UNIT-IV FLEXIBLE MANUFACTURING SYSTEM

BY
V.KARTHIK, A/P MECH
DEPT MECHANICAL ENGINEERING
SNSCT

FMS (Flexible Manufacturing Systems)

- A flexible manufacturing system (FMS) is a highly automated GT(Group technology) 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. 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

TABLE 16.1 Types of Flexibility in Manufacturing. These Concepts of Flexibility Are Not Limited to Flexible Manufacturing Systems. They Apply to Both Manned and Automated Systems. Sources: [3], [7], [23], [26]

Flexibility Type	*Definition*	*Depends on Factors Such As:*
Machine flexibility	Capability to adapt a given machine (workstation) in the system to a wide range of production operations and part styles. The greater the range of operations and part styles, the greater the machine flexibility.	Setup or changeover time. Ease of machine reprogramming (ease with which part programs can be downloaded to machines). Tool storage capacity of machines. Skill and versatility of workers in the system.
Production flexibility	The range or universe of part styles that can be produced on the system.	Machine flexibility of individual stations. Range of machine flexibilities of all stations in the system.
Mix flexibility	Ability to change the product mix while maintaining the same total production quantity; that is, producing the same parts only in different proportions.	Similarity of parts in the mix. Relative work content times of parts produced. Machine flexibility.
Product flexibility	Ease with which design changes can be accommodated. Ease with which new products can be introduced.	How closely the new part design matches the existing part family. Off-line part program preparation. Machine flexibility.

Routing flexibility	Capacity to produce parts through alternative workstation sequences in response to equipment breakdowns, tool failures, and other interruptions at individual stations.	Similarity of parts in the mix. Similarity of workstations. Duplication of workstations. Cross-training of manual workers. Common tooling.
Volume flexibility	Ability to economically produce parts in high and low total quantities of production, given the fixed investment in the system.	Level of manual labor performing production. Amount invested in capital equipment.
Expansion flexibility	Ease with which the system can be expanded to increase total production quantities.	Expense of adding workstations. Ease with which layout can be expanded. Type of part handling system used. Ease with which properly trained workers can be added.

Flexible manufacturing systems can be distinguished according to the kinds of operations they perform:(l) processing operations or (2) assembly operations

Two other ways to classify FMSs are by: (1) number of machines and (2) level Of flexibility.

Types of FMS

- **TYPES OF FMS:**
- Flexible manufacturing systems can be divided into various types depending upon their features. They all are discussed below:

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.

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, co-ordinate measuring machines. These features significantly differentiate it from Flexible manufacturing cell (FMC).

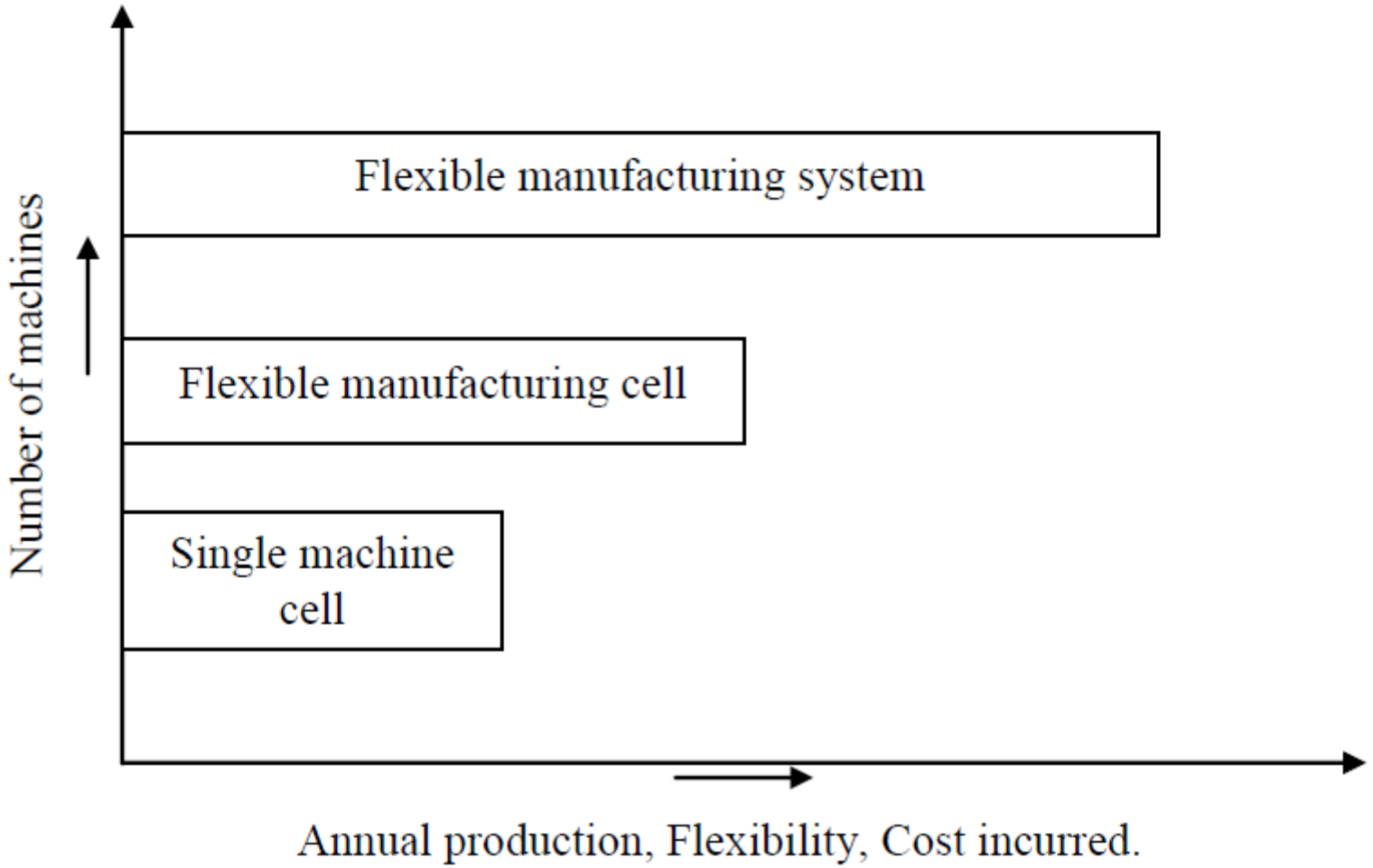

Figure 6.2 Comparison for three categories of FMS

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. Production rate annual volume

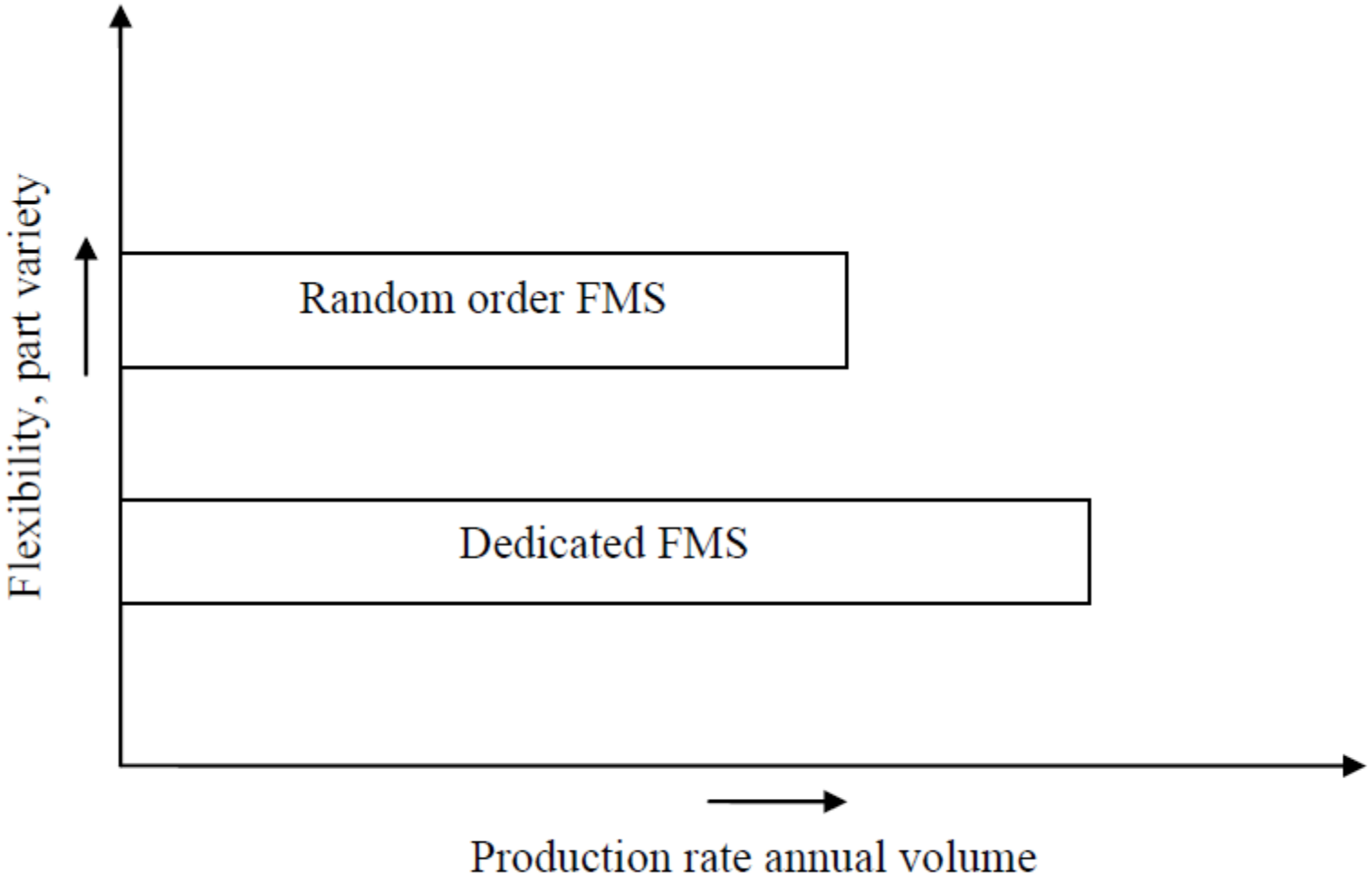

Figure 6.3 differences between dedicated and random-order FMS types

- As indicated in our definition, there are several basic components of an FMS. In the following segment, a framework for understanding the components of an FMS is presented. A flexible manufacturing system consists of two subsystems:
- Physical subsystem
- Control subsystem

- Physical subsystem includes the following elements:
- 1. **Workstations**. It consists of NC machines, machine-tools, inspection equipment's, loading and unloading operation, and machining area.
- **2. Storage-retrieval systems.** It acts as a buffer during WIP (work-in-processes) and holds devices such as carousels used to store parts temporarily between work stations or operations.
- **3. Material handling systems.** It consists of power vehicles, conveyers, automated guided vehicles (AGVs), and other systems to carry parts between workstations.

Control subsystem comprises of following elements:

- **1. Control hardware.** It consists of mini and micro computers, programmable logic controllers, communication networks, switching devices and others peripheral devices such as printers and mass storage memory equipment's to enhance the working capability of the FMS systems.
- **2. Control software.** It is a set of files and programs that are used to control the physical subsystems. The efficiency of FMS totally depends upon the compatibility of control hardware and control software.

FMS COMPONENTS

- As indicated in our definition there are several basic components of an FMS:
- (1) workstations,
- (2) material handling and storage system, and
- (3) computer control system. In addition, even though an FMS is highly automated,
- (4) people are required to manage and operate the system. We discuss these four FMS components in this section.

1.Workstations

The processing or assembly equipment used in an FMS depends on the type of work accomplished by the system. In a system designed for machining operations, the principle types of processing station are CNC machine tools. However, the FMS concept is also applicable to various other processes as well. Following are the types of workstations typically found in an FMS.

a. Load/Unload Stations. The load/unload station is the physical interface between the FMS and the rest of the factory. Raw work parts enter the system at this point, and finished parts exit the system from here. Loading and unloading can be accomplished either manually or by automated handling systems. Manual loading and unloading is prevalent in most FMSs today. The load/unload station should be ergonomically designed to permit convenient and safe movement of work parts. For parts that are too heavy to lift by the operator, mechanized cranes and other handling devices are installed to assist the operator.

b. machining Stations.

- The most common applications of FMSs arc machining operations, The workstations used in these systems are therefore predominantly CNC machine tools. Most common is the CNC machining center in particular. the horizontal machining center.
- CNC machining centers possess features that make them compatible with the FMS, including automatic tool changing and tool storage, use of palletized Work parts, CNC and capacity for distributed numerical control (DNC) Machining centers can be ordered with automatic pallet changers that can be readily interfaced with the FMS part handling system. Machining centers are generally used for non rotational parts. For rotational parts, turning centers are used; and for parts that are mostly rotational but require multitooth rotational cutters (milling and drilling), mill·turn centers can be used.
- *C. Other Processing* Stations. The FMS concept has been applied to other processing operations in addition to machining. One such application is sheet metal fabrication processes, reported in the processing workstations consist of press working operations, such as punching, shearing, and certain bending and forming processes. Also, flexible systems are being developed to automate the forging process. Forging is traditionally a very labor-intensive operation. The workstations in the system consist principally of a heating furnace, a forging press. and a trimming station.

d. Assembly. Some FMSs are designed to perform assembly operations. Flexible automated assembly systems are being developed to replace manual labor in the assembly of products typically made in batches. Industrial robots are often used as the automated workstations in these flexible assembly systems. They can be programmed to perform tasks with variations in sequence and motion pattern to accommodate the different product styles assembled in the system. Other examples of flexible assembly workstations are the programmable component placement machines widely used in electronics assembly.

Other Stations and Equipment. Inspection can be incorporated into an FMS, either by including, an inspection operation at a processing workstation or by including a station specifically designed for inspection. Coordinate measuring machines special inspection probes that can be used in a machine tool spindle and machine vision are three possible technologies for performing inspection on an FMS. Inspection has been found to be particularly important in flexible assembly systems to ensure that components have been properly added at the workstations.

2.Material Handling and Storage System

- The second major component of an FMS is its material handling and storage system. In this subsection, we discuss the functions of the handling system, material handling equipment typically used in an FMS, and types of FMS layout.
- Functions of the Handling System. The material handling and storage system in an FMS performs the following functions:
- Random, independent movement of work parts between stations. This means that parts must be capable of moving from anyone machine in the system to any other machine.to provide various routing alternatives for the different parts and to make machine substitutions when certain stations are busy.
- Handle a variety of work part configurations. For prismatic parts, this is usually accomplished by using modular pallet fixtures in the handling system. The fixture is located on the top face of the pallet and is designed to accommodate different part configurations by means of common components, quick-change features, and other devices that permit a rapid build-up of the fixture for a given part. The base of the pallet is designed for the material handling system. For rotational parts, industrial robots are often used to load and unload the turning machines and to move parts between stations.

Temporary storage. The number of parts in the FMS will typically exceed the number of parts actually being processed at any moment. Thus, each station has a small queue of parts waiting to be processed. which helps to increase machine utilization.

• *Convenient access for loading and unloading work part.* The handling system must
include locations for load/unload stations.

• *Compatible with computer control.* The handling system must be capable of being
controlled directly by the computer system to direct it to the various workstations,
load/unload stations, and storage areas

The primary handling system is sometimes supported by an automated storage system The FMS is integrated with an automated storage/retrieval system (AS/RS), and the S/R machine serves the work handling function for the workstations as well as delivering parts to and from the storage racks,

3.Computer Control System (refer book)page no 478

The FMS includes a distributed computer system that is interfaced to the work stations, material handling system, and other hardware components. A typical FMS computer system consists of a central computer and microcomputers controlling the individual machines and other components. The central computer coordinates the activities of the components to achieve smooth overall operation of the system. Functions performed by the FMS computer control system can be grouped into the following categories:

1.Workstation control.
2. Distribution of control instructions to workstations.
3. Production control.
4. Traffic control.
5. Shuttle control.
6. Work piece monitoring.
7. Tool control.
8.Performance monitoring and reporting.
9. Diagnostics.

4.Human Resources

One additional component in the FMS is human labor. Humans are needed to manage the operations of the FMS. Functions typically performed by humans include:

(1) loading raw Work parts into the system,
(2) Unloading finished parts (or assemblies) from the system.
(3) changing and setting tools.
(4) equipment maintenance and repair,
(5) NC part programming in a machining system,
(6) programming and operating the computer system, and
(7) overall management of the system