– COMPUTER INTEGRATED MANUFACTURING

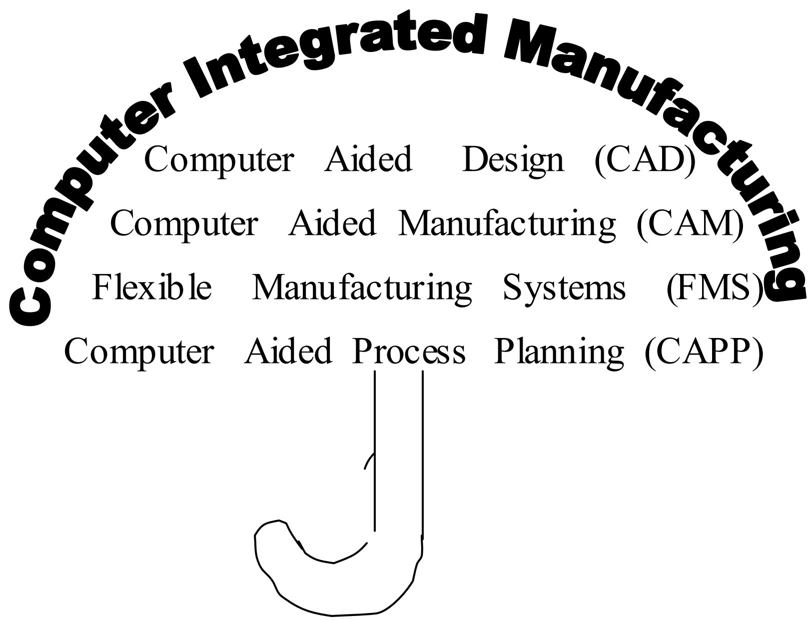
IV year Mechanical Engg .Notes on Lesson

UNIT – I : INTRODUCTION

Introduction

Computer integrated manufacturing(CIM) is a broad term covering all technologies and soft automation used to manage the resources for cost effective production of tangible goods.

- Integration – capital, human, technology and equipment
- CIM – which orchestrates the factors of production and its management.



- CIM is being projected as a panacea for Discrete manufacturing type of industry, which produces 40% of all goods.

"CIM is not applying computers to the design of the products of the company. That is computer aided design (CAD)! It is not using them as tools for part and assembly analysis. That is computer aided engineering (CAE)! It is not using computers to aid the

development of part programs to drive machine tools. That is computer aided manufacturing (CAM)! It is not materials requirement planning (MRP) or just-in-time (JIT) or any other method of developing the production schedule. It is not automated identification, data collection, or data acquisition. It is not simulation or modeling of any materials handling or robots or anything else like that. Taken by themselves, they are the application of computer technology to the process of manufacturing. But taken by themselves they only crate the ***islands of automation****."*

- Leo Roth Klein, Manufacturing Control systems, Inc.

Definition of CIM:

It describes integrated applications of computers in manufacturing. A number of observers have attempted to refine its meaning:

One needs to think of ***CIM as a computer system*** *in which the peripherals, instead of being printers, plotters, terminals and memory disks are robots, machine tools and other processing equipment. It is a little noisier and a little messier, but it's basically a computer system.*

- Joel Goldhar, Dean, Illinois Institute of Technology

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CIM is a management philosophy*, not a turnkey computer product. It is a philosophy crucial to the survival of most manufacturers because it provides the levels of product design and production control and shop flexibility to compete in future domestic and international markets.* - Dan Appleton, President, DACOM, Inc.

CIM is an opportunity for realigning your two most fundamental resources: people and technology. CIM is a lot more than the integration of mechanical, electrical, and even informational systems. It's an understanding of the ***new way to manage****.*

- Charles Savage, president, Savage Associates

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CIM is nothing but a ***data management and networking*** *problem*.

- Jack Conaway, CIM marketing manager, DEC

The preceding comments on CIM have different emphases (as highlighted).

An attempt to define CIM is analogous to a group of blind persons trying to describe an elephant by touching it.

"CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personnel efficiency."

- *Shrensker, Computer Automated Systems Association of the Society of Manufacturing Engineers (CASA/SME)*

Concept or Technology

"Some people view CIM as a concept, while others merely as a technology. It is actually both. A good analogy of CIM is *man*, for what we mean by the word man presupposes both the mind and the body. Similarly, CIM represents both the concept and the technology. The concept leads to the technology which, in turn, broadens the concept."

- According to Vajpayee

The meaning and origin of CIM

The CIM will be used to mean the integration of business, engineering, manufacturing and management information that spans company functions from marketing to product distribution.

The changing and manufacturing and management scenes

The state of manufacturing developments aims to establish the context within which CIM exists and to which CIM must be relevant. Agile manufacturing, operating through a global factory or to world class standards may all operate alongside CIM. CIM is deliberately classed with the technologies because, as will be seen, it has significant technological elements. But it is inappropriate to classify CIM as a single technology, like computer aided design or computer numerical control.

External communications

Electronic data interchange involves having data links between a buying company's purchasing computer and the ordering computer in the supplying company. Data links may private but they are more likely to use facilities provided by telephone utility companies.

Islands of automation and software

In many instances the software and hardware have been isolated. When such computers have been used to control machines, the combination has been termed an island of automation. When software is similarly restricted in its ability to link to other software, this can be called an island of software.

Dedicated and open systems

The opposite of dedicated in communication terms is open. Open systems enable any type of computer system to communicate with any other.

Manufacturing automation protocol (MAP)

The launch of the MAP initiates the use of open systems and the movement towards the integrated enterprise.

Product related activities of a company

1. **Marketing**
   - Sales and customer order serviceing
2. **Engineering**
   - Research and product development
   - Manufacturing development

- Design
- Engineering release and control
- Manufacturing engineering
- Facilities engineering
- Industrial engineering

3. Production planning

- Master production scheduling
- Material planning and resource planning
- Purchasing
- Production control

4. Plant operations

- Production management and control
- Material receiving
- Storage and inventory
- Manufacturing processes
- Test and inspection
- Material transfer
- Packing, dispatch and shipping
- Plant site service and maintenance

5. Physical distribution

- Physical distribution planning
- Physical distribution operations
- Warranties, servicing and spares

6. Business and financial management

- Company services
- Payroll
- Accounts payable, billing and accounts receivable

UNIT – II : GROUP TECHNOLOGY AND COMPUTER AIDED PROCESS PLANNING

Group technology

Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to take the advantage of their similarities in design and manufacturing.

Group Technology or **GT** is a manufacturing philosophy in which the parts having similarities (Geometry, manufacturing process and/or function) are grouped together to achieve higher level of integration between the design and manufacturing functions of a firm. The aim is to reduce work-in-progress and improve delivery performance by reducing lead times. GT is based on a general principle that many problems are similar and by grouping similar problems, a single solution can be found to a set of problems, thus saving time and effort. The group of similar parts is known as **part family** and the group of machineries used to process an individual part family is known as **machine cell**. It is not necessary for each part of a part family to be processed by every machine of corresponding machine cell. This type of manufacturing in which a part family is produced by a machine cell is known as **cellular manufacturing**. The manufacturing efficiencies are generally increased by employing GT because the required operations may be confined to only a small cell and thus avoiding the need for transportation of in-process parts

Role of GT in CAD/CAM integration

1. Identifying the part families.
2. Rearranging production machines into machine cells

Part family

A part family is a collection of parts having similarities based on design or shape or similar manufacturing sequence.

Comparison of Functional layout with GT layout

Methods of Grouping of parts

1. visual inspection
2. parts classification and coding system
3. production flow analysis

Parts classification and coding system

1. system based on part design attributes
2. system based on manufacturing attributes
3. system based on design and manufacturing attributes

Methods of coding

1. hierarchical coding
2. poly code
3. decision tree coding

Coding system

1. OPITZ system
2. DCLASS
3. MICLASS etc.

Production flow analysis (PFA)

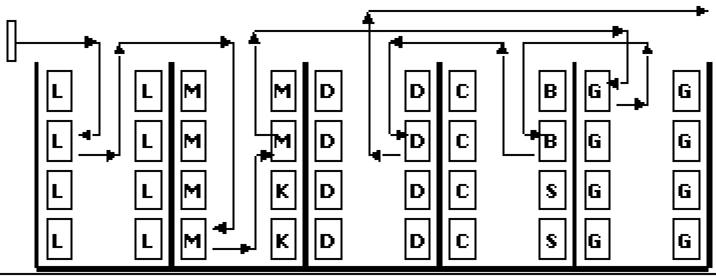
Various steps of PFA

1. Data collection
2. Part sorting and routing
3. PFA chart
4. Analysis

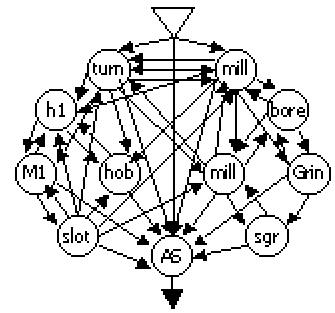
Production Flow Analysis

During the past ten years the people behind QDC Business Engineering have performed several Production Flow Analyses (PFA) in manufacturing industries. In short, PFA provides well-established, efficient and analytical engineering method for planning the change from "process organisation" to "product organisation”. This means that traditional production layouts are transformed into production groups, which each make a particular set of parts and is equipped with a particular set of machines and equipment enabling them to complete the assigned parts. The following figure illustrates the conventional process layout and its corresponding product based layout after PFA has been applied.

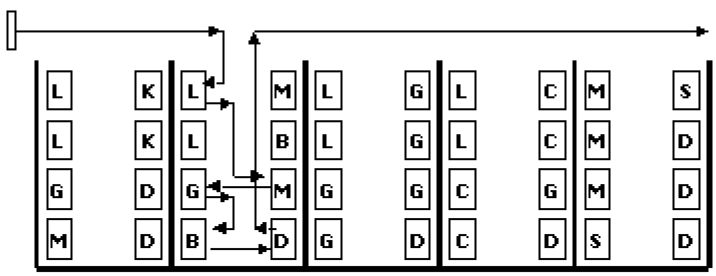
Traditional Process Layout



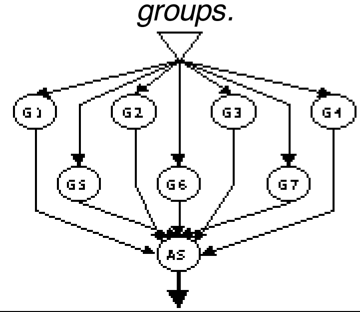
The resulting overall material flow between functional cells.



Product Layout



The resulting smooth material flow between dedicated product groups.



Complex material flow systems resulting from process based production layouts have long throughput times, high inventories and work in progress, which increase cost and reduce profitability. From the organisation’s point of view, delegation and control are difficult to implement, which leads to bureaucratic and centralised management structures, thus increasing overhead. Applying PFA produces a plan to change the layout and organisation in such a way that production throughput times can be reduced radically, while at the same time inventories go down and delivery punctuality and quality improve to a completely new level. QDC has applied the method successfully in several manufacturing industries, especially in job-shops and electronics industries, but good results have also been obtained in service industries. Once the layout has been changed to a product based one, new and simple production scheduling routines have been implemented to ensure excellent delivery performance.

Anticipated results

Companies that have gone through PFA and the resulting change to product based layout, have experienced the following positive effects:

- in operations management: reduced production throughput times, significantly less capital tied into the material flow and improved delivery performance;

- in general management: makes it possible to delegate the responsibility for component quality, cost and completion by due-date to the group level, which in turn reduced overhead;

- in worker's motivation: clearer responsibilities and decision making on the spot increase job satisfaction;

- in the point of information technology: simplified material flow speeds up the implementation of factory automation and simplifies software applications used to support efficient operations.

The content of Production Flow Analysis

The main method of the PFA is a quantitative analysis of all the material flows taking place in the factory, and using this information and the alternative routings to form manufacturing groups that are able to finish a set parts with the resources dedicated to it. Depending on the scale of the project this logic is applied on company, factory, group, line and tooling level respectively. Whichever the case, the work breaks down into the following steps:

- to identify and classify all production resources, machines and equipment;

- to track the all product and part routes that the company, factory or group produces;

- to analyse the manufacturing network through the main flows formed by the majority of parts;

- to study alternative routings and grouping of the machines to fit parts into a simplified material flow system;

- to further study those exceptional parts not fitting into the grouping of production resources;

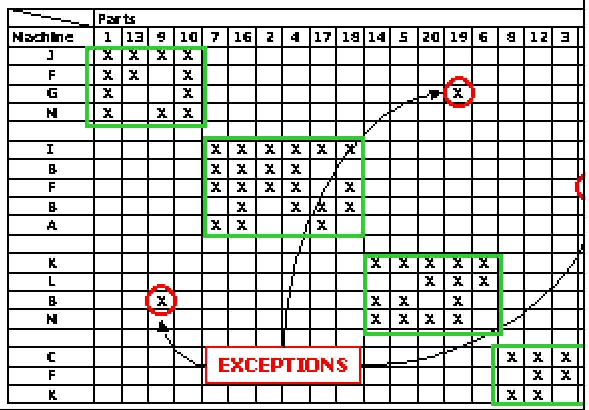
- to validate the new material flow system and implementing the scheduling system based on single-piece flow.

Most production units and their layouts are the result of organic growth, during which the products have experienced many changes affecting the arsenal of the equipment in the workshop. This continuously evolving change process leads in conventional factories into complex material flow systems. PFA reveals the natural grouping of production resources like the following small-scale yet real-world example shows.

The Machine-Part matrix as raw data gathered in the first steps of the PFA

Machine \ Parts	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A						x								x				x
B		x								x								
C				x				x				x					x	
D	x				x									x				
E			x														x	
F		x					x	x	x	x	x	x						
G	x			x					x					x				
H						x						x						
I										x		x					x	
J			x		x		x			x		x						
K					x				x				x				x	
L		x								x					x			
M						x	x	x			x			x				
N		x		x												x		
O					x										x			

The Machine-Part matrix reorganised into natural groups that finish parts.



Most of our previous cases have focused on the forming of groups in job-shops, which are part of a larger production facility. These test cases have been used as eye-openers for the rest of the organisation. Our recommendation, however, is to continue with PFA on higher level. Product and component allocation in the whole supply chain combined with product and customer segmentation is an area where not only vast savings in operating costs can be achieved, but also competitive advantage can be created.

Manufacturing science knows numerous cases where complete product-oriented re-organisation of the company has produced staggering results in productivity, throughput times and competitive advantage. PFA is one of the few systematic engineering methods for achieving these results.

Production Flow Analysis was developed by Professor John L. Burbidge of the Cranfield Institute of Technology.

Facility design using G.T.

1. Line layout
2. Group layout, machines grouped by part family
3. Functional layout, machines grouped by process

Benefits of group technology

1. Design
2. Tooling and setups
3. Material handling
4. Production and inventory control
5. Process planning
6. Employee satisfaction

Cellular manufacturing

- **Machine cell design**
- **The composite part concept**

Types of cell design

1. Single machine cell
2. Group machine cell with manual handling
3. Group machine cell with semi-integrated handling
4. Flexible manufacturing system

Determining the best machine arrangement

Factors to be considered:

- Volume of work to be done by the cell
- Variations in process routings of the parts
- Part size, shape, weight and other physical attributes

Key machine concept

Role of process planning

1. Interpretation of product design data
2. Selection of machining processes.
3. Selection of machine tools.
4. Determination of fixtures and datum surfaces.

5. Sequencing the operations.
6. Selection of inspection devices.
7. Determination of production tolerances.
8. Determination of the proper cutting conditions.
9. Calculation of the overall times.
10. Generation of process sheets including NC data.

Approaches to Process planning

1. Manual approach
2. Variant or retrieval type CAPP system
3. Generative CAPP system

CAPP and CMPP (Computer Managed Process Planning)

UNIT – III : SHOP FLOOR CONTROL AND INTRODUCTION OF FMS

Shop floor control

The three phases of shop floor control

1. Order release
2. Order scheduling
3. Order progress

Factory Data Collection System

- On-line versus batch systems
- Data input techniques
    - Job traveler
    - Employee time sheets
    - Operation tear strips
    - Prepunched cards
    - Providing key board based terminals
        - One centralized terminal
        - Satellite terminals

- Workstation terminals

Automatic identification methods

- Bar codes
- Radio frequency systems
- Magnetic stripe
- Optical character recognition
- Machine vision

Automated data collection systems

- Data acquisition systems
- Multilevel scanning

Components of Flexible Manufacturing Systems(FMS)

- Workstations
- Material handling and storage
- Computer control system
- Human resources

A **flexible manufacturing system** (**FMS**) is a manufacturing system in which there is some amount of flexibility that allows the system to react in the case of changes, whether predicted or unpredicted. This flexibility is generally considered to fall into two categories, which both contain numerous subcategories.

The first category, *machine flexibility*, covers the system's ability to be changed to produce new product types, and ability to change the order of operations executed on a part. The second category is called *routing flexibility*, which consists of the ability to use multiple machines to perform the same operation on a part, as well as the system's ability to absorb large-scale changes, such as in volume, capacity, or capability.

Most **FMS systems** consist of three main systems. The work machines which are often automated CNC machines are connected by a material handling system to optimize parts flow and the central control computer which controls material movements and machine flow.

The main advantages of an FMS is its high flexibility in managing manufacturing resources like time and effort in order to manufacture a new product. The best application of an FMS is found in the production of small sets of products like those from a mass production.

Faster, Lower- cost/unit, Greater labor productivity, Greater machine efficiency, Improved quality, Increased system reliability, Reduced parts inventories, Adaptability to CAD/CAM operations. Shorter lead times

Disadvantages

Cost to implement.

Training FMS with learning robot SCORBOT-ER 4u, workbench CNC Mill and CNC Lathe

An **Industrial Flexible Manufacturing System** (FMS) consists of robots, Computer-controlled Machines, Numerical controlled machines (CNC), instrumentation devices, computers, sensors, and other stand alone systems such as inspection machines. The use of robots in the production segment of manufacturing industries promises a variety of benefits ranging from high utilization to high volume of productivity. Each Robotic cell or node will be located along a material handling system such as a conveyor or automatic guided vehicle. The production of each part or work-piece will require a different combination of manufacturing nodes. The movement of parts from one node to another is done through the material handling system. At the end of part processing, the finished parts will be routed to an automatic inspection node, and subsequently unloaded from the Flexible Manufacturing System.

CNC machine

The FMS data traffic consists of large files and short messages, and mostly come from nodes, devices and instruments. The message size ranges between a few bytes to several hundreds of bytes. Executive software and other data, for example, are files with a large size, while messages for machining data, instrument to instrument communications, status monitoring, and data reporting are transmitted in small size.

There is also some variation on response time. Large program files from a main computer usually take about 60 seconds to be down loaded into each instrument or node at the beginning of FMS operation. Messages for instrument data need to be sent in a periodic time with deterministic time delay. Other type of messages used for emergency reporting is quite short in size and must be transmitted and received with almost instantaneous response.

The demands for **reliable FMS protocol** that support all the FMS data characteristics are now urgent. The existing IEEE standard protocols do not fully satisfy the real time communication requirements in this environment. The delay of CSMA/CD is unbounded as the number of nodes increases due to the message collisions. Token Bus has a deterministic message delay, but it does not support prioritized access scheme which is needed in FMS communications. Token Ring provides prioritized access and has a low message delay, however, its data transmission is unreliable. A single node failure which may occur quite often in FMS causes transmission errors of passing message in that node. In addition, the topology of Token Ring results in high wiring installation and cost.

A design of **FMS communication protocol** that supports a real time communication with bounded message delay and reacts promptly to any emergency signal is needed. Because of machine failure and malfunction due to heat, dust, and electromagnetic interference is common, a prioritized mechanism and immediate transmission of emergency messages are needed so that a suitable recovery procedure can be applied. A modification of standard Token Bus to implement a prioritized access scheme was proposed to allow transmission of short and periodic messages with a low delay compared to the one for long messages.

Flexibility in manufacturing means the ability to deal with slightly or greatly mixed parts, to allow variation in parts assembly and variations in process sequence, change the production volume and change the design of certain product being manufactured.

Workstations

- Load/unload stations
- Machining stations
- Other processing stations

- Assembly

Material handling and storage systems

- Primary material handling
- Secondary material handling

FMS layout

- In-line layout
- Loop layout
- Ladder layout
- Open field layout
- Robot centered layout

Computer control system

- Workstation control
- Distribution of control instructions to workstations
- Production control
- Traffic control
- Shuttle control
- Workpiece monitoring
- Tool control
- Performance monitoring and reporting
- Diagnostics

UNIT – II : COMPONENTS OF CIM

CIM and company strategy

Does that mean the starting point for CIM is a network to link all the existing islands of automation and software? Or is it the integration of the existing departmental functions and activities as suggested by the CIM wheel?

The answer to both the questions just posed is no. the starting point for CIM is not islands of automation or software, not is it the structure presented by the CIM wheel, rather it is a ***company's business strategy.***

System modeling tools

It is helpful if the modeling tool is of sufficient sophistication that it exists in three forms:

- As a representation of the system
- As a dynamic model
- As an executable model

IDEF and IDEF0

IDEF initially provided three modeling methods

- IDEF0 is used for describing the activities and functions of a system
- IDEF1 is used for describing the information and its relationships
- IDEF2 is used for describing the dynamics of a system

Activity cycle diagrams

This modeling approach follows the notation of IDEF0 by having activities represented as rectangles and by having the activity names specified inside the rectangle. All resources which are to be represented in the model are classified as entity classes.

CIM open system architecture(CIMOSA)

CIMOSA was produced as generic reference architecture for CIM integration as part of an ESPRIT project. The architecture is designed to yield executable models or parts of models leading to computerized implementations for managing an enterprise.

Manufacturing enterprise wheel

he new manufacturing enterprise wheel's focus is now the customer at level 1, and it identifies 15 key processes circumferentially at level 4. These are grouped under the headings of customer support, product/process and manufacturing.

CIM architecture

CIM ARCHITECTURE

CIM Architecture Overview

To develop a comprehensive CIM strategy and solutions, an enterprise must begin with .solid foundations such as CIM architecture. A CIM architecture is an information systems structure that enables industrial enterprises integrate information and business processes It accomplishes this first by establishing the direction integration will take; and second, by defining the interfaces between the users and the providers of this integration function.The chart (Figure 2.1) illustrates how a CIM architecture answers the enterprise's integration needs. As you can see here, a CIM architecture provides a core of common services. These services support every other area of the enterprise—from its common support functions to its highly specialized business processes.

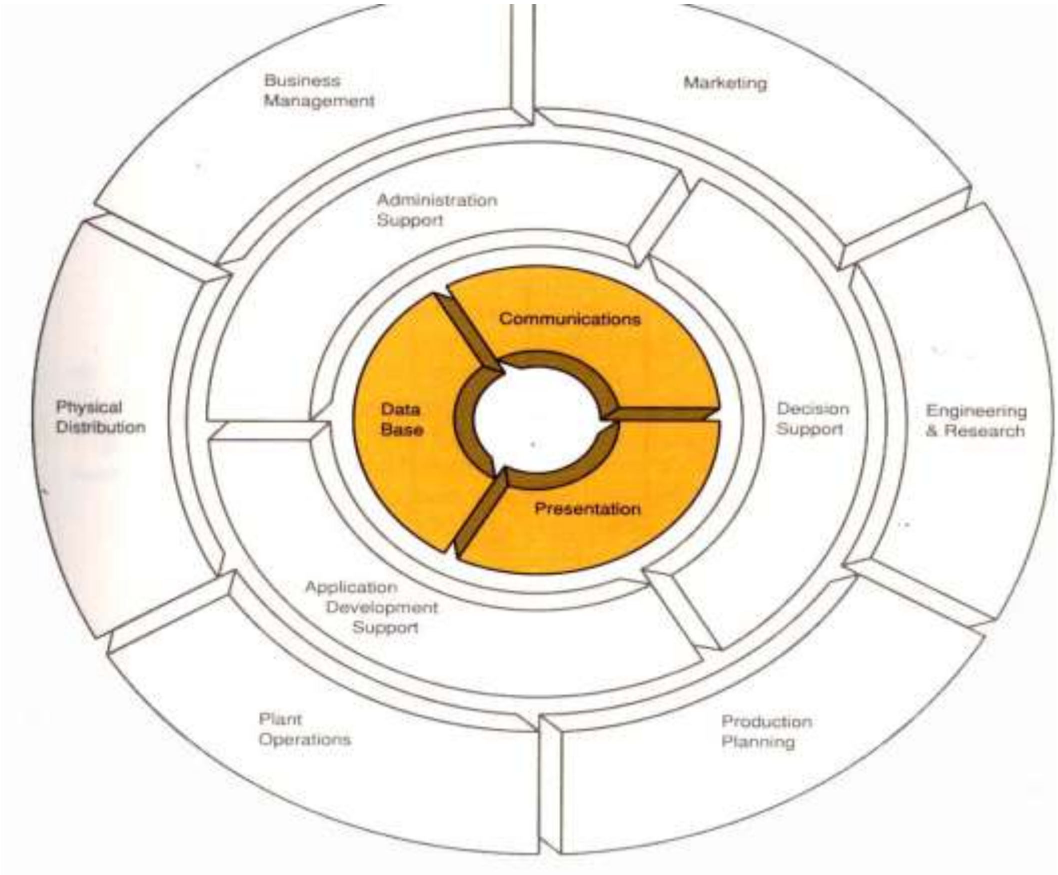
2.1.1 Three key building blocks

The information environment of an industrial enterprise is subject to frequent changes in systems configuration and technologies. A CIM architecture can offer a flexible structure that enables it to react to these changes. This structure relies on a number of modular elements that allow systems to change more easily to grow along with enterprise needs. And as you can see from the chart on the facing page, the modular elements that give a CIM architecture its flexible structure are based on three key building blocks:

• *Communications*—the communication and distribution of data.

• *Data management*—the definition, storage and use of data

• *Presentation*—the presentation of this data to people and devices throughout the enterprise



- Data dictionary
- Data repository and store
- A layered structure
- Repository builder

Product data management (PDM): CIM implementation software

The four major modules typically contained within the PDM software are

- Process models
- Process project management
- Data management
- Data and information kitting

The PDM environment provides links to a number of software packages used by a company. They are

- A CAD package
- A manufacturing/production management package
- A word processing package
- Databases for various applications
- Life-cycle data

Communication fundamentals

- A frequency
- An amplitude
- A phase which continuously changes
- A bandwidth
- An introduction to baseband and broadband
- Telephone terminology
- Digital communications

Local area networks

- Signal transmission, baseband and broadband
- Interconnection media

Topology

- Star topology
- Ring topology
- Bus topology
- Tree topology

LAN implementations

- Client server architecture
- Networks and distributed systems

- Multi-tier and high speed LANs

Network management and installation

- Security and administration
- Performance
- Flexibility
- User interface
- Installation

UNIT – V : OPEN SYSTEM AND DATABASE FOR CIM

Open system interconnection (OSI) model

- The physical layer
- The data link layer
- The network layer
- The transport layer
- The session layer
- The presentation layer
- The application layer

Manufacturing automation protocol and technical office protocol

Basic database terminology

- Database management system
- Database system
- Data model
- Transaction
- Schema
- Data definition language
- Data manipulation language
- Applications program
- Host language

- Database administrator

The architecture of a database system

- Internal schema
- External schema
- Conceptual schema

Data modeling and data associations

Data modeling is carried out by using a data modeling method and one of a number of graphic representations to depict data groupings and the relationship between groupings.

Data modeling diagram – Entity-Relationship diagram

Data associations

- One-to-One
- One-to-Many
- Many-to-One
- Many-to-Many

Relational databases

The terms illustrated are relation, tuple, attribute, domain, primary key and foreign key.

Database operators

- Union
- Intersection
- Difference
- Product
- Project
- Select
- Join
- Divide