ME-6703-Computer Integrated Manufacturing

Unit-I

1.1 INTRODUCTION

Computer Integrated Manufacturing (CIM) encompasses the entire range of productdevelopment and manufacturing activities with all the functions being carried out withthe help of dedicated software packages. The data required for various functions are passedfrom one application software to another in a seamless manner. For example, the productdata is created during design. This data has to be transferred from the modeling softwareto manufacturing software without any loss of data. CIM uses a common databasewherever feasible and communication technologies to integrate design, manufacturingand associated business functions that combine the automated segments of a factory ora manufacturing facility. CIM reduces the human component of manufacturing andthereby relieves the process of its slow, expensive and error-prone component. CIM standsfor a holistic and methodological approach to the activities of the manufacturing enterprisein 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 techniquesin order to achieve production improvement, cost reduction, fulfillment of scheduleddelivery 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 productdevelopment and manufacture. In such a holistic approach, economic, social and humanaspects have the same importance as technical aspects.

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

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

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

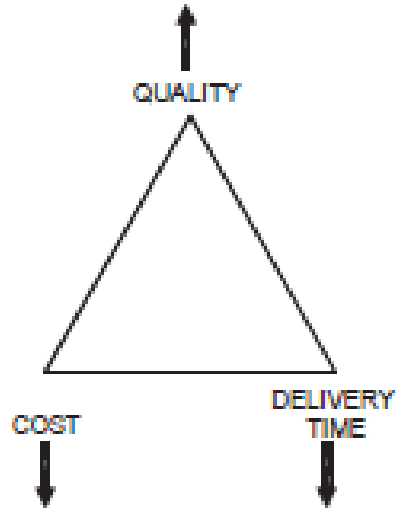


Fig.1.1 Challenges in Manufacturing

Manufacturing industries strive to reduce the cost of the product continuously to remaincompetitive in the face of global competition. In addition, there is the need to improve thequality 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 acrossseveral international borders, the task of continuously reducing delivery times is really anarduous task. CIM has several software tools to address the above needs.

Manufacturing engineers are required to achieve the following objectives to becompetitive 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 themanufacturing

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

CIM makes full use of the capabilities of the digital computer to improvemanufacturing. 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 ofmanufacturing (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 andpieces of manufacturing activity but also for the entire system of manufacturing. Computershave the tremendous potential needed to integrate the entire manufacturing system andthereby 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, electronicindustries making microelectronic components, printed circuit boards, computers andentertainment electronic products etc. are examples of manufacturing industriesManufacturing 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 specificsequence. These industries can be easily automated and computers are widelyused for process monitoring, control and optimization. Oil refineries, chemicalplants, food processing industries, etc are examples of continuous processindustries.

ii. Mass Production Industries

Industries manufacturing fasteners (nuts, bolts etc.), integrated chips, automobiles,entertainment electronic products, bicycles, bearings etc. which are all massproduced can be classified as mass production industries. Production lines arespecially 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 batchproduction industries. The distinguishing features of this type of manufacture arethe small to medium size of the batch, and varieties of such products to be takenup in a single shop. Due to the variety of components handled, work centersshould have broader specifications. Another important fact is that small batchsize 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

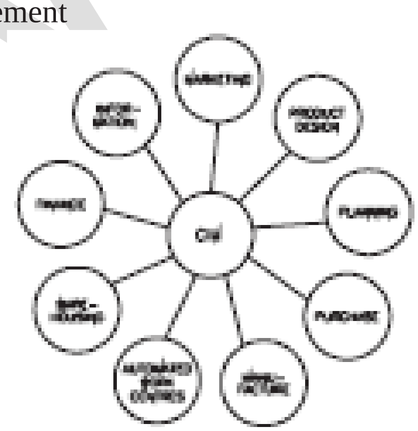


Fig.1.2 Major Elements of a CIM System

i. Marketing: The need for a product is identified by the marketing division. Thespecifications of the product, the projection of manufacturing quantities and thestrategy for marketing the product are also decided by the marketing department.Marketing also works out the manufacturing costs to assess the economic viabilityof the product.

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

iii. Planning: The planning department takes the database established by thedesign department and enriches it with production data and information toproduce a plan for the production of the product. Planning involves severalsubsystems 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 bythe production equipment and process capability, in order to generate anoptimized plan.

iv. Purchase: The purchase departments is responsible for placing the purchaseorders 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 orarrange timely delivery depending on the production schedule for eventual supplyto manufacture and assembly.

v. Manufacturing Engineering: Manufacturing Engineering is the activity of carryingout the production of the product, involving further enrichment of the databasewith performance data and information about the production equipment andprocesses. In CIM, this requires activities like CNC programming, simulation andcomputer aided scheduling of the production activity. This should include onlinedynamic scheduling and control based on the real time performance of theequipment and processes to assure continuous production activity. Often, theneed to meet fluctuating market demand requires the manufacturing systemflexible and agile.

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

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

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

1.4 CONCURRENT ENGINEERING

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

Parallel Engineering. Concurrent Engineering brings together a widespectrum of people from several functional areas in the design and manufacture of aproduct. Representatives from R & D, engineering, manufacturing, materialsmanagement, quality assurance, marketing etc. develop the product as a team. Everyoneinteracts with each other from the start, and they perform their tasks in parallel. Theteam reviews the design from the point of view of marketing, process, tool design andprocurement, 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 vendordevelopment department is associated with the prototype development. Any possiblebottleneck in the development process is thoroughly studied and rectified. All thedepartments get a chance to review the design and identify delays and difficulties.

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

Concurrent Engineering (CE) gives marketing and other groups the opportunity toreview the design during the modeling, prototyping and soft tooling phases ofdevelopment. CAD systems especially 3D modelers can play an important role in earlyproduct development phases. In fact, they can become the core of the CE. They offer avisual check when design changes cost the least.Intensive teamwork between product development, production planning andmanufacturing is essential for satisfactory implementation of concurrent engineering.The teamwork also brings additional advantages ; the co-operation between variousspecialists and systematic application of special methods such as QFD (Quality FunctionDeployment), DFMA (Design for Manufacture and Assembly) and FMEA (Failure Modeand Effect Analysis) ensures quick optimization of design and early detection of possiblefaults in product and production planning. This additionally leads to reduction in leadtime 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 toautomate a fixed sequence of processing or assembly operations. It is typically associated withhigh production rates and it is relatively difficult to accommodate changes in the product design. Thisis also called hard automation. For example, GE manufactures approximately 2 billion light bulbsper year and uses fairly specialized, high-speed automation equipment. This kind of automationdates back to WWI when the first mechanized assembly lines were used. Fixed automation makessense only when product designs are stable and product life cycles are long. The primarydrawbacks are the large initial investment in equipment and the relative inflexibility.

Programmable automation

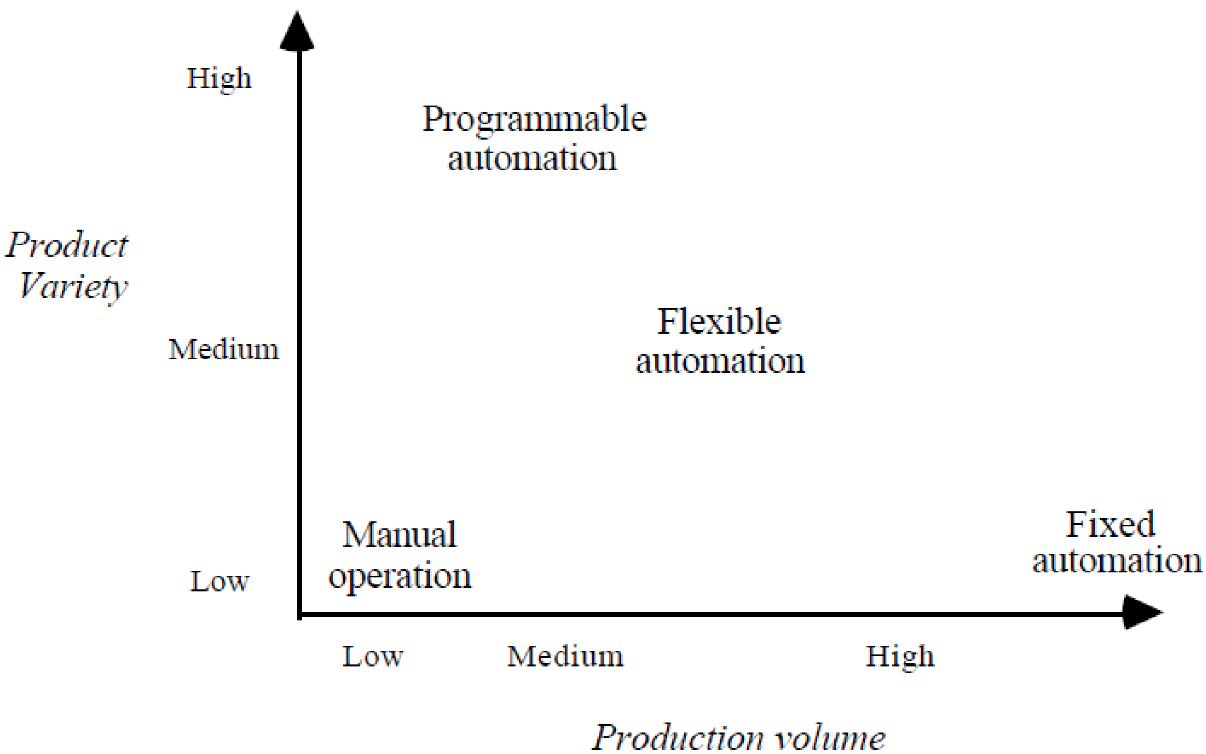
In programmable automation, the equipment is designed to accommodate a specific class ofproduct changes and the processing or assembly operations can be changed by modifying thecontrol program. It is particularly suited to “batch production,” or the manufacture of a product inmedium lot sizes (generally at regular intervals). The first example of this kind of automation is theJacquard 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 thiswas a tedious process) to produce a new weave pattern for the next batch. A more recent exampleis the CNC lathe that produces a specific product in a certain product class (axisymmetric, within acertain diameter, length, tolerance, etc.) according to the “input program.” In programmableautomation, reconfiguring the system for a new product is time consuming because it involvesreprogramming and set up for the machines, and new fixtures and tools.

Table 1 Types of automation: Advantages and disadvantagesAutomation When to consider Advantages Disadvantages

Automation	When to consider	Advantages	Disadvantages
Fixed	High demand volume, long product life cycles	• maximum efficiency • low unit cost	• large initial investment • inflexibility
Programmable	Batch production, products with different options	• flexibility to deal with changes in product • low unit cost for large batches	• new product requires long set up time • high unit cost relative to fixed automation
Flexible	Low production rates, varying demand, short product life cycles	• flexibility to deal with design variations • customized products	• 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 partsand very little time is spent on changing from one product to another. Thus, a flexiblemanufacturing system can be used to manufacture various combinations of products according toany specified schedule. With a flexible automation system it is possible to quickly incorporatechanges in the product (which may be redesigned in reaction to changing market conditions and toconsumer 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 ofmotorcycle products in the 1970's. Flexible automation gives the manufacturer the ability toproduce multiple products cheaply in combination than separately (where the product volume is nothigh enough to justify dedicating a single production line to a single product).



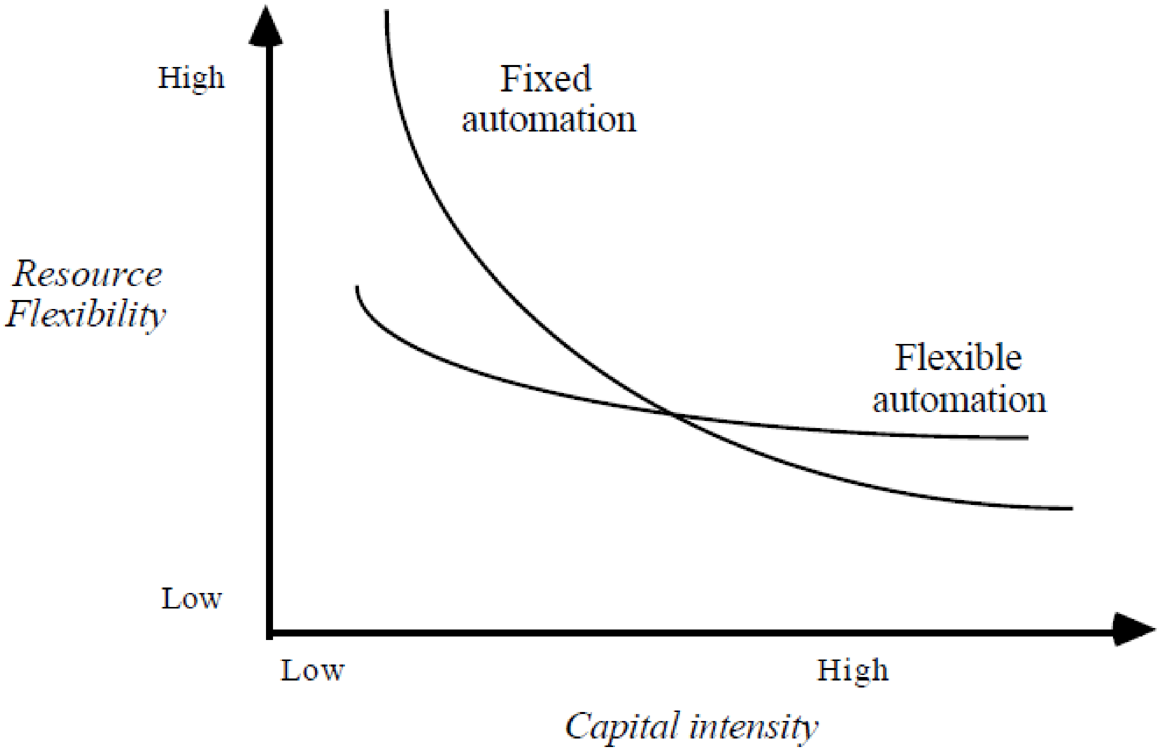


Figure 1 Types of automation

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