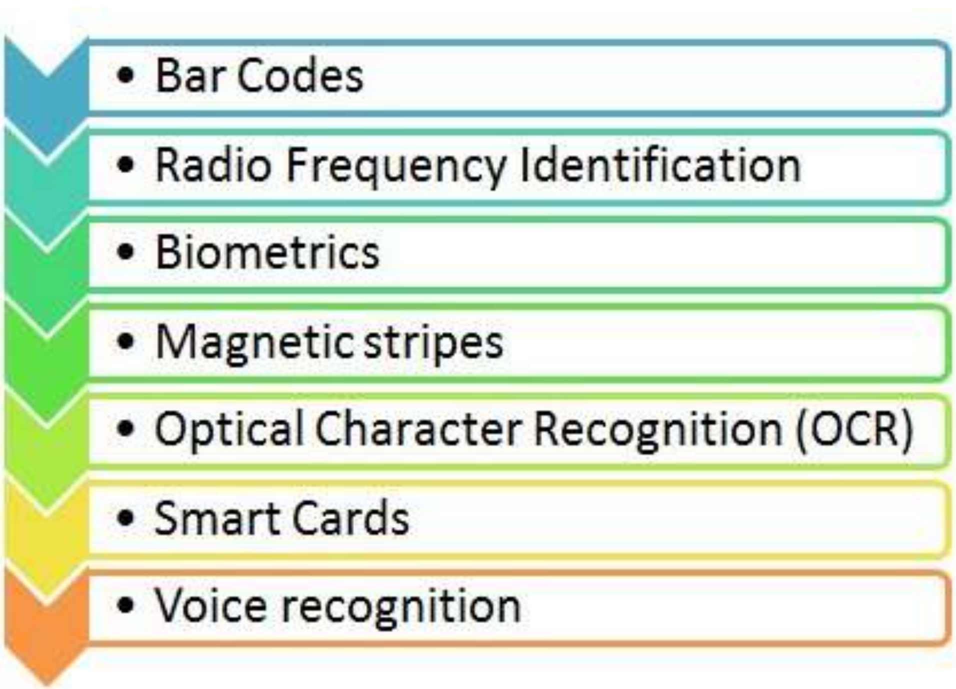
- **Mini load AS/RS:** This storage system is used to handle small loads (individual parts or supplies) that are contained in bins or drawers in the storage system. The S/R machine is designed to retrieve the bin and deliver it to a P&D station at the end of the aisle so that individual items can be withdrawn from the bins The P&D station is usually operated by a human worker. The bin or drawer must then be returned to location in the system. A miniload AS/RS system is generally smaller than a unit load AS/RS and is often enclosed for security of the items stored.
- **Man-on-board AS/RS:** A man-on-board (also called man-aboard) storage/retrieve system represents an alternative approach to the problem of retrieving individual items from storage. In this system, a human operator rides on the carriage of the S/R machine. Whereas the miniload system delivers an entire bin to the end-of-aisle pick station and must return it subsequently to its proper storage compartment, the man- on-board system permits individual items to be picked directly at their storage locations. This offers an opportunity to increase system throughput.

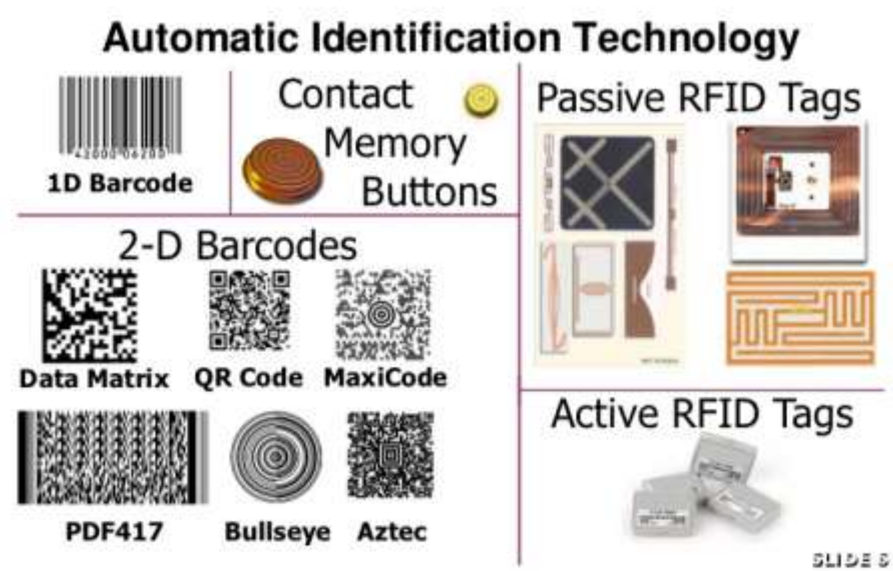
AS/RS Types

- **Automated item retrieval system:** These storage systems are also designed for retrieval of individual items or small product cartons; however, the items are stored in lanes rather than bins or drawers. When an item is retrieved, it is pushed from its lane and drops onto a conveyor for delivery to the pickup station. The operation is somewhat similar to a candy vending machine, except that an item retrieval system has more storage lanes and a conveyor to transport items to a central location. The supply of items in each lane is periodically replenished, usually from the rear of the system so that there is flow-through of items, thus permitting first-in/first-out inventory rotation.

Automatic identification and data capture (AIDC)

- Automatic identification and data capture (AIDC) refers to the methods of automatically identification objects, collecting data about them, and entering them directly into computer system, without human involvement.





Automatic identification and data capture (AIDC)

1. **Bar Code Scanning :**Bar coding is the most popular form of automatic identification as evidenced by supermarket check-out lanes and other retail business use. It is being applied more and more throughout the manufacturing process. With NC (FMS), bar codes are imprinted on paper or Mylar and fastened to the tool holder with adhesive or engraved in the tool. The control unit remembers the pocket where each unique coded tool was placed. Bar codes are made up of binary digits arranged so that the bars and spaces in different configurations represent numbers, letters, or other symbols, depending on the symbology used. Scanners that read bar codes contain a source of intense light produced by a laser or light-emitting diode and aimed at the pattern of black bars and spaces of varying widths. The black bars absorb the light, and the spaces reflect it back into the scanner. The scanner then transforms the patterns of light and dark into electrical impulses that are measured by a decoder and translated into binary digits for transmission to the computer.
2. **Machine Vision:** Machine vision is an imaging process involved with scanning and interpreting objects, documents, or labels. Although the imaging process itself is more complex than that of bar code scanning, the technology has potential for a large number of applications, many of which are FMS related. Applications would include character reading, sorting by shape or markings, locating defective parts, inspecting products, and positioning carts, parts, or pallets. Continued advances in machine vision technology and capabilities will make this method of automated identification more applicable for a variety of potential uses.

Automatic identification and data capture (AIDC)

3. **Radio Frequency Identification:** This form of automatic identification employs bidirectional radio signals as the encoding medium and is widely used to provide hands-free access control. Radio-frequency identification offers solutions to application problems in industrial automation and material handling where there is no line of direct sight between the scanner and the identification plate or tag.
4. **Optical Character Recognition:** Optical character recognition utilizes human readable letters and numerals, rather than the lines and bars of bar coding, that are scanned with a light source. When a particular pattern is recognized by the scanner, the data are converted to electronic impulses for transmission to the computer. Optical character recognition and bar code scanning have been combined to implement automation in the U.S. Postal Service.
5. **The Microchip:** Microchip identification employs the use of a microchip embedded in a sealed capsule that can be inserted in the object. This system uses a non-contact read-only head that can he attached to Object, tool changers, presetting fixtures, or tool grippers. Reading can occur at a distance of up to 0.080 inch, and the read time is less than 50 milliseconds, with an allowable 0.120 inch misalignment. The microchip can also be pro off-line with the tool identification and other dimensional data. The embedded microchip can he read by a proximity sensor to identify each tool. Although, read-write microchip identification systems exist, read-only is most appropriate in an FMS or host computer application.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