13.3 MANUFACTURING SYSTEMS

Manufacturing of products draws on different resources such as people, machinery and equipment. A manufacturing system can be defined as a combination of people, machinery and equipment which is constrained by material and information flow. Manufacturing systems can be classified into discrete part manufacturing and continuous process manufacturing. The former refers to manufacturing a product where the product undergoes a finite number of production or assembly operations. The latter refers to the production of a product that undergoes continuous changes such as chemical reactions which transform raw materials into final products. Here, we concern ourselves with discrete part manufacturing and, more specifically, the manufacturing of machined parts.

Manufacturing systems have undergone radical changes since the industrial revolutions began around the 1900s. These changes can be viewed as an outcome of customer demands for higher performance and yet less expensive products. Changes in materials and society combined with fierce competition have shortened product life expectancy. The general trend is that manufacturing systems are becoming more flexible, to adapt to rapid product changes and more automated to meet accuracy and cost requirements.

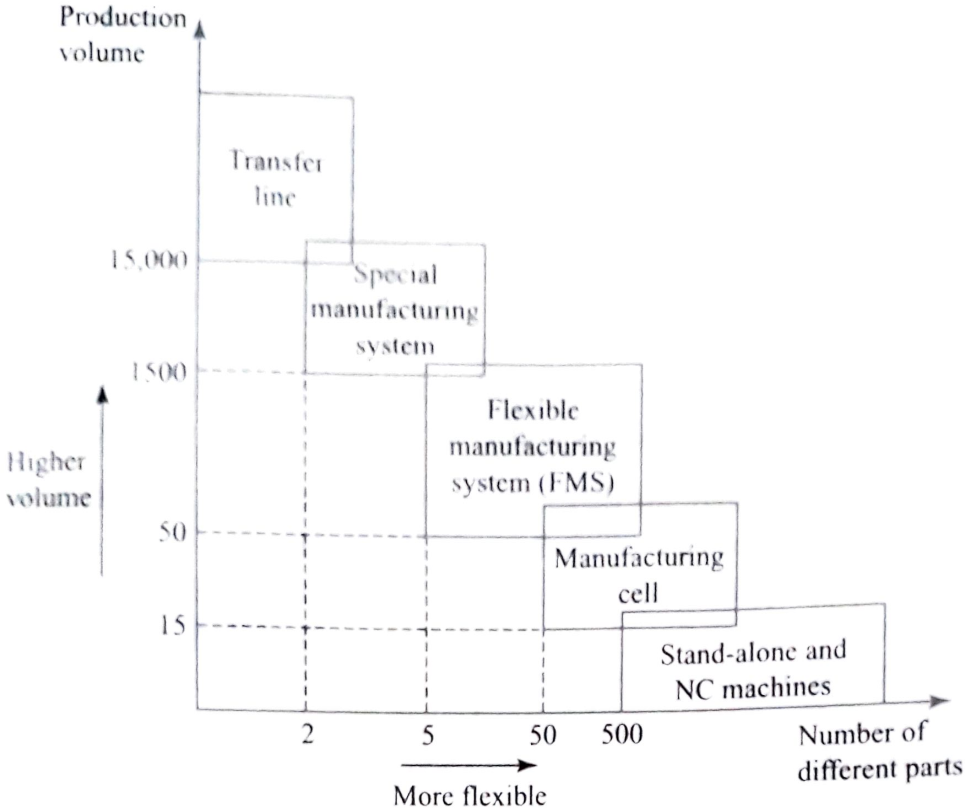

Fig. 13.2 *Types of Manufacturing Systems*

Manufacturing procedures vary from transfer line techniques for high-volume production to job shop procedures for low-volume items. Figure 13.2 classifies manufacturing systems into the following systems:

1. ***Transfer line*** This represents the oldest type of manufacturing systems. Transfer lines are very efficient for mass production (large volumes at a high output rate). They represent what is sometimes called hard automation. They are suitable for manufacturing identical parts. Thus, they are inflexible and cannot tolerate variations in part design. Any change in part design requires the line to shut down and be retooled. Moreover, if drastic changes in part design occur, the line becomes obsolete.

2. ***Special Manufacturing System*** This system together with the next two systems represent the various types of CIM (Computer Integrated Manufacturing) systems. This system is the least flexible while a manufacturing cell is the most flexible. The system is suitable to produce a very limited number of different parts and a medium production rate per part. The system is configured in a similar way to transfer lines; thus only limited changes in the system are possible.

3. ***Flexible Manufacturing System (FMS)*** A mid-volume, mid-variety production range is covered by this system. Most of the system activities and coordination are done automatically under computer control. Work parts are automatically loaded at central locations on to the handling system (pallets) and are routed to the proper machine tools. The computer job in an FMS includes the control of machine tools and the material handling system, monitoring the performance of the system and scheduling production. FMSs are not totally under computer control. Humans and human

labor are needed to set up machine tools for production, that is, load and unload workparts, prepare and change tools and perform initial settings of machine tools.

4. ***Manufacturing Cell*** This is the most flexible CIM system. It has the lowest production rate of the three types (systems 2, 3 and 4 presented here). A manufacturing cell typically contains many stand-alone machine tools and robots.

5. ***Stand-alone and NC Machines*** These machines are highly flexible. Their production rates are too slow due to tool setting-up time and tool changes. They are highly programmable and can deal with product changeovers and part design changes. They are appropriate for job shop and small batch manufacturing.

It is important to mention that although flexibility and automation are desired characteristics of manufacturing systems, these systems must be carefully designed to handle the expected production volume from them on a continuous basis. If a system is designed to handle a given production volume that is higher than the expected market projections or consumer needs, the system would have to stay idle for certain periods of time. Therefore, productivity gains during the operation of the system is lost by its periods of shutdown.