

## Flexible Manufacturing System

Unit-10

Def Flexible manufacturing system is a system dealing with group of machining stations (NC, CNC machine tools and automated material handling system using computer controlled machines).

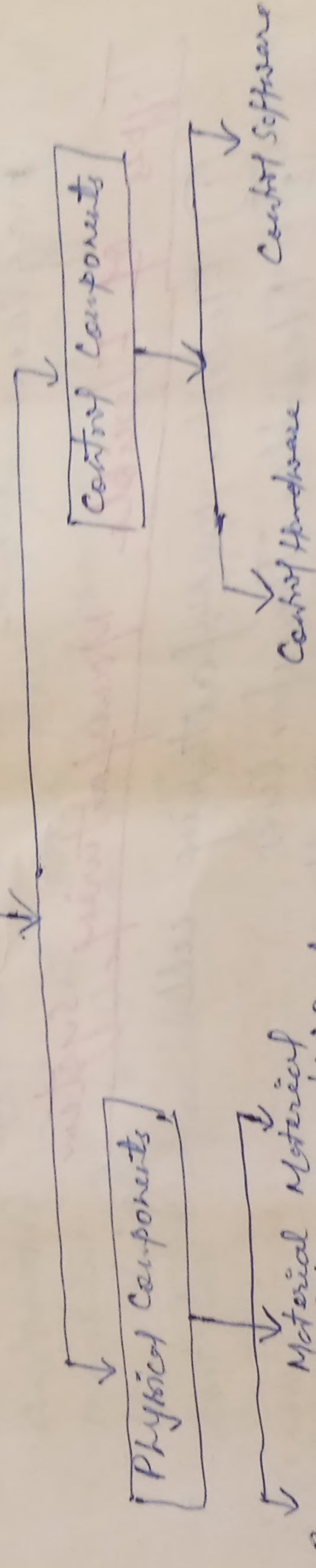
FMS is a group of CNC machine tools integrated with automated material handling system to process a variety of different types of parts at various workstations.

FMS consists of several machine tools along with part and tool handling devices such as industrial robots, inspection machines. It covers broad areas of manufacturing activities such as machining, fabricating, sheet metal, welding and assembly.

This Flexible manufacturing is a group of machines and related equipments brought together to process a group or family of parts completely.

### Components of FMS

FMS components



#### ① Physical components

##### ① Processing Stations

part families. These workstations are CNC machine tools, inspection equipments, assembly stations, head changers and loading/unloading area.

##### ② Material Handling System

It is used to move the material or parts from one machine to another machine and from machine to storage points.

These systems include automated guided vehicles (AGVs)

roller conveyor, tow line, Shuttle car, etc.

(iii) Material storage and retrieval systems: It is used to store and retrieve the work parts automatically. Various types of storage retrieval systems are pallets, carousels. It helps in convenient access of different types of parts from store and increase machine utilization.

(2) Control components: Its main functions are:

- (i) controls the working of each processing station.
- (ii) Distributes the control instructions to processing units.
- (iii) Monitors the status of handling system.
- (iv) Helps in traffic and shuttle control.
- (v) Performs the function of a system monitor.

Control components have two subparts.

(i) Control hardware. This includes the different types

of computers, programming logic controller (PLC), sensors, switch communication networks and some other devices.

(ii) Control software. It includes the set of files and programs used to control physical subsystems.

### Types of Flexible Manufacturing system

- 1 Flexible manufacturing cell
- 2 Flexible Transfer lines
- 3 Flexible Machining system

#### 1 Flexible Manufacturing cell

In this system, group of CNC machine tools are interconnected with AMH systems, Pallet changers and tool changers to manufacture some families of parts. AMH system could be a robot, automated guided vehicles etc. It has the following characteristics.

- (a) More flexible than FMS but having lower production rate.
- (b) Work parts are manufactured in a small batch.
- (c) It is a flexible machining system but without central control.

(d) Used when low/mid volume of parts and medium variety is required.

(2) Flexible transfer lines This is a high volume, low variety manufacturing system. It is a kind of fixed automation manufacturing system in which dedicated processing and material handling equipment is used. It consists of a special purpose machine, pallets, conveyors and dedicated equipment. In this each operation is assigned to and performs only one machine and resetting procedure is automatic. It has following characteristics

(a) There is a maximum machine utilization and high production volume.

(b) Less flexibility because of dedicated equipment.

(c) It minimizes the unit cost of production and

Direct labour involvement.

(3) Flexible Machining system It uses 6/8 transfer lines and flexible manufacturing cell. It consists of series of flexible automated machine tools, AMH system, and automated tool changers. These are interconnected to machine different work pieces at same time. It has the higher production rate than manufacturing cell but less flexible.

Flexible manufacturing system workstations

FMS workstation include following equipments/stations:

(a) Machining centres It offers greatest flexibility because they can perform different operations such as milling, turning, drilling, boring etc. These are capable of performing different machining operations on a workpiece in single setup.

(b) Milling and turning units There are specialised workstations which concentrate only on specific category of machinery such as milling units may be of vertical spindle type or horizontal spindle type.

In turning unit, single point cutting tool rotates around the work piece to turn it.

(C) Sheet metal stations. FMS is also extended to the sheet metal operations such as blanking, punching, shearing, bending etc.

(D) Assembly workstations — Industrial robots are used.

(E) Inspection stations — CMM (Coordinate measuring machines) are used to ensure that components are made as per specifications.

(F) Other workstations — Welding workstations and forging workstations.

### Material handling equipments

Major material handling equipments used in FMS are:

(I) Automated guided vehicles. These are AMH system powered by battery and can move and transfer material along defined paths. Guidance is achieved by sensors attached on the AGVs. The path or the route of AGVs can be easily changed or modified.

(II) Conveyor: This is an automated transport system to move workstations from one location to another location over a fixed path. It is limited to one directional flow of material.

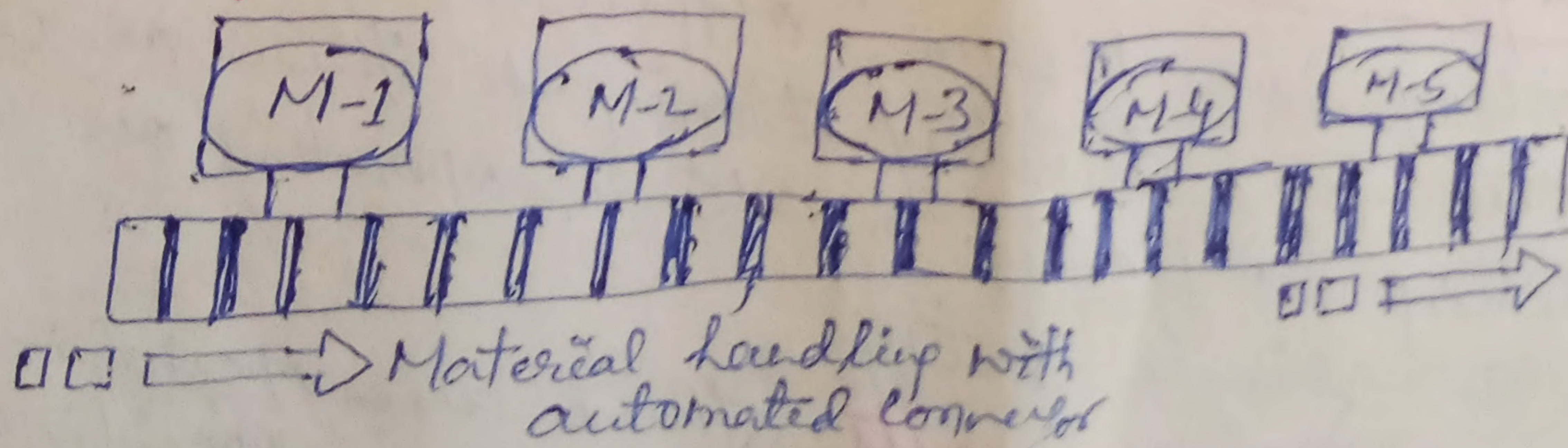
(III) Robots It is used for two functions.

(i) Material transfer

(ii) Machine Loading/Unloading

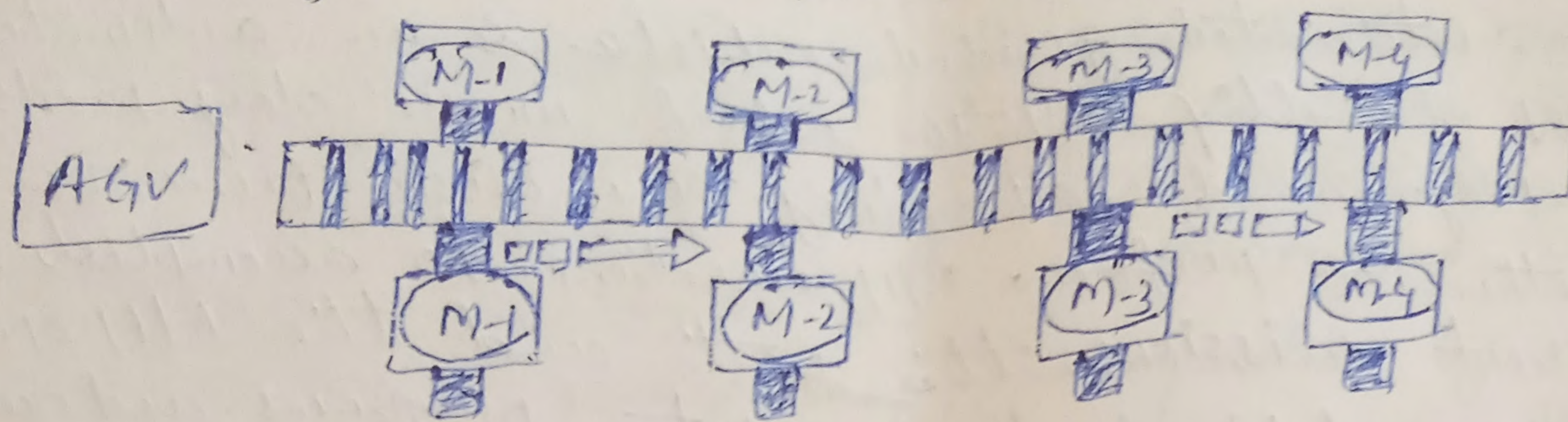
### FMS Layout

(1) Single and Double row machine layout



In this type of layout, material handling equipment moves in straight lines. AGVs are mostly used in such type of layout.

In double line layout, machines are arranged on both sides of guidance path. Here work flows in one direction only.

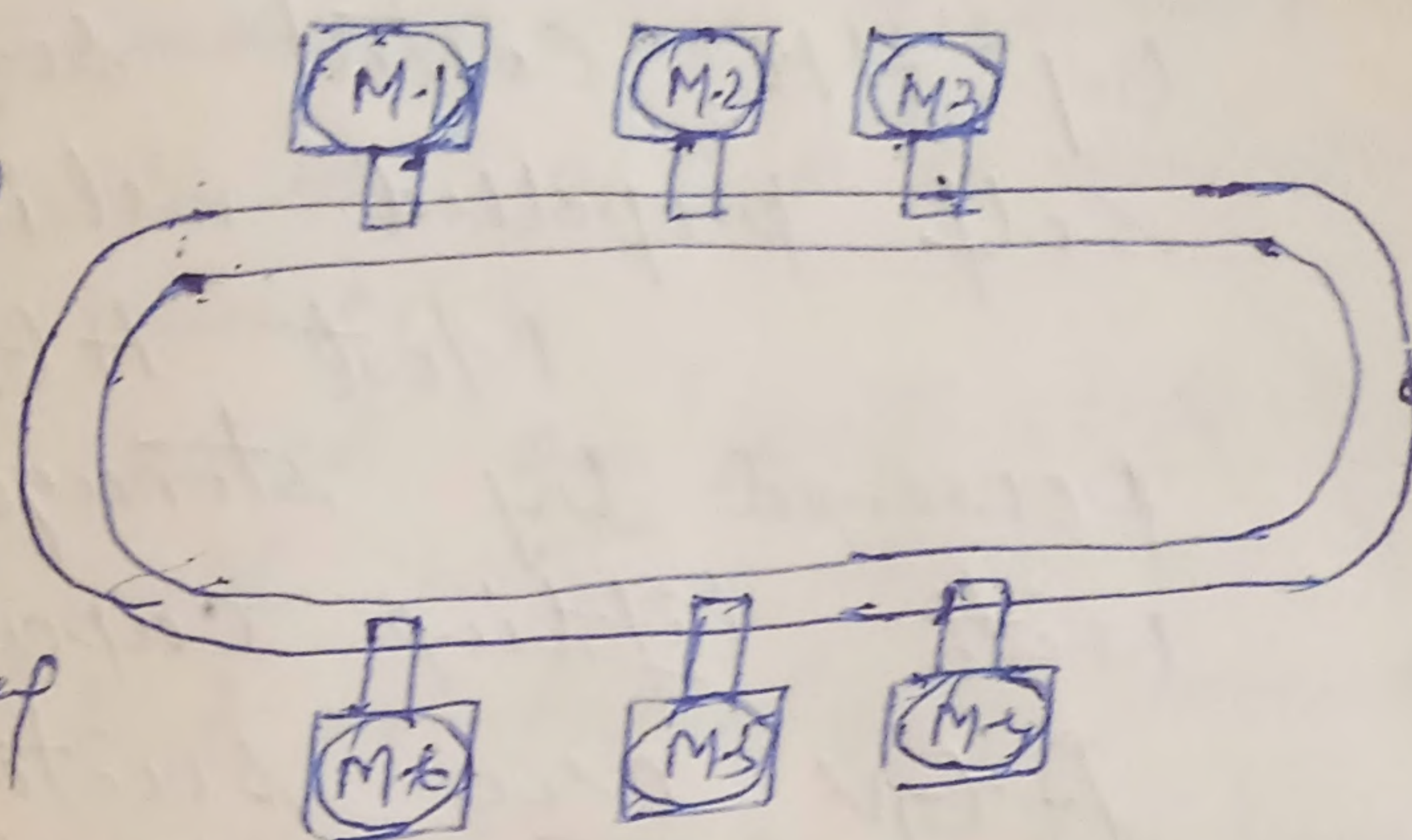


## ② Loop layout

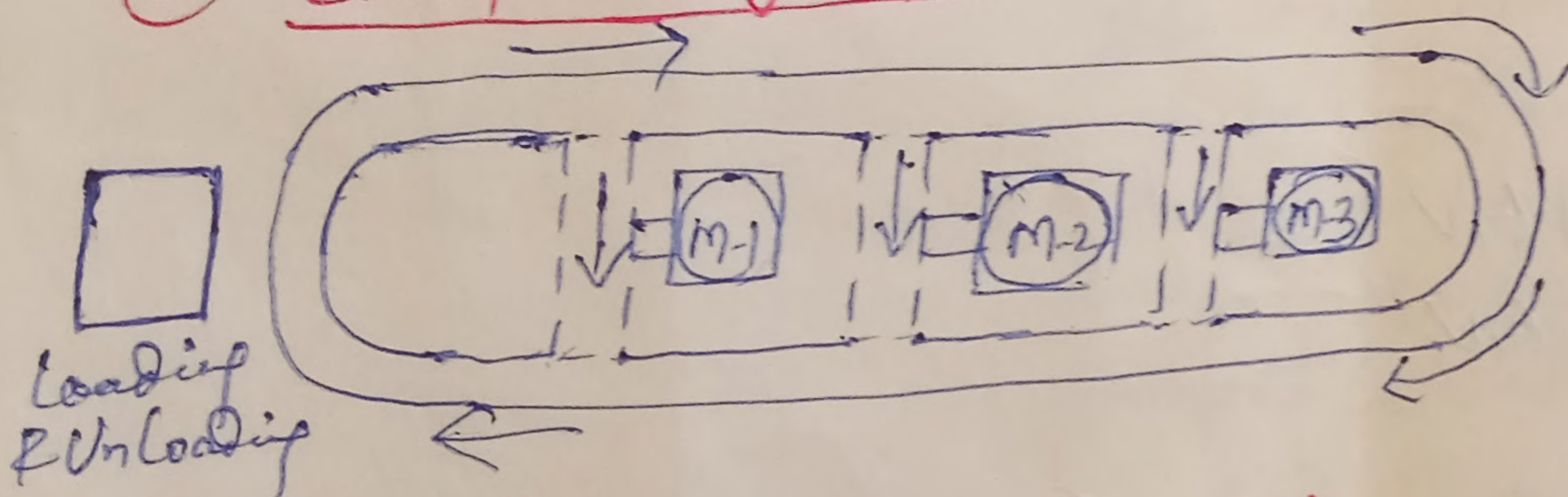
It allows only a unidirectional flow around the loop.

Parts flowing in the flow can be stopped loading or unloading at any workstation for smooth flow of parts.

Loading and unloading stations are provided at one end of the loop.



## ③ Ladder layout



These are provided for smooth flow of material and low traffic congestion. Main advantage of this type of layout is less travel distance and transfer time b/w workstations.

## ④ Circular machine layout

In this type of layout, machines are arranged in a circle. Industrial robot is used for material handling purposes.

## ⑤ Open field layout

It consists of loops, ladders and sidings organized to achieve desired processing requirements.

## Benefits of FMS

- ① It reduces the cost in production
- ② Reduces the work in process inventory.
- ③ Improves the productivity using the same number of workers/labour.
- ④ It brings the better utilization of machine and workers.
- ⑤ It helps to reduce manufacturing lead times.
- ⑥ Better utilization of machine and labour floor space.
- ⑦ It reduces the unit cost and labour requirements.
- ⑧ It reduces the material handling.

## Automated Guided Vehicles (AGVs)

An automated guided vehicle is an automated material handling system which moves along predefined or preprogrammed path along an aisle from one station to another to perform MH operations. To accomplish different missions, the path and the MH operations can be defined by computer programs and executed by the control software. These are self operated, self propelled vehicles.

Most AGV are driven by electric motors powered by storage batteries. They are also equipped with lifting capabilities for handling of materials. AGV are suitable for low-to-medium volume, and medium-to-long distance random material flow operations.

### Types of AGV

- (i) Tow AGV
- (ii) Unit load AGV
- (iii) Light load AGV
- (iv) Assembly AGV
- (v) Fork lift AGV

## Cellular Manufacturing System (CMS)

For the development of effective quality systems and automation, low volume is a major obstacle. When only a few parts will be produced, little capital is made available for purchasing automated systems and up-to-date test equipment. In addition, other benefits resulting from learning curves and quality feedback may not be possible. Long lead times, high levels of inventory and poor levels of quality usually result. Cellular manufacturing using the techniques of GT and FMS was developed to help solve these problems. Cellular manufacturing increases the apparent production volumes by grouping similar parts.

## Group Technology

It is a philosophy in which similar parts are identified and grouped together in order to take advantage of their similarities in design and production.

— Group technology in manufacturing, is the replacing of traditional jobbing shop manufacture by analysis and grouping of work into families and the information of groups of machines to manufacture these families on a flow-line principle with the object of minimizing setting times and throughout times.

— Group technology is based on 'product specialisation'. In this case each group of workers specialises in the production of a particular list or family of production and is equipped with all machines and equipment needed to complete these products.

— In group technology similar parts are arranged into part families. For example, a plant producing 1000 different part members may be able to group the vast majority of these parts into 40 or 50 distinct families. Each family would possess similar design and manufacturing characteristics. Hence the processing of each member of a given family would be similar and this results in manufacturing efficiencies. These efficiencies are achieved by arranging the production equipment into machine groups, or cells, to facilitate workflow.

### Part families

A part family or group is a collection of parts, which either because of geometric shape and size or because of similar processing steps are required in their manufacture. The parts within a family are different, but their similarities are close enough to merit their identification as members of the part family.

The biggest single obstacle in changing over to GT from a traditional production shop is the problem of grouping parts into families. There are three general methods for solving this problem.

- ① Visual Inspection
- ② Classification and coding by examination of designed production data
- ③ Production flow analysis (PFA).

## Benefits / advantages of GT

- ① Design -
  - (i) Reduction in number of drawings
  - (ii) Reduces time to identify the drawings
  - (iii) Easy modification of designs
- ② Production, Planning and Control -
  - (i) Reduction setup and production time
  - (ii) Improved machine loading
  - (iii) Reduction in work in process inventory
  - (iv) Simplified production scheduling
  - (v) Reduces manufacturing lead time
- ③ Layout -
  - (i) Reduces floor space required for production
  - (ii) Less material movements
  - (iii) Reduces change in set up
  - (iv) Standardization of tools and equipments
  - (v) Better utilization of tools and equipments
- ④ Quality control -
  - (i) Less number of defects and rejections
  - (ii) Better output quality
  - (iii) Leads to automated quality control system
- ⑤ Human Resource -
  - (i) Improved worker's attitude
  - (ii) Higher level of job satisfaction
  - (iii) Better management worker relationship

## Limitations of GT

① High cost of implementation.

② Rearranging or reorganising of machines is very difficult and time consuming.

③ Expense of parts classification and coding

GT machine cells - Groups of machines arranged to produce similar part families

- ① Single machine cell
- ② Group machine layout
- ③ Flow line design

## Production Flow analysis (PFA)

It is a method for identifying part families and associated grouping of machine tools.

It is used to eliminate all unnecessary routes or material flow paths, in order to find out the simplest material system.

In this method route sheet is used to find out the sequence of operations to be carried out on different machine tools.

## Dedicated manufacturing Systems (DMS)

The conception of mass production introduced by Henry Ford, contributes to development of DMS which generally appear in two forms.

- Continuous manufacturing system
- Intermittent manufacturing system

Continuous manufacturing system In this system the items are produced for the stocks and not for specific orders.

Before planning manufacturing to stock, a sale forecast is made to estimate likely demand of the product and a master schedule is prepared to adjust the sales forecast according to past orders and level of inventory.

In this system each production run manufactures in large lot sizes and the production production is carried on in a definite sequence of operations in a pre-determined order. Storage is not necessary and first in first out (FIFO) rules are followed in the system.

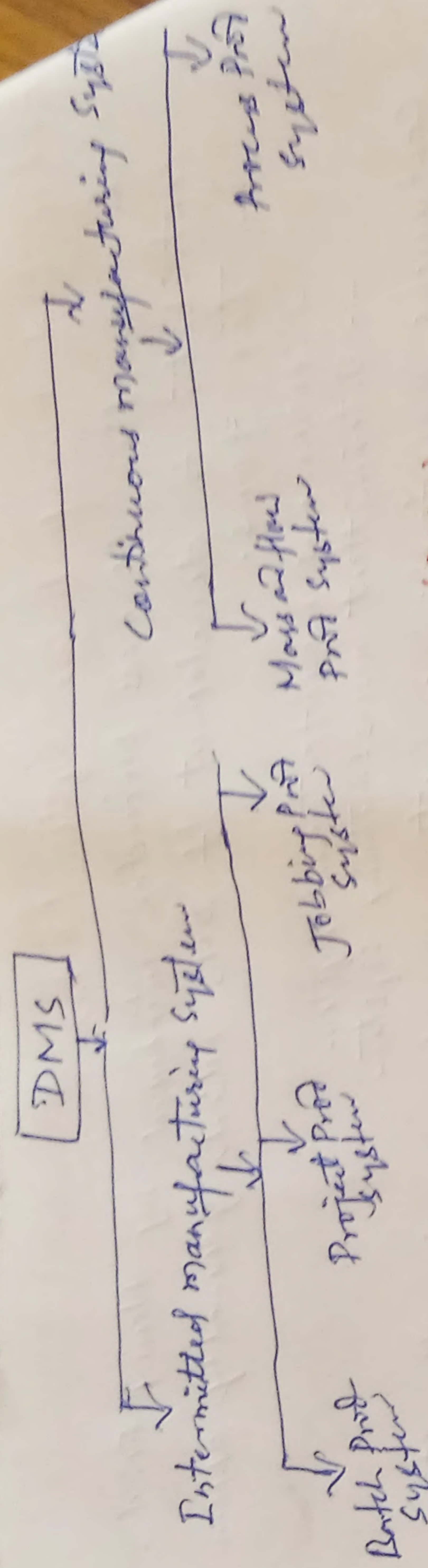
Chief Characteristics are:

- Routing standardized route and Schedule Sheets are prepared.
- Master route sheets are prepared for more effective co-ordination of various departments.
- Scheduling is required to rate the output of various standard products in their order of priority, operations and correct sequence to meet sales requirements.
- Dispatch Schedules can be prepared well in advance in such systems.

Intermittent manufacturing systems In this system goods are manufactured specially to fulfill orders made by customers rather than for stock. These can be used to manufacture those products where the basic nature of input changes with the change in the design of the product and the production process requires continuous adjustment. Considerable storage b/w operation is required.

Chief Characteristics are:

- Most products are produced in small quantities.
- Machines and equipment are laid out by process.
- Work loads are generally unbalanced.
- Highly skilled operators are required for efficient use of mechanical equip<sup>ment</sup>.
- In process inventory is large.
- Flexible to suit production varieties.



## Reconfigurable Manufacturing System (RMS)

The main goal of RMS is — Exactly the capacity and flexibility needed, exactly when needed.

A RMS having an adjustable structure is designed based upon market demand and can be readily changed from a fixed desire production capacity to second desired production capacity to manufacture a desired amount of product from a family of products.

In general, RMS are designed at the outset for rapid change in structure as well as in hardware or software components, in order to quickly adjust production capacity and functionality within a part family in response to sudden changes in market or regulatory requirements.

characteristics and principles of RMS

- ① Customization (Flexibility limited to part family) → System or machine flexibility limited to a single product family, thereby obtaining customized flexibility.
- ② Convertibility (Design for functionality changes) → The ability to easily transform the functionality of existing systems and machines to suit new production requirements.
- ③ Scalability (Design for capacity changes) → The ability to easily modify production capacity by adding or subtracting manufacturing resources (eg. machines) and/or changing components of the system.
- ④ Modularity (components are modules) → The compartmentalization of operational functions into units that can be recombined or alternate parts schemes for optional arrangement.
- ⑤ Integrability (interfaces for rapid integration) → The ability to integrate modules rapidly and precisely by a set of mechanical, informational and control interfaces that facilitate integration.
- ⑥ Diagnosability (Design for easy diagnostic) → The ability to automatically read the current state of a system to detect and diagnose the root cause of off-product defects, and quickly correct operational defects.

## Comparison of Different forms of manufacturing systems

|                                | DMS       | FMS        | RMS         |
|--------------------------------|-----------|------------|-------------|
| System Structure               | Fixed     | Changeable | Changeable  |
| Machine Structure              | Fixed     | Fixed      | Changeable  |
| System Focus                   | Part      | Machine    | Part family |
| Scalability                    | No        | Yes        | Yes         |
| Flexibility                    | No        | General    | Customized  |
| Simultaneously operating tools | Yes       | No         | Possible    |
| Productivity                   | Very high | Low        | High        |
| Cost per part                  | Low       | Reasonable | Medium      |
| Cost of Investment             | Average   | Very high  | High        |

## Cellular Manufacturing System (CMS)

The machine in a multi station system with variable routing may be operated manually, semi-automatic or fully automatic, when operated manually or semi-automatic, the machine groups are called machine cells and the use of these cells in a factory are called cellular manufacturing.

The concepts of GT can effectively be implemented in cellular manufacturing which consists of one or more manufacturing cells. A manufacturing cell is a small unit consisting of one or more workstations. A workstation typically contains either one machine (single-machine cell) or several machines (group-machine cell), each of which performs a different operation on the part. The machine can be modified, retooled and regrouped for different product lines within the same family of parts. Manufacturing cells are particularly effective in producing family of parts for which there is a constant demand.

Cellular manufacturing is used primarily in material removal and sheet metal forming operations and to a lesser extent in polymer processing involving injection or compression molding.

The machine tools commonly used in manufacturing cells are lathes, milling, drills, grinders, EDM and machine centres, and for sheet metal forming, they consist of shearing, punching, bending and other forming machines.

Cellular manufacturing has some degree of automatic control for the following typical operations:

- ① Loading and unloading of raw materials and workpieces at workstations.
- ② Changing of tools and dies at workstations.
- ③ Transfer of workpieces and tools to the workstations.
- ④ Scheduling and controlling of the total operation in the manufacturing cell.

Automated inspection and testing equipment also may be components of such a cell.