

ME-6703-Computer Integrated Manufacturing

Unit-I

1.1 INTRODUCTION

Computer Integrated Manufacturing (CIM) encompasses the entire range of product development and manufacturing activities with all the functions being carried out with the help of dedicated software packages. The data required for various functions are passed from one application software to another in a seamless manner. For example, the product data is created during design. This data has to be transferred from the modeling software to manufacturing software without any loss of data. CIM uses a common database wherever feasible and communication technologies to integrate design, manufacturing and associated business functions that combine the automated segments of a factory or a manufacturing facility. CIM reduces the human component of manufacturing and thereby relieves the process of its slow, expensive and error-prone component. CIM stands for a holistic and methodological approach to the activities of the manufacturing enterprise in order to achieve vast improvement in its performance.

This methodological approach is applied to all activities from the design of the product to customer support in an integrated way, using various methods, means and techniques in order to achieve production improvement, cost reduction, fulfillment of scheduled delivery dates, quality improvement and total flexibility in the manufacturing system. CIM requires all those associated with a company to involve totally in the process of product development and manufacture. In such a holistic approach, economic, social and human aspects have the same importance as technical aspects.

CIM also encompasses the whole lot of enabling technologies including total quality management, business process reengineering, concurrent engineering, workflow automation, enterprise resource planning and flexible manufacturing.

A distinct feature of manufacturing today is mass customization. This implies that though the products are manufactured in large quantities, products must incorporate customer-specific changes to satisfy the diverse requirements of the customers. This requires extremely high flexibility in the manufacturing system.

The challenge before the manufacturing engineers is illustrated in Fig. 1.1.

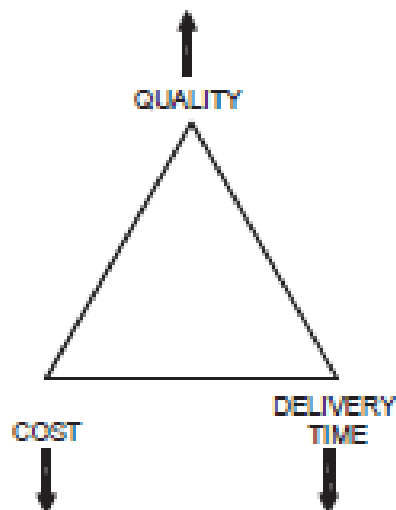


Fig.1.1 Challenges in Manufacturing

Manufacturing industries strive to reduce the cost of the product continuously to remain competitive in the face of global competition. In addition, there is the need to improve the quality and performance levels on a continuing basis. Another important requirement is on time delivery. In the context of global outsourcing and long supply chains cutting across several international borders, the task of continuously reducing delivery times is really an arduous task. CIM has several software tools to address the above needs.

Manufacturing engineers are required to achieve the following objectives to be competitive in a global context.

- Reduction in inventory
- Lower the cost of the product
- Reduce waste
- Improve quality
- Increase flexibility in manufacturing to achieve immediate and rapid response to:
 - Product changes
 - Production changes
 - Process change
 - Equipment change
 - Change of personnel

CIM technology is an enabling technology to meet the above challenges to the manufacturing

The advances in automation have enabled industries to develop islands of automation. Examples are flexible manufacturing cells, robotized work cells, flexible inspection cells etc. One of the objectives of CIM is to achieve the consolidation and integration of these islands of automation. This requires sharing of information among different applications or sections of a factory, accessing incompatible and heterogeneous data and devices. The ultimate objective is to meet the competition by improved customer satisfaction through reduction in cost, improvement in quality and reduction in product development time.

CIM makes full use of the capabilities of the digital computer to improve manufacturing. Two of them are:

- i. Variable and Programmable automation
- ii. Real time optimization

The computer has the capability to accomplish the above for hardware components of manufacturing (the manufacturing machinery and equipment) and software component of manufacturing (the application software, the information flow, database and so on).

The capabilities of the computer are thus exploited not only for the various bits and pieces of manufacturing activity but also for the entire system of manufacturing. Computers have the tremendous potential needed to integrate the entire manufacturing system and thereby evolve the computer integrated manufacturing system.

1.2 TYPES OF MANUFACTURING

The term “manufacturing” covers a broad spectrum of activities. Metal working industries, process industries like chemical plants, oil refineries, food processing industries, electronic industries making microelectronic components, printed circuit boards, computers and entertainment electronic products etc. are examples of manufacturing industries. Manufacturing involves fabrication, assembly and testing in a majority of situations. However, in process industries operations are of a different nature.

Manufacturing industries can be grouped into four categories:

i. Continuous Process Industries

In this type of industry, the production process generally follows a specific sequence. These industries can be easily automated and computers are widely used for process monitoring, control and optimization. Oil refineries, chemical plants, food processing industries, etc are examples of continuous process industries.

ii. Mass Production Industries

Industries manufacturing fasteners (nuts, bolts etc.), integrated chips, automobiles, entertainment electronic products, bicycles, bearings etc. which are all mass produced can be classified as mass production industries. Production lines are especially designed and optimized to ensure automatic and cost effective operation. Automation can be either fixed type or flexible.

iii. Batch Production (Discrete Manufacturing)

The largest percentage of manufacturing industries can be classified as batch production industries. The distinguishing features of this type of manufacture are the small to medium size of the batch, and varieties of such products to be taken up in a single shop. Due to the variety of components handled, work centers should have broader specifications. Another important fact is that small batch size involves loss of production time associated with product changeover

1.3 NATURE AND ROLE OF THE ELEMENTS OF CIM SYSTEM

Nine major elements of a CIM system are in Fig 1.2. They are:

- Marketing
- Product Design
- Planning
- Purchase
- Manufacturing Engineering
- Factory Automation Hardware
- Warehousing
- Logistics and Supply Chain Management
- Finance
- Information Management



Fig.1.2 Major Elements of a CIM System

i. Marketing: The need for a product is identified by the marketing division. The specifications of the product, the projection of manufacturing quantities and the strategy for marketing the

product are also decided by the marketing department. Marketing also works out the manufacturing costs to assess the economic viability of the product.

ii. Product Design: The design department of the company establishes the initial database for production of a proposed product. In a CIM system this is accomplished through activities such as geometric modeling and computer aided design while considering the product requirements and concepts generated by the creativity of the design engineer. Configuration management is an important activity in many designs. Complex designs are usually carried out by several teams working simultaneously, located often in different parts of the world. The design process is constrained by the costs that will be incurred in actual production and by the capabilities of the available production equipment and processes. The design process creates the database required to manufacture the part.

iii. Planning: The planning department takes the database established by the design department and enriches it with production data and information to produce a plan for the production of the product. Planning involves several subsystems dealing with materials, facility, process, tools, manpower, capacity, scheduling, outsourcing, assembly, inspection, logistics etc. In a CIM system, this planning process should be constrained by the production costs and by the production equipment and process capability, in order to generate an optimized plan.

iv. Purchase: The purchase department is responsible for placing the purchase orders and follow up, ensure quality in the production process of the vendor, receive the items, arrange for inspection and supply the items to the stores or arrange timely delivery depending on the production schedule for eventual supply to manufacture and assembly.

v. Manufacturing Engineering: Manufacturing Engineering is the activity of carrying out the production of the product, involving further enrichment of the database with performance data and information about the production equipment and processes. In CIM, this requires activities like CNC programming, simulation and computer aided scheduling of the production activity. This should include online dynamic scheduling and control based on the real time performance of the equipment and processes to assure continuous production activity. Often, the need to meet fluctuating market demand requires the manufacturing system flexible and agile.

vi. Factory Automation Hardware: Factory automation equipment further enriches the database with equipment and process data, resident either in the operator or the equipment to carry out the production process. In CIM system this consists of computer controlled process machinery such as CNC machine tools, flexible manufacturing systems (FMS), Computer controlled robots, material handling systems, computer controlled assembly systems, flexibly automated inspection systems and so on.

vii. Warehousing: Warehousing is the function involving storage and retrieval of raw materials, components, finished goods as well as shipment of items. In today's complex outsourcing scenario and the need for just-in-time supply of components and subsystems, logistics and supply chain management assume great importance.

viii. Finance: Finance deals with the resources pertaining to money. Planning of investment, working capital, and cash flow control, realization of receipts, accounting and allocation of funds are the major tasks of the finance departments.

1.4 CONCURRENT ENGINEERING

Concurrent engineering or Simultaneous Engineering is a methodology of restructuring the product development activity in a manufacturing organization using a crossfunctional team approach and is a technique adopted to improve the efficiency of product design and reduce the product development cycle time. This is also sometimes referred to as

Parallel Engineering. Concurrent Engineering brings together a wide spectrum of people from several functional areas in the design and manufacture of a product. Representatives from R & D, engineering, manufacturing, materials management, quality assurance, marketing etc. develop the product as a team. Everyone interacts with each other from the start, and they perform their tasks in parallel. The team reviews the design from the point of view of marketing, process, tool design and procurement, operation, facility and capacity planning, design for manufacturability, assembly, testing and maintenance, standardization, procurement of components and sub-assemblies, quality assurance etc as the design is evolved. Even the vendor development department is associated with the prototype development. Any possible bottleneck in the development process is thoroughly studied and rectified. All the departments get a chance to review the design and identify delays and difficulties.

The departments can start their own processes simultaneously. For example, the tool design, procurement of material and machinery and recruitment and training of manpower which contributes to considerable delay can be taken up simultaneously as the design development is in progress. Issues are debated thoroughly and conflicts are resolved amicably.

Concurrent Engineering (CE) gives marketing and other groups the opportunity to review the design during the modeling, prototyping and soft tooling phases of development. CAD systems especially 3D modelers can play an important role in early product development phases. In fact, they can become the core of the CE. They offer a visual check when design changes cost the least. Intensive teamwork between product development, production planning and manufacturing is essential for satisfactory implementation of concurrent engineering. The teamwork also brings additional advantages; the co-operation between various specialists and systematic application of special methods such as QFD (Quality Function Deployment), DFMA (Design for Manufacture and Assembly) and FMEA (Failure Mode and Effect Analysis) ensures quick optimization of design and early detection of possible faults in product and production planning. This additionally leads to reduction in lead time which reduces cost of production and guarantees better quality.

1.5 INTRODUCTION TO AUTOMATION

What is automation?

It is a technology dealing with the application of

- mechatronics
- computers

for production of goods and services.

Automation is broadly classified into

- manufacturing automation
- service automation

We will be primarily concerned with manufacturing automation and therefore with the production of goods.

Examples of manufacturing automation include:

- automatic machine tools to process parts
- automatic assembly machines
- industrial robots
- automatic material handling
- automated storage and retrieval systems
- automatic inspection systems
- feedback control systems

- computer systems for designing products and for analyzing them
- computer systems for automatically transforming designs into parts
- computer systems for planning and decision making to support manufacturing

2. Types of automation

Fixed automation

Fixed automation refers to the use of custom-engineered (special purpose) equipment to automate a fixed sequence of processing or assembly operations. It is typically associated with high production rates and it is relatively difficult to accommodate changes in the product design. This is also called hard automation. For example, GE manufactures approximately 2 billion light bulbs per year and uses fairly specialized, high-speed automation equipment. This kind of automation dates back to WWI when the first mechanized assembly lines were used. Fixed automation makes sense only when product designs are stable and product life cycles are long. The primary drawbacks are the large initial investment in equipment and the relative inflexibility.

Programmable automation

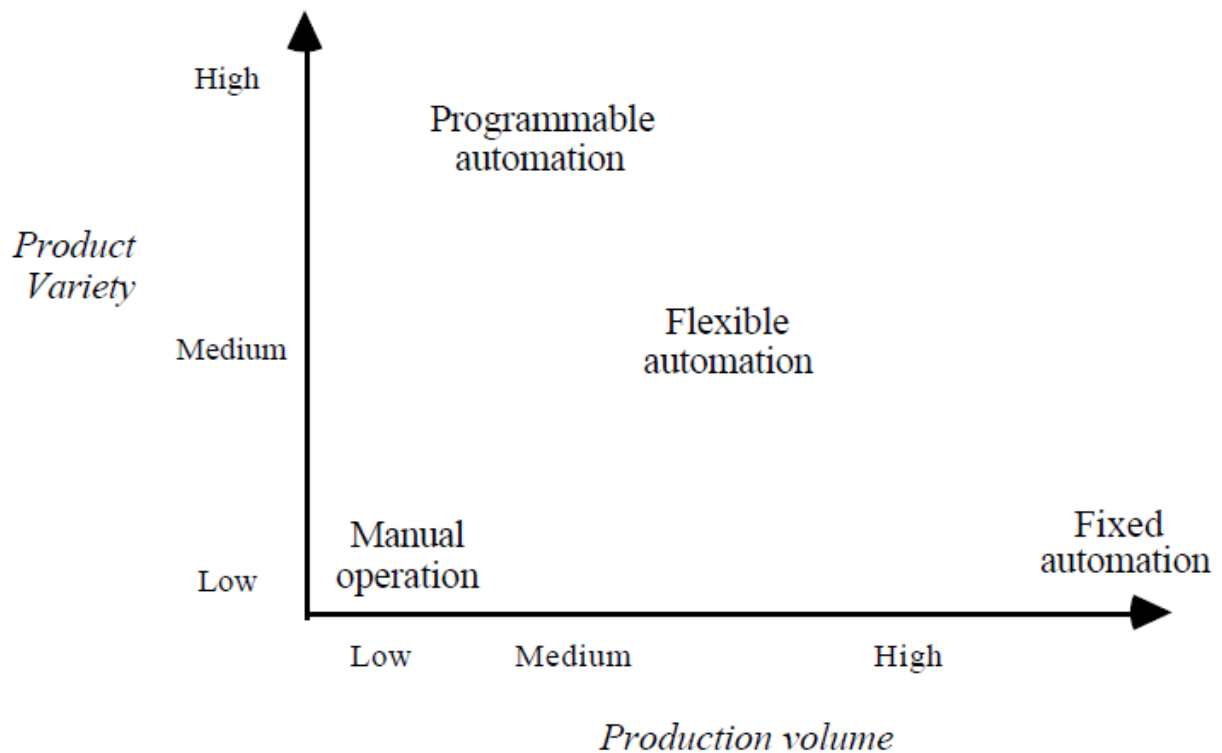
In programmable automation, the equipment is designed to accommodate a specific class of product changes and the processing or assembly operations can be changed by modifying the control program. It is particularly suited to “batch production,” or the manufacture of a product in medium lot sizes (generally at regular intervals). The first example of this kind of automation is the Jacquard loom (1801) where the weave pattern for a weave fabric could be “pre-programmed.” Once the required quantity of fabric was produced, the loom could be programmed (although this was a tedious process) to produce a new weave pattern for the next batch. A more recent example is the CNC lathe that produces a specific product in a certain product class (axisymmetric, within a certain diameter, length, tolerance, etc.) according to the “input program.” In programmable automation, reconfiguring the system for a new product is time consuming because it involves reprogramming and set up for the machines, and new fixtures and tools.

Table 1 Types of automation: Advantages and disadvantages

Automation	When to consider	Advantages	Disadvantages
Fixed	High demand volume, long product life cycles	<ul style="list-style-type: none"> • maximum efficiency • low unit cost 	<ul style="list-style-type: none"> • large initial investment • inflexibility
Programmable	Batch production, products with different options	<ul style="list-style-type: none"> • flexibility to deal with changes in product • low unit cost for large batches 	<ul style="list-style-type: none"> • new product requires long set up time • high unit cost relative to fixed automation
Flexible	Low production rates, varying demand, short product life cycles	<ul style="list-style-type: none"> • flexibility to deal with design variations • customized products 	<ul style="list-style-type: none"> • large initial investment • high unit cost relative to fixed or programmable automation

Flexible automation

In flexible automation, the equipment is designed to manufacture a variety of products or parts and very little time is spent on changing from one product to another. Thus, a flexible manufacturing system can be used to manufacture various combinations of products according to any specified schedule. With a flexible automation system it is possible to quickly incorporate changes in the product (which may be redesigned in reaction to changing market conditions and to consumer feedback) or to quickly introduce a new product line. For example, Honda is widely credited with using flexible automation technology to introduce 113 changes to its line of motorcycle products in the 1970's. Flexible automation gives the manufacturer the ability to produce multiple products cheaply in combination than separately (where the product volume is not high enough to justify dedicating a single production line to a single product).



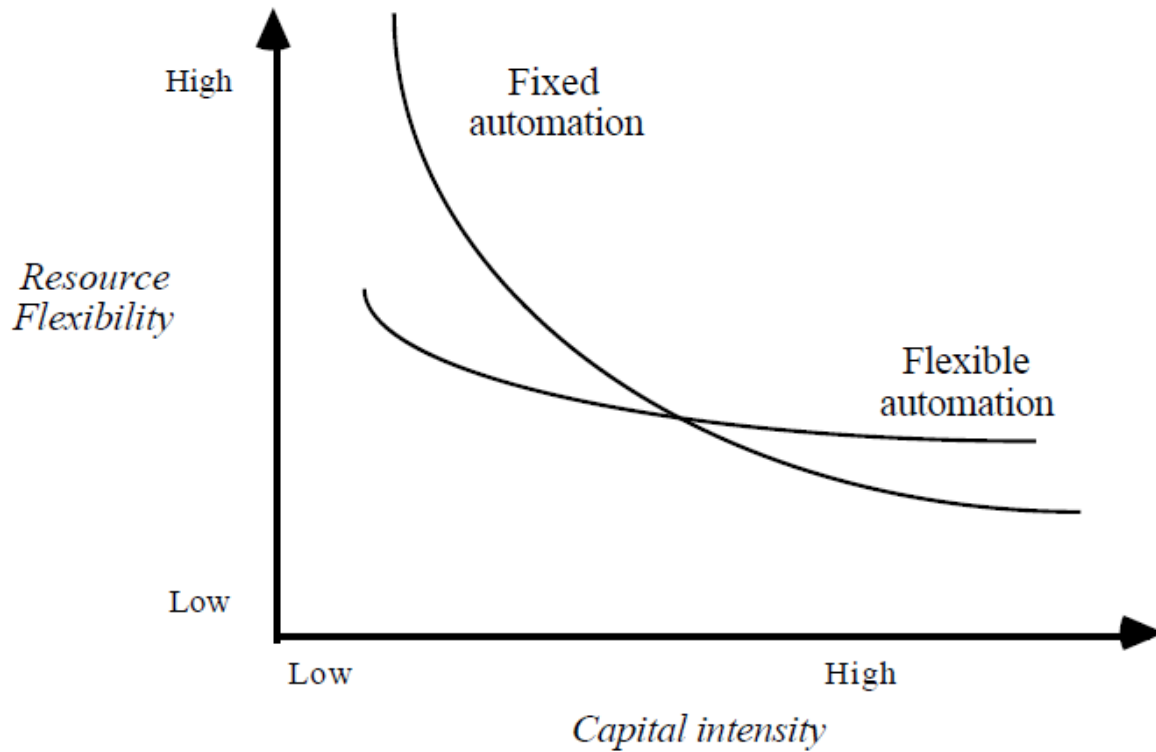


Figure 1 Types of automation

(*Capital intensity* is the mix of equipment and human skills in a production process; the greater the relative cost of the equipment, the greater is the capital intensity. *Resource flexibility* is the ease with which the equipment and the employees can handle a wide variety of products and volumes.)