CHAPTER 3

MANUFACTURING SYSTEMS AND PROCESSES

3.1 INTRODUCTION

The word “Manufacturing” is derived from the Latin *manu factus*, meaning made by hand. In modern sense, manufacturing involves making products from raw materials by means of various processes, machineries and operations, through a well-organized plan of activities. In general, it encompasses the design of the product, selection of raw materials and the sequence of processes through which the product will be manufactured. In early times, manufacturing was carried out by an individual artisan who created a product for the specific purpose. The attributes were tailored to meet the needs of the user. But, the modern manufacturing system is a complex arrangement, which consists of engineers, manufacturers and end users. The product is delivered to population whose expectations and needs are subject to frequent change. The old way of doing business by treating markets and competition as local is no longer adequate. A manufacturer who is unwilling or incapable of adjusting to the new competitive environment is unlikely to survive. To serve in the competitive environment, an aggressive and effective program of continuing improvement involving all parts of the manufacturing enterprise must be established. A large part of the difficulty lies in the fact that a manufacturing is a very complex system comprising a large number of complex and interdependent subsystems. Only a limited amount of work has been done to understand the problems of managing the totality of the
manufacturing system and to identify the degree and nature of the interrelationship of the systems.

This research work focuses on the manufacturing system as an entity. It explores principles that have been demonstrated as generic to improve the effectiveness of the manufacturing system. Manufacturing system, which receives inputs from the outside world, uses a set of resources to respond on those inputs (product and service concepts, orders, materials and energy) and transforms materials or components into a useful form that is needed to customer. The manufacturing system might be viewed as a collection of transformation subsystems that must be properly integrated. These might include the materials transformation subsystem; the customer needs transformation subsystem, the knowledge learning and improvement subsystem, and organization subsystem. The changes in the manufacturing technology are inevitable. Instead of resisting these changes, as we have tended to do in the past, we must find ways to take advantage of them. We must investigate those technologies that can operate effectively in a changing environment. The ability to apply trial and error learning to tune the performance of manufacturing systems becomes almost useless in an environment in which change occurs faster than the lessons learnt. There is now a greater need for formal predictive methodology based on the understanding of cause and effect. Of course, a good deal of such methodology already exists, but the practices of industries tend to place greater reliance on experience-based knowledge than theory based knowledge. This difference is due to the failure of experts to formalize the analytical tools that are available.

World-class manufacturers will be recognized by the leadership they provide in attacking and resolving complex customer problems. World-
class manufacturers must be in a position to offer their customers with some over all set of product attributes equal to or better than those of any other manufacturer in the world. Excelling in any single area, such as cost is never sufficient to guarantee world-class status. A manufacturer must be prepared to excel simultaneously in many ways, such as cost, quality, flexibility, service and fast response to customer demand. In order to excel simultaneously in many areas, a multiple objective analysis is required for the considered manufacturing system/process/product. It is also must to understand the system completely to act upon it.

3.2 MANUFACTURING SYSTEM

Manufacturing is the backbone of any industrialized nation and it comprises 30% of the value of all goods and services produced. Manufacturing System is defined as a collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material part or set of parts.

![Figure 3.1 Components of a manufacturing system](image)

Figure 3.1 Components of a manufacturing system

A Manufacturing system consists of several components. Components of manufacturing systems are input, process and output, which are shown in figure 3.1.
a. Input

Customer demand, Material, Money, Energy, Human Resources and Education are considered as the input for the manufacturing system. In this, customer demand serves as the stimulant to encourage business to provide products. The Materials, which are minerals of nature such as coal, ores, hydrocarbons and many more, are converted into products. Money is used to buy materials, machines and pay salary to employees. Energy is important in manufacturing and it exists in many different forms such as electricity, compressed air, steam or coal.

b. Processes

Process is the next step of the manufacturing system. It includes design, production and management. Management provides planning, organization, direction control and leadership of the business enterprise to make it productive and profitable. The designing of elements is creating plans for products, so that the product is attractive and provide better service at low cost. The third element is production. It is the best combination of men, machines, and management to accomplish the objectives of the firm, shareholders, employee and customer.

c. Output

The output of the manufacturing system is a product. Classes of goods (products) can be divided into consumer goods or capital goods. Consumer goods are the products purchased by the people for their personal use, such as food, cars, etc. Capital goods are products purchased by the firms to make consumer goods. Machine tools, robots and plants are examples of capital goods.
The manufacturing system also includes
i. Production machines plus tools, fixtures and other related hardware
ii. Material handling system
iii. Computer control system to coordinate and/or control the above components
iv. Human workers

i. Production machines can be classified as: 1. Manually operated 2. Semi automated and 3. Fully automated. Manually operated machines are supervised by human workers. The machine provides the power for the operation and the worker provides the control. A semi-automated machine performs a portion of the work cycle under some form of program control and the remaining work cycle like loading and unloading the work will be performed by the human worker. A fully automated machine is capable of performing all the operations of the work cycle without human intervention.

ii. Material handling system is the system, which transforms raw material, tool, and product from one place to another place. Most of the processing and assembly operations performed on discrete parts and products require the following functions: 1. loading and unloading of work units, 2. positioning the work units at each station and 3. transporting work unit between stations. These functions are accomplished by material handling system. Most of the material handling systems used in production also provides a temporary storage function.

iii. Computer control system is required to control the automated and semi automated equipment and to participate in the overall coordination and management of the manufacturing system. Even in completely manual
assembly line, a computer system is useful to support production. The functions of the computer control system include the following:

- Communicate instruction to workers
- Download part programmes to computer controlled machines
- Material handling system control
- Schedule production
- Failure diagnosis
- Safety monitoring
- Quality control
- Operations management

iv. In manufacturing systems, human operator performs some or all the value added activities that are accomplished on the parts or the products. In these cases, human workers are referred to as direct labors. Human workers are also needed to manufacturing systems as part programmer, and computer operators for CNC machine tool, and repair and maintenance personnel and they are referred as indirect labor.

### 3.2.1 Classification of manufacturing systems

Manufacturing systems are classified based on the factors that define and distinguish the different types. The factors are: 1. Types of operations performed, 2. No. of workstations and system layout, 3. Level of automation, and 4. Part or product variety.

1. **According to the types of operations performed**

   Manufacturing systems are distinguished by the types of operations they perform. They are 1. Processing operations on individual work units and 2. Assembly operation to combine individual parts into assembled entities.
2. According to the number of workstations and system layout

According to the number of stations and the layout of the stations, the manufacturing systems are classified as

Type 1. Single station

This is the simplest case consisting of one workstation usually including a production machine that can be manually operated, semi automated or fully automated.

Type 2. Multiple stations with variable routing

This manufacturing system consists of two or more stations that are designed to accommodate the processing stations and the assembly stations for different parts or product models.

Type 3. Multiple stations with fixed routing

This system has two or more workstations, which are laid out as a production line.

3. According to the level of automation

The level of automation is another factor that characterizes the manufacturing system. The work stations in the manufacturing system can be manually automated, semi automated or automated.

4. According to the part or product variety

If a single item is produced in huge volume, the system is called as mass production system. If the product is small in volume, the system is called as batch production system.
3.3 MANUFACTURING PROCESS

A manufacturing process is defined as one or more physical mechanisms to transform the material’s shape and/or form and/or properties. Manufacturing processes can be further divided into discrete parts processes and continuous processes. The metal working industry, where many single items are produced, uses discrete parts manufacturing. Chemical processing, used, for example, in the film or fiber-making industries, uses continuous processing.

3.3.1 Classifications and characteristics of the manufacturing processes

Manufacturing processes can be classified into five major categories:

1. Forming or primary forming processes

   Processes in which an original shape is created from a molten or gaseous state, or from solid particles of an undefined shape. During primary forming processes, cohesion is normally created among the particles.

2. Deforming processes

   Processes that convert the original shape of a solid to another shape without changing its mass or material composition. During this process, cohesion is maintained among the particles.

3. Removing processes

   Processes during which the material removal occurs; cohesion between the particles is destroyed.
4. Joining processes

Processes that unite individual work pieces to make subassemblies or final products. These include additive processes, such as filling and impregnating of work pieces; cohesion among the particles is increased.

5. Material properties modification processes

Processes that purposely change the material properties of a work piece in order to achieve desirable characteristics without changing its shape.

These categories are applied to a variety of engineering materials, which can be classified into metals, ceramics, polymers and composites. Some of the basic characteristics of the manufacturing processes such as cost, production rate, quality and flexibility are given in the following table 3.1.

<table>
<thead>
<tr>
<th>Manufacturing process</th>
<th>Cost</th>
<th>Production rate</th>
<th>Quality</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forming</td>
<td>High tooling cost/Low labor cost</td>
<td>High</td>
<td>Medium to Low</td>
<td>Low</td>
</tr>
<tr>
<td>Deforming</td>
<td>High tooling cost/Low labor cost</td>
<td>High</td>
<td>Medium to Low</td>
<td>Low</td>
</tr>
<tr>
<td>Removing</td>
<td>Medium tooling cost/High labor cost</td>
<td>Medium (milling) to Low (grinding)</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Removing</td>
<td>Low capital cost/High labor cost</td>
<td>Medium (welding) To Low (adhesives)</td>
<td>Medium to Low</td>
<td>High</td>
</tr>
<tr>
<td>Modifying</td>
<td>Medium to high capital cost /low labor cost</td>
<td>Low</td>
<td>High</td>
<td>Medium to High</td>
</tr>
</tbody>
</table>