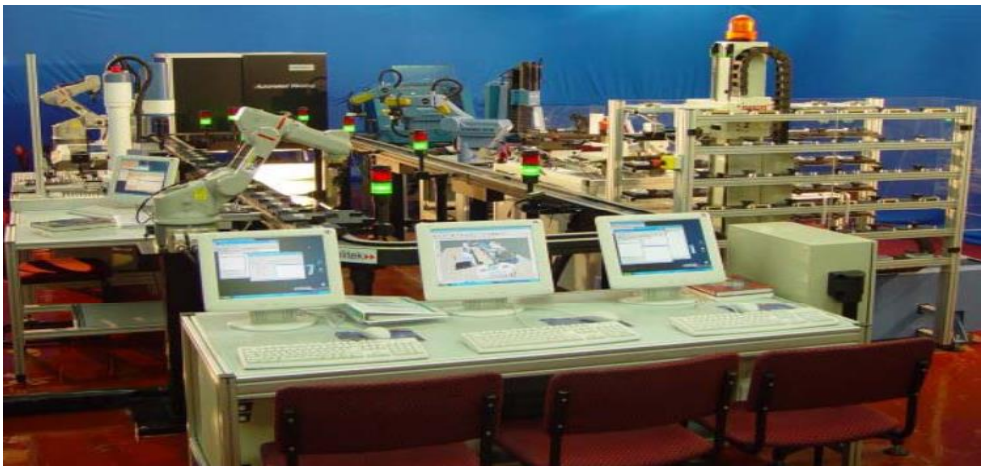
Machining

Level-IV

Based on October 2023, curriculum version II



Module Title: - Supervising CIM Production Operations

Module Code: INDMAC4 M02 1023

Nominal Duration: 80Hour

Prepared by: Ministry of Labor and Skill

October, 2023

Addis Ababa, Ethiopia

Acknowledgment

The Ministry of Labor and skill wishes to thank and appreciation to MoLS leaders and experts, Regional Labor and skill/training Bureaus leader, experts, TVT College Deans, Instructors and industry experts who contribute their time and professional experience to the development of this Training Module.

Acronym

CIM	Computer integrated manufacturing
FMS	Flexible manufacturing
GT	Group Technology
LAN	Local Area Network
WAN	Wide Area Network
MRP	Material Requirement Plan
CIA	Computer aided inspection
CAT	Computer Aided Testing
To	Operation time
MTBF	Mean time to repair
TTLM	Teaching, Training and Learning Material.
TVT	Technical and Vocational Training.
FMC	Flexible Manufacturing Cell
MLT	Manufacturing lead Time

Table of Contents

Acknowledgment.....i
Acronym.....ii
Table of Contents.....iii
Introduction to the Module.....iv
Unit one:- An overview of CIM system.....1
1.1 Introduction to CIM.....2
1.2 Parameters of CIM system.....6
1.3 Communication protocols.....8
1.4 Feasibility study of the project.....11
1.5 OHS and Shop safety.....12
Self-Check 1.....14
Unit Two: CIM System Production Process.....16
2.1 Investigation and measurements of CIM process.....17
2.2. Modeling and calculation.....20
2.3. Conventional and CIM production process solution arrangement.....26
2.4 sustainability implication in CIM system.....36
Self-Check 2.....40
LAP Test 2.....42
Unit Three: Features of CIM system.....43
3.1 Computer Aided Process Planning.....44
3.2 Customer service or Consult approach in CIM system.....47
3.3 Implementation CAD/CAM.....49
3.4 Documentation of The Final Design.....53
Self-Check 3.....54
Unit Four: Production process quality.....56
4.1 Standards and cods of CIM system.....57
Self – Check 4.....68
Reference.....70

Introduction to the Module

Manufacturing systems must respond to their rapidly changing marketplace and to the new technologies being produced and used in industry. Nowadays, the problems of manufacturing are more complicated due to many changes occurring not only simultaneously but also more rapidly than in the past. These changes are occurring in all fields of manufacturing systems. These changes include: more complex product, higher quality, increased product liability, more customized products, shorter product life cycle, fewer skilled workers, increased competition, etc. Manufacturing change can be an effective competitive weapon if it is well planned, designed and supported by powerful modeling methods and technologies. Many factors such as reduced lead time, greater flexibility, improved communications and co-ordination with suppliers, increased productivity, improved design and greater manufacturing control can make industrial organizations far more competitive in the future.

This module is designed to meet the industry requirement under the machining occupational standard, particularly for the unit of competency Supervise CIM Production Operations.

This module covers the units:

- Overview of CIM system
- CIM system production process
- Features of CIM system
- Production process quality

Learning objectives of the Module

At the end of this session, the students will able to:

- Interpret the design brief or scope of production including CIM system
- Prepare production process including possible CIM system
- Perform supervision of conventional and /or CIM supported production
- Assure quality of production process

Module Learning Instructions:

For effective use these modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” given at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one:- An overview of CIM system

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Introduction to CIM
- Parameters of CIM system
- Communication protocols
- Feasibility study of manual and CIM project
- OHS and Shop safety

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Establish required features and extent of integration of the CIM system.
- Establish technical, commercial and environmental parameters
- Consult technical managers and senior design engineers.
- Consider OHS, regulatory requirements and enterprise procedures.
- Collect and present preliminary advice on feasibility of manual or possible CIM project.

1.1 Introduction to CIM

CIM is a key to the survival of many industries requiring to remain competitive by producing high quality products at the right time and at acceptable costs, to satisfy the fast-changing market. CIM is one of the fastest growing fields. It is not a single concept or tool but integration of the elements of the system as a whole. In the CIM system all the technology and strategies are based on the concept of "integration". CIM is a strategy for economical production by effective utilization of different data resources through computer-based methods. Without any doubt, CIM systems, with their long-term impact, require alignment of business and manufacturing strategy. The current view of CIM appears to represent a strategic panacea for the organization being studied. [Ref.1

1.1.1. COMPONENTS OF CIM

Computer Integrated Manufacturing, known as CIM, is the phrase used to descry be the complete automation of a manufacturing plant, with all processes functioning under computer control and digital information tying them together. The heart of computer integrated manufacturing is CAD/CAM. Computer Aided design (CAD) and computer aided manufacturing (CAM) systems are essential to reducing cycle times in the organization. CAD/CAM is a high technology integrating tool between design and manufacturing. CAD techniques make use of group technology to create similar geometries for quick retrieval.

CAD/CAM integrated systems provide design/drafting, planning and scheduling, and fabrication capabilities. CAD provides the electronic part images, and CAM provides the facility for tool path cutters to take on the raw piece.

1.1.2 CIM Concept Vs CIM Technology

- CIM is both a concept and a technology.
- For top management, CIM is a concept, a blueprint for success.
- For middle managers and line managers, CIM is a technology

1.1.3 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."

1.1.4 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.

1.1.4.1 CIM-Definition;

CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency. Computer integrated manufacturing is defined as the effective use of computers to design the products, plan the production, control the operations and perform the various business related functions needed in a manufacturing firm.

1.1.4.2 Objective of CIM;

The main aim of CIM is to use the advanced information processing technology into all areas of manufacturing industry in order

- To make the total process more productive and efficient;
- increase product reliability;
- Decrease the cost of production and maintenance relating to the manufacturing system as well as to the product; and
- Reduce the number of hazardous jobs and Subsystems in computer integrated manufacturing.

A computer integrated manufacturing system is not the same as a "lights out" factory, which would run completely independent of human intervention, although it is a big step in that direction. Part of the system involves flexible manufacturing, where the factory can be quickly modified to produce different products, or where the volume of products can be changed quickly with the aid of computers. Some or all of the following subsystems may be found in a CIM operation:

1.1.5 **CIM system Hardware & Software**;

- CIM Hardware consists of manufacturing equipment and Computer related hard ware with the office equipment.
- CIM Software consists of computer programs to carry out the various functions and transfer the data from various areas of the industry.

1.1.5.1 Elements of CIM hardware;

Manufacturing equipment such as CNC machines, robots, DNC / FMS systems, work holding and tool handling devices, Storage devices, sensors, shop floor data collection devices, inspection machine etc.

Computers, Controllers, CAD /CAM systems, workstations, data entry terminals, bar code readers, printers, plotters, modems, cables, connectors etc. are part of CIM hardware

1.1.5.2 Elements of CIM software;

- MIS- management information system
- Sales, marketing, finance
- Data base management
- Modeling and design
- Analysis, simulation, communications
- Monitoring, production control
- Manufacturing area control, job tracking
- Inventory control
- Shop floor data collection,
- Order entry, materials handling, Device drivers,

- Process planning, manufacturing facilities
- Work flow automation,
- Business process engineering, Network management, Automation;

Automation may be defined as the process of having machines follow a predetermined sequence of operations with little or no human labor, using specialized equipment and devices that perform and control manufacturing processes.

'Islands of automation;

The individually automated workstations or processes are called islands of automation. In other words, the term 'islands of automation' represents the various technologies that facilitate manufacturing automation in isolation, without having integrated with other manufacturing technologies

1.1.6 Major elements of CIM systems;

- Marketing,
- Product design,
- Planning,
- Purchase,
- Manufacturing engineering,
- Factory automation hardware,
- warehousing, finance, and
- Information management

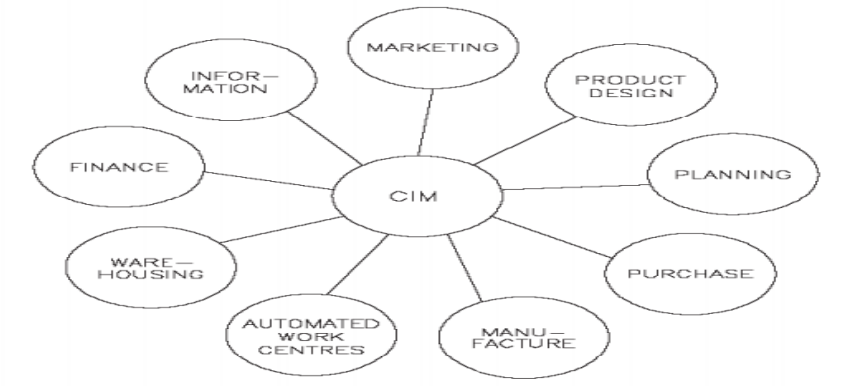


Figure 1.1 elements of CIM

1.1.7 CIM wheel components

Distinct components of CIM wheel

- Manufacturing / Human resource management
- Marketing
- Strategic planning
- Finance
- Product and process design and planning
- Manufacturing planning and control
- Factory automation

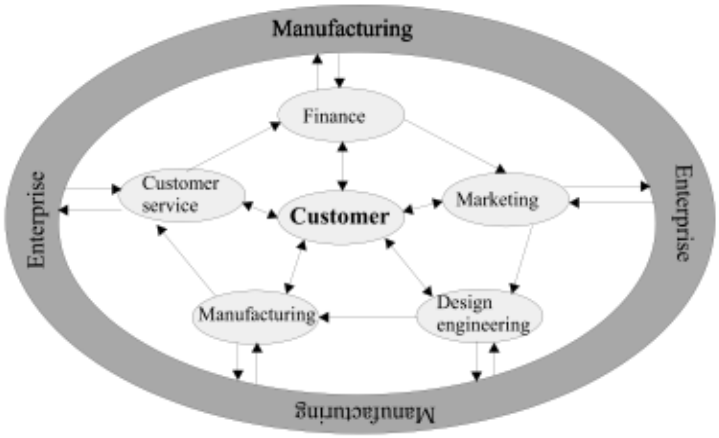


Figure 1.2 CIM wheel components

1.2 Parameters of CIM system

CIM (Computer Integrated Manufacturing) is a system that integrates various manufacturing processes and functions through the use of computer systems and software. The specific parameters of a CIM system can vary depending on the implementation and requirements of a particular manufacturing environment. However, some common parameters and components that are typically found in a CIM system:

Glossary;

- Computer-aided design (CAD)
- Computer-aided engineering (CAE)
- Computer-aided industrial design (CAID)
- Computer-aided manufacturing (CAM)
- Computer-aided rule definition (CARD)
- Computer-aided rule execution (CARE)
- Computer-aided software engineering (CASE)
- Computer-aided surgical simulation (CASS)
- Computational fluid dynamics (CFD)
- Component information system (CIS)
- Computer-integrated manufacturing (CIM)
- Automated Guided Vehicle (AGV)
- Manufacturing Automation Protocol (MAP)
- Flexible manufacturing module (FMM)
- Flexible manufacturing cell (FMC)
- Flexible manufacturing group (FMG)
- Flexible fabrication-machining-assembly system (FFMAS)
- Shop Floor Control (SFC)

It's important to note that the parameters and components of a CIM system can vary significantly depending on the specific industry, manufacturing processes, and organizational requirements. The above list provides a general overview of common parameters, but the actual implementation may include additional components or variations based on the specific needs of a manufacturing environment.



Figure 1.3 elements of CIM

1.3 Communication protocols

1.3.1 Computer communication in CIM;

- Communication is the nervous systems of CIM and this is an integral part of CIM.
- The development in communication / network engineering have made implement of CIM easier that before.

1.3.2 Various needs of communication;

- The information need for manufacturing in a company requires as follows.
- Person-to-person, computer-to-computer, machine-to-machine, person to computer or computer to person, person to machine or machine to person, computer to machine or machine to computer

1.3.3 Fundamental needs of computer communications;

- **Data**: entities that convey meaning
- **Information**: the content or interpretation of data
- **Signals**: electric or electromagnetic encoding of data
- **Signaling:** the act of propagating the signal along a medium
- **Transmission:** propagating of data by processing of signals

1.3.4 Data Transmission Methods.

- Serious & Parallel Communications.
- Synchronous & Asynchronous methods.
- Simplex & Duplex methods.

1.3.5 Communication Networks;

A communication network is the backbone of an enterprise integration. Networks help to unify a company by linking together all the computerized devices irrespective of their physical location.

Through networks the whole enterprise can be integrated, including suppliers and customers. For example, sales and marketing can send customer requirements for new products to design engineering.

A CAD generated bill of materials can then be transferred to “material requirements planning(MRP)” systems. Product design information can be transmitted to manufacturing for use in process planning

1.3.5.1 There are two main types of communication networks:

a. Telecommunication Networks;
b. Computer communication Networks.

Telecommunication network is mainly used for voice communication.
Computer communication network is a system of interconnected computers and other devices capable exchanging information.

Types of Computer networks;

The computer networks can be classified into four categories depending upon the physical separations of the communication devices.

- Miniature - <50m
- Small - <500m
- Medium - <1km
- Large - >1km - WAN & LAN.

A. Local Area Network;

Local Area Network is intended to serve a number of users who are physically located close together.

B. Wide Area Network;

Wide Area Network more like to telephone network, tying different people in different buildings, cities or even countries.

Network Topologies.

There are several commonly used network topology or ways of routing the interconnections. It classified as Star, Ring, Bus topologies.

- Star topology
- Ring topology

- Bus topology
- Tree topology

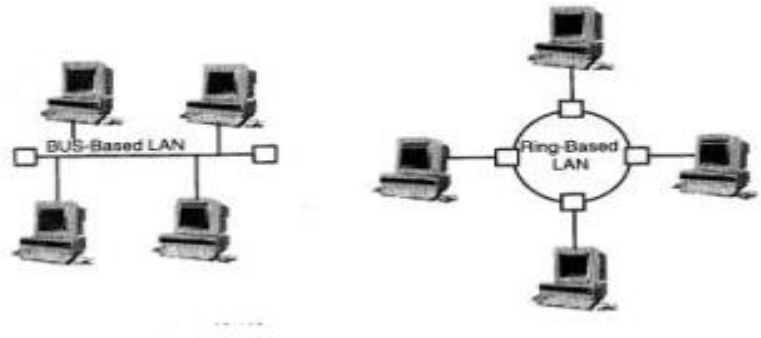
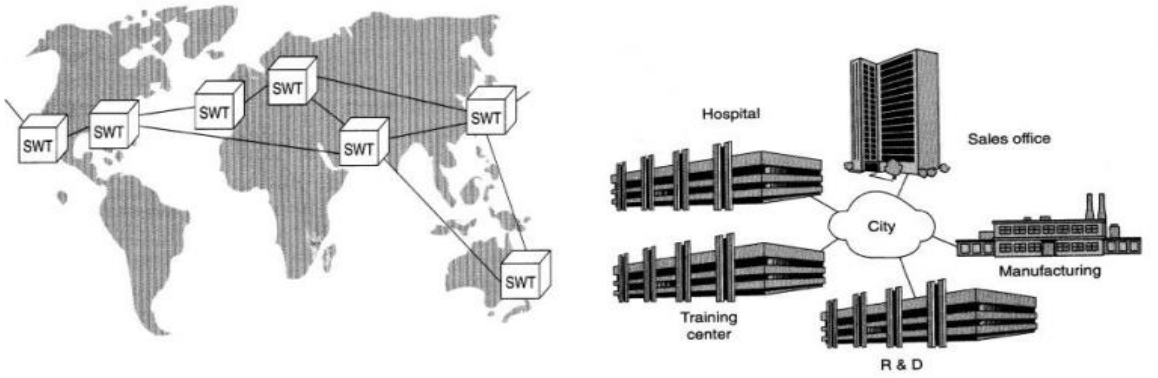


Figure 1.3 network topology



The protocol layers are;

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

Components of LAN;

The various components of LAN are listed below;

- Computers,
- Network interface card,
- Network cable,
- Network server,

- Central mass storage.

Star network communications

The star network consists of a central control station to which each of the individual devices or user stations are connected. To send messages from one workstation to the other is through the central station.

Ring network communication

In ring network communication the individual stations are connected in a continuous ring. Each station has a neighboring station on either side. To communicate from one station to other, the message must be relayed from station to station until it finally arrives at its designated destination station.

Bus network communication

The bus network consists of a single main transmission line to which the individual devices are attached. Any device or station can communicate with any other device in the network by sending its message through the bus with the address of the desired recipient.

1.4 Feasibility study of the project

A feasibility study is a crucial step in evaluating the viability and potential benefits of implementing a project, whether it's manual or CIM (Computer Integrated Manufacturing). Let's explore how a feasibility study would differ for both scenarios.

1.4.1 Feasibility Study for CIM Project

Identify the project objectives: Clearly define the goals and objectives of the CIM project, such as integrating manufacturing processes, improving automation, or enhancing data management.

Evaluate current manufacturing processes: Assess the existing manufacturing processes and identify areas where CIM implementation can bring improvements, such as reducing manual intervention, streamlining data flow, or increasing production efficiency.

Technology assessment: Evaluate the available CIM technologies, software, and hardware solutions that align with the project objectives.

Cost analysis: Analyze the costs associated with implementing the CIM project, including software licenses, hardware investments, training, and maintenance expenses.

Resource availability: Assess the availability of skilled personnel, technical expertise, and infrastructure required for successful CIM implementation.

Risk analysis: Identify potential risks and challenges associated with CIM implementation, such as compatibility issues, resistance to change, or disruptions during the transition phase.

Evaluation of alternatives: Explore alternative CIM solutions or technologies that could potentially better meet the project objectives or mitigate identified risks.

Financial analysis: Conduct a financial analysis to determine the project's ROI, payback period, and other financial metrics, considering both initial investment and long-term benefits.

Conclusion: Based on the findings of the feasibility study, determine whether the CIM project is feasible, considering its potential benefits, risks, technical requirements, and financial viability.

In both cases, the feasibility study aims to provide an objective assessment of the project's viability and help decision-makers make informed choices regarding implementation. The specific parameters and considerations within the feasibility study will differ based on whether it's a manual or CIM project, reflecting the unique characteristics and requirements of each approach.

1.5 OHS and Shop safety

Safety is a critical consideration in any computer integrated manufacturing (CIM) system. CIM systems are complex and interconnected, and a failure in any one component can

have cascading effects on the entire system. This can lead to accidents, injuries, and even fatalities.

There are a number of things that can be done to improve safety in CIM systems. Some of the most important include:

- **Risk assessment:** The first step is to conduct a thorough risk assessment of the entire CIM system. This will identify all of the potential hazards and assess the likelihood and severity of each hazard.
- **Hazard mitigation:** Once the hazards have been identified, steps should be taken to mitigate them. This may involve engineering controls, such as guards and safety interlocks, or administrative controls, such as training and procedures.
- **Emergency response planning:** In the event of an accident, it is important to have a plan in place to respond quickly and effectively. This plan should include procedures for evacuating personnel, shutting down the system, and cleaning up the mess.

In addition to these general measures, there are a number of specific safety features that can be incorporated into CIM systems. For example:

- **Machine guarding:** Machines should be properly guarded to protect operators from moving parts and other hazards.
- **Safety interlocks:** Safety interlocks should be used to prevent machines from operating when they are not safe.
- **Emergency stop buttons:** Emergency stop buttons should be located throughout the CIM system so that operators can quickly stop the system in the event of an accident.
- **Lighting and signage:** The CIM system should be well-lit and have clear signage to warn operators of potential hazards.
- **Training:** Operators should be properly trained on the safe operation of all of the equipment in the CIM system.

By taking these steps, manufacturers can significantly improve the safety of their CIM systems

Self-Check 1
Instructions: answer all questions given below accordingly

- Given 25 minutes,
- Enumerate the following. Use a separate sheet of paper for answering.
- For Short answers, write the answer for the questions on the provided space.

Part I. Choose the Correct answer from the given alternatives

1. **One of the following is not elements of CIM hardware?**
    a. Sensor
    b. Shop floor data collection device
    c. Inspection devise
    d. Modeling and designing
2. **Which of the following is safety feature of CIM?**
    a. Machine guarding
    b. Safety interlock
    c. Emergency stope button
    d. All
3. **CIM feasibility study will include?**
    a. Cost analysis
    b. Material required planning
    c. Flexible manufacturing system
4. **Network topology include?**
    a. Start topology
    b. Ring topology
    c. Bus topology
    d. All
5. **Which one of the following is parameters of CIM system?**
    a. CAD

b. CAM
c. CAE
d. All of the above are the parameters of CIM

Part II. Say True if the statement is true or else say False

1. CIM is both concept and technology
2. For middle managers and line managers CIM is a technology
3. Feasibility study is not a critical in manufacturing system
4. Communication is the nervous systems of CIM
5. Product design information can be transmitted to manufacturing for use in process planning

Part III: - Give clear answer to the given questions bellow

1. Explain fundamental needs of computer communication
2. Discuss in detail about computer network in CIM production
3. List and explain feasibility study procedure of CIM project
4. Explain the difference between CIM concept versus CIM technology
5. List the major elements of CIM system

Unit Two: CIM System Production Process

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Investigation and measurements of CIM process
- Modeling and calculation
- Conventional and CIM production solution arrangement
- Sustainability implication
- Review Concept proposals

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Preform investigations and measurements.
- Carry out required modelling and calculations.
- Generate arrangement of conventional and CIM production solutions.
- Determine Social and sustainability implications of solutions.
- Review Concept proposals with client.

2.1 Investigation and measurements of CIM process

Computer process monitoring (Computer assisted data collection systems);

Computer process monitoring is a data collection system in which the computer is directly connected to the workstation and associated equipment for the purpose of observing the operation.

Components used to build a computer process monitoring system

- Transducers and sensors,
- Analog to digital converters (ADC),
- Multiplexers,
- Real time clocks, and
- Other electronic devices
- Configurations of computer assisted data collection systems
- Or (Automated data collection system)?
- Data logging systems
- Data acquisition systems
- Multilevel scanning

Types of data collection systems;

- On-line data collection systems
- Off-line data collection systems

Factory Data Collection System

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

- ✓ Workstation terminals

Data acquisition system (DAS);

The data acquisition system that collects data from the various production operations for direct communication to a central computer. Hence it is called as online system.

Automatic identification methods;

Automatic identification is a term that refers to various technologies used in automatic or semi-automatic acquisition of product data for entry into a computer system.

Automatic identification methods

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

Classifications of bar codes according to the dimensions of width

High density: X dimension is 0.010 in. or less.

Medium density: X dimension is between 0.010 and 0.030 in.

Low density: X dimension is 0.030 in. or greater.



Figure 2,1 bar code

A barcode is an optical machine-readable representation of data relating to the object to which it is attached. Originally barcodes systematically represented data by varying the widths and spacing's of parallel lines, and may be referred to as linear or one-dimensional (1D).

Barcode Reader

A barcode reader is used to read the code. The reader uses a laser beam that is sensitive to the reflections from the line and space thickness and variation. The reader translates the reflected light into digital data that is transferred to a computer for immediate action or storage.

Barcode Scanning Technology

Scanning technology is constantly evolving and providing industries with more choices in data capture solutions. Two competing data capture devices: the laser scanner and the digital imager have many businesses facing a tough decision.

Deciding which scanning technology is right for your application can be a difficult task. Knowing the advantages and applications in which these two technologies are used is the first step to success.

The key to deciding between these two technologies is determining which fits the requirements and budget of your business most accurately.



Figure 2.2 2D Data Matrix Code

Types of bar code readers;

- Fixed beam reader,
- Moving beam reader.
- Smart cards
- Smart cards are made of plastic.

They are of the size of a credit card and are embedded with one or more microchips.

These have a 8 bit or higher level microprocessors and a storage capacity of about 8kB-256kB. Personal identification numbers prevent their unauthorized use.

2.2. Modeling and calculation

The computer has had and continues to have a dramatic impact on the development of production automation technologies. Nearly all modern production systems are implemented today using computer systems. The term computer integrated manufacturing (CIM) has been coined to denote the pervasive use of computers to design the products, plan the production, control the operations, and perform the various business related functions needed in a manufacturing firm. CAD/CAM (computer-aided design and computer-aided manufacturing) is another term that is used almost synonymously with CIM.

2.2.1 **Computer Aided Design**

Computer aided design can be defined as any design that involves the effective use of computers to create, modify or document an engineering design.

i. CAD system;

The cad system consists of two basic components; they are;

- Computer Hardware;
  - It consists of graphic workstations,
  - Graphic input devices like keyboard, mouse etc.,
  - Graphic output devices like printer and plotters.
- Computer Software;
  - It consists of operating system for basic operations,
  - Software package used for geometric modeling,
  - Application software for design, analysis and synthesis.

ii. Elements of CAD; (or) Various phases of CAD;

The design process in a CAD system consists of 4 stages / phases, they are;

- Geometric modeling,
- Design analysis and optimization,

- Design review and evaluation,
- Documentation and drafting.

iii. Drawing entities;

A drawing is created using a no. of entities. A large no. of options are provided to draw the entities depending upon the requirements.

Common entities are;

- Point, * Line, * Arc, * Ellipse,
- Circle, *Polygon, *Spline, *Rectangle, etc.,

iv. Drawing Utilities;

Drawing utilities include several functions to have the creation and storage of drawings. Common utilities are;

- *Screen size, * Line type, * Scaling * Layers,
- *Grid, *Snap,, *Units, , *file utilities, etc.,

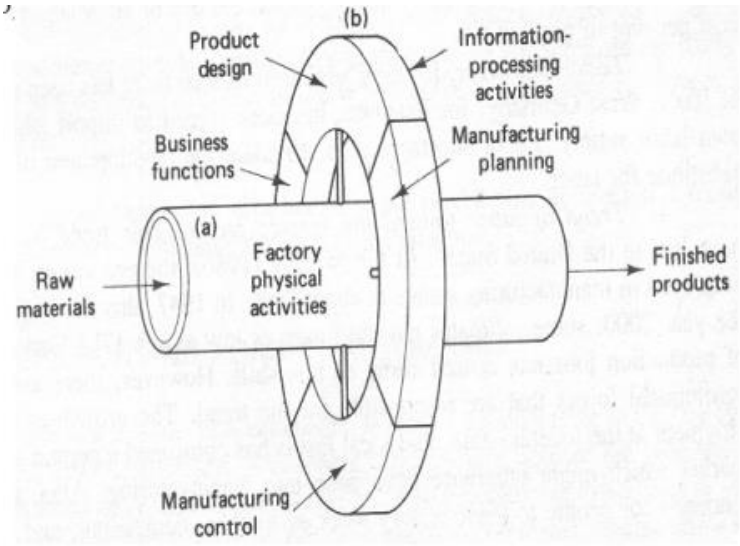
v. Editing commands in CAD;

It is necessary to make the corrections and alterations to the entities of a drawing. Editing commands are used for this process. A few editing commands are listed below,

- *Erase, *Move, *Array, *Fillet, * Chamfer
- *Mirror *Rotate, *Trim, *Copy *Scale, etc.,

vi. Geometric modeling;

Geometric modeling involves the use of a CAD system to develop a mathematical description of the geometry of an object.



The mathematical description, called a geometric model is contained in computer memory. These operations include creating new geometric models from basic building blocks available in the system.

vii. **Geometric modeling techniques**;

These are various types of geometric models used in CAD,

- Based on the dimensioning,
  - Two-dimensional modeling,
  - Three-dimensional modeling.
- Based on the modeling,
  - Wire frame modeling,
  - Surface modeling,
  - Solid modeling

viii. 2D Vs 3D;

2D models are best utilized for design problems, such as flat objects and layouts of building.

3D models are capable of modeling an object in three dimensional according to user instructions. This is helpful in conceptualizing the object since in true 3D models can be displayed in various views and form different angles.

ix. Advantages of CAD;

- High productivity and reduced lead time,
- Accuracy in design,
- Better central over the complete project process,
- Modifications in design relatively easy,
- Simulations of the computer generated model can reduce or eliminate prototype testing,
- Effective creation of manufacturing documentation,
- Optimized solution can be received,

x. Various 2D transformations;

In computer graphics drawing are created by serious primitives which are represented by the coordinates of their end points.

Certain changes in these drawings can be made by performing some mathematical operations on these coordinates. The basic transformations are Scaling, Rotation, translation, etc..,

xi. CAD software package;

Auto CAD, CATIA, Iron CAD, Pro-E, Turbo CAD, Solid Edge, etc..,

xii. Advantages of Wireframe Modeling;

- Simple to construct,
- Designer needs little training.
- It needs less memory space,
- It takes less manipulation time,
- It is best suitable for manipulation as orthographic, isometric and perspective views



Figure 2.3 wire frame model

xiii. Surface modeling

Surface modeling is the next stage of wireframe modeling. In wireframe modeling models are unable to represent complex surfaces of objects like car, ship, airplane, wings, castings etc. only a surface profile of these objects. A surface model represents the skin of an object. These skins have no thickness or material type. Surface models define the surface properties, as well as the edges of objects.

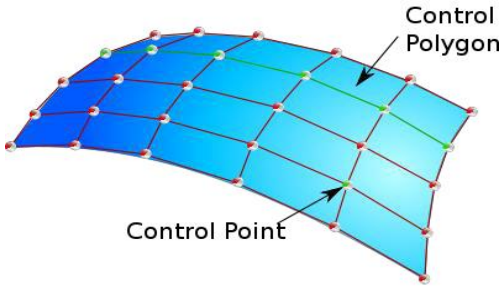


Figure 2.4 surface modeling

xiv. CSG – Constructive Solid Geometry;

CSG technique uses Boolean combinations or primitive's solids to build a part.

The Boolean operations are addition (+), subtraction (-), as illustrated in three dimensions.

Solid modeling is the most powerful of 3D modeling technique. This includes vertices (nodes), edges, surfaces, weight and volume. This model consisting of the complete description of the solid in a certain form is the most ideal representation, as all the information requires at every stage of product cycle can be obtained with technique.

xv. Advantages of Solid Modeling;

- It is complete and unambiguous.
- Suitable for automated applications like creating part program without much human involvement. [Ref.3]

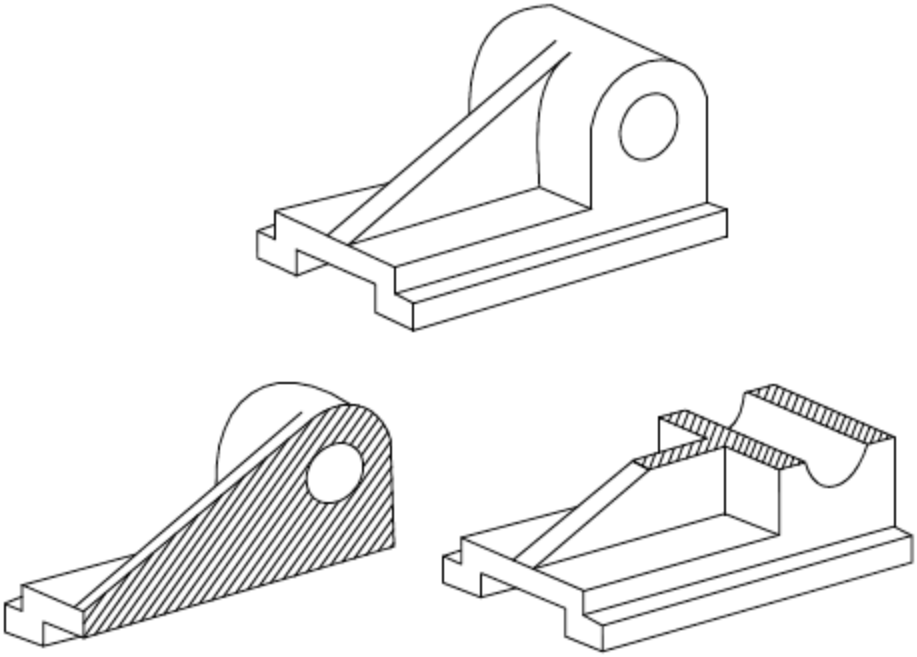


Figure 2.5 solid modeling

In engineering practice, CAD/CAM has been utilized in different ways by different people.

- Some utilize it to produce drawings and document designs.
- Others may employ it as a visual tool by generating shaded images and animated displays.
- A third group may perform engineering analysis of some sort on geometric models such as finite element analysis.
- A fourth group may use it to perform process planning a generate NC part programs. In order to establish the scope and definition of CAD/CAM in an engineering environment and identify existing and future related tools, a study of a typical product cycle is necessary. Figure 2.3 shows a flowchart of such a cycle.

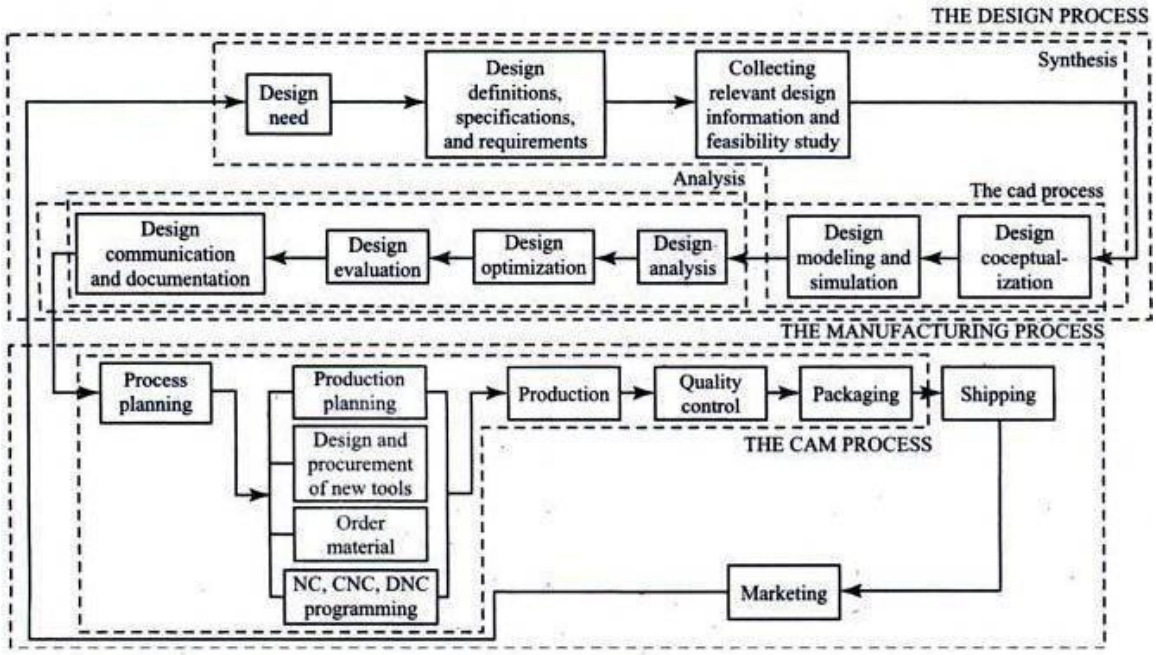


Figure 2.6 Typical Product Cycle

- CAD tools can be defined as the intersection of three sets: geometrical modeling, computer graphics and the design tools.
- Figure 1.2 shows such definition. As can be perceived from this figure, the abstracted concepts of geometric modeling and computer graphics must be applied innovatively to serve the design process.

2.3. Conventional and CIM production process solution arrangement

Process Planning Definition

It can be defined as "an act of preparing a detailed processing documentation for the manufacture of a piece part or assembly." According to the American Society of Tool and Manufacturing Engineers.

Process planning is the systematic determination of the methods by which a product is to be manufactured economically and competitively

It consists of devising, selecting and specifying processes, machine tools and other equipment, transform the raw material into finished product as per the specifications called for by the drawings.

Process Planning Vs Production Planning

Process planning

It is concerned with the engineering and technological issues of how to make the product and its parts.

It specifies types of equipment and tooling required to fabricate the parts and assemble the product.

Production planning

- It is concerned with the logistics issues of making the product.
- It is concerned with ordering the materials and obtaining the resources required to make the product in sufficient quantities to satisfy demand for it.
- Production is done only after the process planning.

Types of Production

Another way of classifying production activity is according to the quantity of product made. In this classification, there are three types of production:

- Job shop production
- Batch production
- Mass production

Job shop production. The distinguishing feature of job shop production is low volume. The manufacturing lot sizes are small, often one of a kind. Job shop production is commonly used to meet specific customer orders, and there is a great variety in the type of work the plant must do. Therefore, the production equipment must be flexible and general-purpose to allow for this variety of work. Also, the skill level of job shop workers must be relatively high so that they can perform a range of different work assignments. Examples of products manufactured in a job shop include space vehicles, aircraft, machine tools, special tools and equipment, and prototypes of future products. Construction work and shipbuilding are not normally identified with the job shop category, even though the quantities are in the appropriate range. Although these two activities involve the

transformation of raw materials into finished products, the work is not performed in a factory

Batch production: This category involves the manufacture of medium-sized lots of the same item or product. The lots may be produced only once, or they may be produced at regular intervals. The purpose of batch production is often to satisfy continuous customer demand for an item. The manufacturing equipment used in batch production is general-purpose but designed for higher rates of production. Examples of items made in batch-type shops include industrial equipment, furniture, textbooks, and component parts for many assembled consumer products (household appliances, lawn mowers, etc.). Batch production plants include machine shops, casting foundries, plastic molding factories, and press working shops. Some types of chemical plants are also in this general category.

Mass production: This is the continuous specialized manufacture of identical products. Mass production is characterized by very high production rates, equipment that is completely dedicated to the manufacture of a particular product, and very high demand rates for the product. Not only is the equipment dedicated to one product, but the entire plant is often designed for the exclusive purpose of producing the particular product. The equipment is special-purpose rather than general-purpose.

Group Technology (GT)

Group technology is a manufacturing technique and philosophy to increase production efficiency by exploiting the “underlying sameness” of component shape, dimensions, process route, etc.

GT is a manufacturing philosophy in which similar parts are identified & grouped together to make advantage of their similarities in design and production.

Part Family

part family is a Collection of parts that are similar either because of geometric shape and size or because similar processing steps are required in their manufacture.

Design attributes

- Part configuration
- Dimension envelope
- Surface integrity
- Material type
- Raw material state

Manufacturing attributes

- Operation and operation sequence
- Batch size
- Machine tools
- Cutting tools
- Work holding devices
- Processing time

Process layout

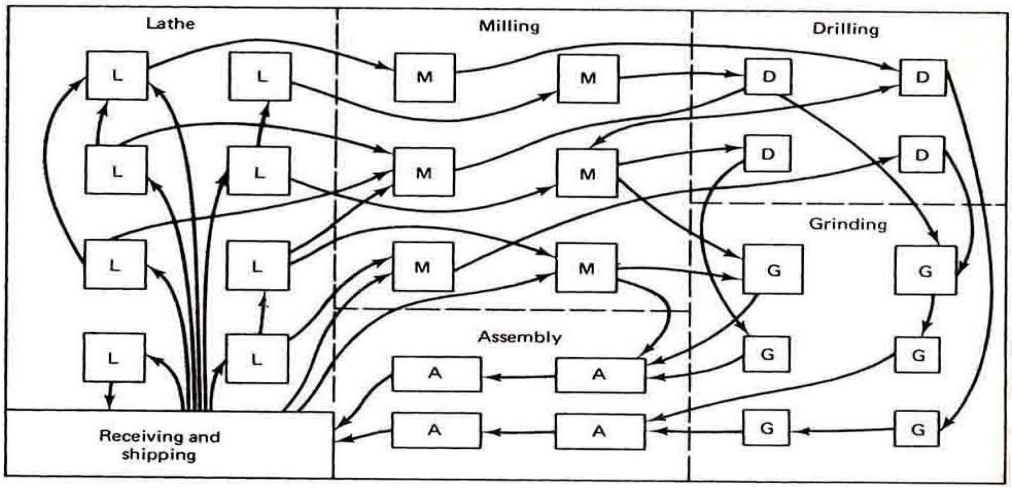


Figure 2.7 process layout

Implementing group technology (GT)

Identifying the part families If the plant makes 10,000 different parts, reviewing all of the part drawings and grouping the parts into families is a substantial task that consumes a significant amount of time.

Rearranging production machines into cells It is time consuming and costly to plan and accomplish this rearrangement, and the machines are not producing during the changeover.

Group Technology Layout

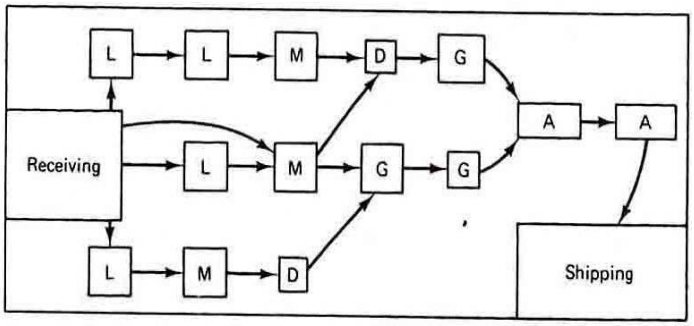


Figure 2.8 group technology

Methods for Part Family

There are three general methods for solving part families grouping. All the three are time consuming and involve the analysis of much of data by properly trained personnel. The three methods are:

- Visual inspection.
- Parts classification and coding.
- Production flow analysis.

Visual Inspection Method

The visual inspection method is the least sophisticated and least expensive method.
• It involves the classification of parts into families by looking at either the physical parts or their photographs and arranging them into groups having similar features.

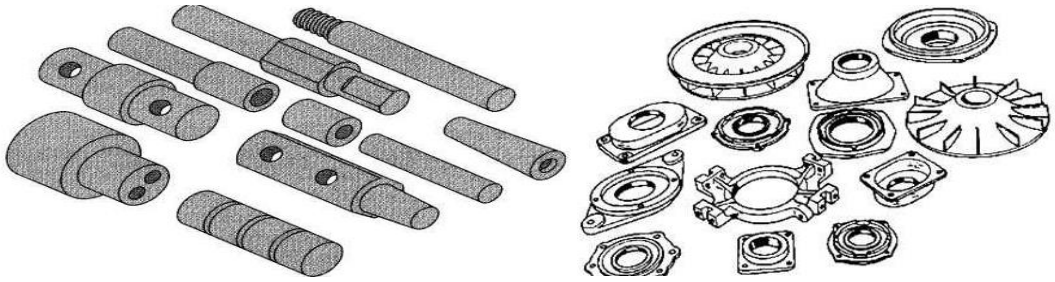


Figure 2.9 visual inspection

Production Concepts and Mathematical Models

A number of production concepts are quantitative, or require a quantitative approach to measure them.

Manufacturing lead time

Our description of production is that it consists of a series of individual steps: processing and assembly operations. Between the operations are material handling, storage, inspections, and other nonproductive activities. Let us therefore divide the activities in production into two main categories, operations and non-operation elements. An operation on a product (or work part) takes place when it is at the production machine. The non-operation elements are the handling, storage, inspections, and other sources of delay. Let us use ***To*** to denote the Time per operation at a given machine or workstation, and ***Tno*** to represent the non-operation time associated with the same machine. Further, let us suppose that there are $\mathbf{n_m}$ separate machines or operations through which the product must be routed in order to be completely processed. If we assume a batch production situation, there are Q units of the product in the batch, a setup procedure is generally required to prepare each production machine for the particular product. The setup typically includes arranging the workplace and installing the tooling and featuring required for the product. Let this setup time be denoted as *Tm*.

Given these terms, we can define an important production concept, manufacturing lead time. The manufacturing lead lime (MLT) is the total time required to process a given product (or work part) through the plant. We can express it as follows:

$$\boldsymbol{MLT = \sum_{i=1}^{nm}(T_{sui} + QT_{oi} + T_{noi}}\text{-------equ. 1}$$

Where i indicates the operation sequence in the processing, i = 1, 2, ..n The MLT equation does not include the time the raw work part spends in storage before its turn in the production schedule begins.

Let us assume that all operation times, setup times, and non-operation times are equal, respectively then MLT is given by

$$\boldsymbol{MLT = n_m(T_{su} + QT_o + T_{no})}\text{----------equ.2}$$

For mass production, where a large number of units are made on a single machine, the MLT simply becomes the operation time for the machine after the setup has been completed and production begins.

For flow-type mass production, the entire production line is set up in advance. Also, the non operation time between processing steps consists simply of the time to transfer the product (or pan) from one machine or workstation to the next. If the workstations are integrated so that parts are being processed simultaneously at each station, the station with the longest operation time will determine the MLT value. Hence

$$MLT = n_m(Transfer\ time + \ \ Longst\ T_0$$

In this case, nm represents the number of separate workstations on the production line. The values of setup time, operation time, and non-operation time are different for the different production situations. Setting up a flow line for high production requires much more time than setting up a general-purpose machine in a job shop. However, the concept of how time is spent in the factory for the various situations is valid.

Production Rate

The production rate for an individual manufacturing process or assembly operation is usually expressed as an hourly rate (e.g., units of product per hour). The rate will be symbolized as ***Rp***

$$R_p = \frac{1}{T_p}$$

Where Tp is given by

$$T_P = \frac{Batch\ time\ per\ machine}{Q}$$

$$T_p = \frac{(T_{su} + QT_0)}{Q}$$

If the value of Q represents the desired quantity to be produced, and there is a significant scrap rate, denoted by q, then T_P is given by

$$T_P = \frac{(T_{su+(\frac{QT_0}{1-q})})}{Q}$$

Components of the operation time

The components of the operation time ***To***, The operation time is the time an individual Work part spends on a machine, but not all of this time is productive. Let us try to relate the operation time to a specific process. To illustrate, we use a machining operation, as machining is common in discrete-parts manufacturing. Operation lime for a machining operation is composed of three elements: the actual machining time ***Tm***, the workpiece handling time T_h, and any tool handling time per workpiece Th. Hence,

$$T_0 = T_m + T_h + T_{th}$$

The tool handling time represents all the time spent in changing tools when they wear out, changing from one tool to the next for successive operations performed on a turret lathe, changing between the drill bit and tap in a drill-and-tap sequence performed at one drill press, and so on. *T,h* is the average time per workpiece for any and all of these tool handling activities.

Each of the terms T_m,T_h, and T,$_h$ has its counterpart in many other types of discrete-item production operations. There is a portion of the operation cycle, when the material is actually being worked (Tm), and there is a portion of the cycle when either the work part is being handled (T_k) or the tooling is being adjusted or changed (T,$_h$). We can therefore generalize to cover many other manufacturing processes in addition to machining.

Capacity

The term capacity, or plant capacity, is used to define the maximum rate of output that a plant is able to produce under a given set of assumed operating conditions. The assumed operating conditions refer to the number of shifts per day (one, two, or three), number of days in the week (or month) that the plant operates, employment levels, whether or not overtime is included, and so on. For continuous chemical production, the plant may be operated 24 h per day, 7 days per week.

Let $\boldsymbol{PC}$ be the production capacity (plant capacity) of a given work center or group of work centers under consideration. Capacity will be measured as the number of good units produced per week. Let $\boldsymbol{W}$ represent the number of work centers under consideration. A work center is a production system in the plant typically consisting of one worker and one machine. It might also be one automated machine with no worker, or several workers acting together on a production line. It is capable of producing at a rate $\boldsymbol{Rp}$ units per hour. Each work center operates for $\boldsymbol{H}$ hours per shift. $\boldsymbol{H}$ is an average that excludes time for machine breakdowns and repairs, maintenance, operator delays, and so on. Provision for setup time is also included

If we include the possibility that in a batch production plant, each product is routed through $\boldsymbol{n_m}$ machines, the plant capacity equation must be amended as follows:

$$\boldsymbol{PC} = (\frac{\boldsymbol{WS_wHR_p}}{\boldsymbol{n_m}}$$

Another way of using the production capacity equation is for determining how resources might be allocated to meet a certain weekly demand rate requirement. Let $\boldsymbol{Dw}$ be the demand rate for the week in terms of number of units required. Replacing $\boldsymbol{PC}$ and rearranging, we get

$$\boldsymbol{WS_wH} = \frac{\boldsymbol{D_w n_m}}{\boldsymbol{R_p}}$$

Given a certain hourly production rate for the manufacturing process, indicates three possible ways of adjusting the capacity up or down to meet changing weekly demand requirements:

- Change the number of work centers, $\boldsymbol{W}$, in the shop. This might be done by using equipment that was formerly not in use and by hiring new workers. Over the long term, new machines might be acquired.
- Change the number of shifts per week, $\boldsymbol{5W}$. For example, Saturday shifts might be authorized.

- Change the number of hours worked per shift, $\boldsymbol{W}$. For example, overtime might be authorized

In cases where production rates differ, the capacity equations can be revised, summing the requirements for the different products.

$$\boldsymbol{WS_wH = \sum \frac{(D_w n_m)}{R_p}}$$

Utilization

Utilization refers to the amount of output of a production facility relative to its capacity. Letting U represent utilization, we have

$$\boldsymbol{U = \frac{output}{capacity}}$$

Availability

The availability is sometimes used as a measure of-reliability for equipment. It is especially germane for automated production equipment. Availability is defined using two other reliability terms, *the mean time between failures* (MTBF) and the *mean time* to repair (MTTR). The MTBF indicates the average length of time between breakdowns of the piece of equipment. The MTTR indicates the average time required to service the equipment and place it back into operation when a breakdown does occur:

$$\text{Availability } = \frac{MTBF_MTTR}{MTBF}$$

Work-in-process

Work-in-process (WIP) is the amount of product currently located in the factory that is either being processed or is between processing operations. WIP is inventory that is in the state of being transformed from raw material to finished product. A rough measure of work-in-process can be obtained from the equation

$$WIP = \frac{PCU}{S_w H}(MLTR)$$

Where WIP represents the number of units in-process.

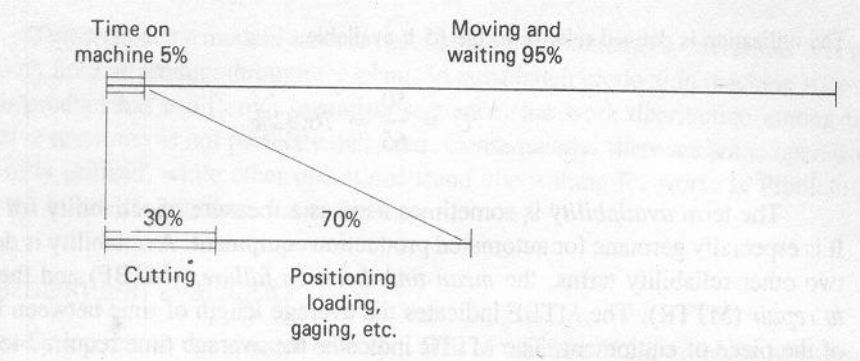


Figure 2.10 Time spent a part in batch production shop

The WIP ratio is therefore determined as

$$\boldsymbol{WIP\ ratio\ = \frac{WIP}{Number\ of\ machine\ processing}}$$

$$\boldsymbol{Number\ of\ processing\ machine\ = WU\frac{QT_0}{T_{su}\ + QT_o}}$$

2.4 sustainability implication in CIM system

CIM systems can have a significant impact on sustainability in a number of ways. For example:

Reduced energy consumption: CIM systems can help to reduce energy consumption by optimizing the manufacturing process and eliminating waste. For example, MES software can be used to schedule machines and processes in a way that minimizes energy consumption.

Reduced material waste: CIM systems can help to reduce material waste by automating the manufacturing process and ensuring that materials are used efficiently. For example, CAM software can be used to generate machine instructions that minimize material waste.

Reduced environmental impact: CIM systems can help to reduce the environmental impact of manufacturing by reducing emissions and pollution. For example, MES software can be used to monitor and control emissions from manufacturing processes.

In addition to these specific benefits, CIM systems can also support sustainability initiatives in a number of other ways. For example, CIM systems can be used to:

Improve product design: CIM systems can be used to design products that are more energy-efficient and environmentally friendly. For example, CAD software can be used to simulate the performance of products in different conditions, which can help to identify and reduce potential environmental impacts.

Optimize the supply chain: CIM systems can be used to optimize the supply chain and reduce transportation emissions. For example, ERP software can be used to track inventory levels and coordinate shipments in a way that minimizes transportation distances.

Reduce waste: CIM systems can be used to reduce waste throughout the manufacturing process. For example, MES software can be used to track production data and identify areas where waste can be reduced.

Overall, CIM systems can have a significant positive impact on sustainability in manufacturing. By automating and coordinating the manufacturing process, CIM systems can help businesses to reduce energy consumption, material waste, and environmental impact.

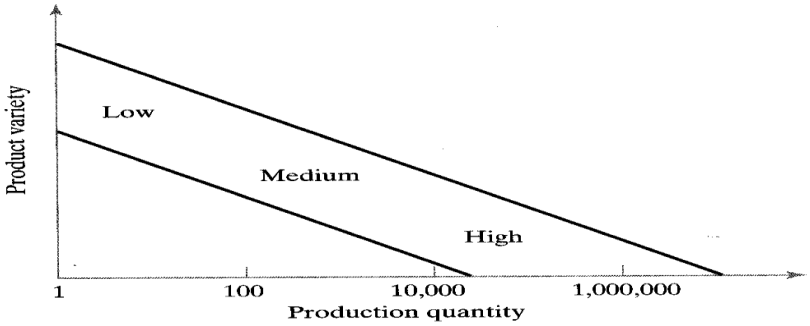
These are just a few examples of how CIM systems can be used to improve sustainability in manufacturing. As CIM technology continues to develop, we can expect to see even more innovative and effective ways to use CIM systems to reduce the environmental impact of manufacturing

Flexible Manufacturing System (FMS)

A flexible manufacturing system (FMS) is a highly automated GT machine cell, consisting of a group or processing workstations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by a distributed computer system.

The reason the FMS is called flexible is that it is capable of processing a variety of different part styles simultaneously at the various workstations, and the mix of part styles and quantities of production can be adjusted in response to changing demand patterns.

The FMS is most suited for the mid-variety, mid-volume production range



Types of FMS Systems

Flexible manufacturing systems can be distinguished according to the number of machines in the system. The following are typical categories:

- Single machine cell (Type I A)
- Flexible manufacturing cell (usually type II A, sometimes type III A)
- Flexible manufacturing system (usually Type II A, sometimes type III A)

I. Single Machine Cell (SMC)

A single machine cell consists of one CNC machining center combined with a parts storage system for unattended operation. Completed parts are periodically unloaded from the parts storage unit, and raw work parts are loaded into it.

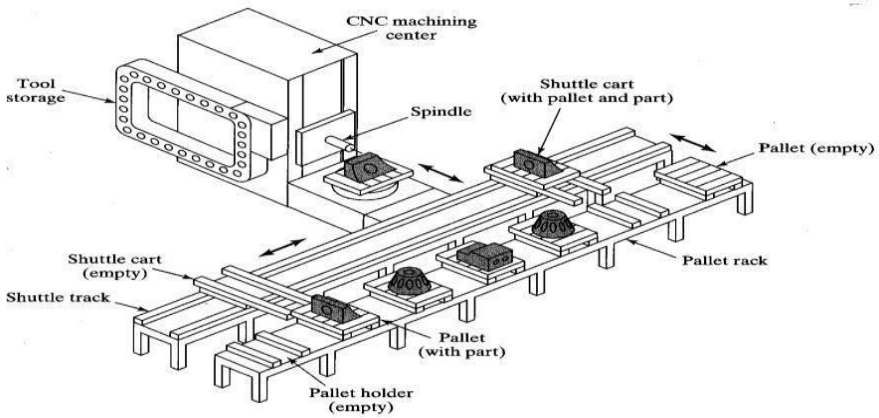


Figure 2.11 single machine cell

II. Flexible Manufacturing Cell (FMC)

A flexible manufacturing cell consists of two or three processing workstations (typically CNC machining centers) plus a part handling system. The part handling system is connected to a load/unload station.

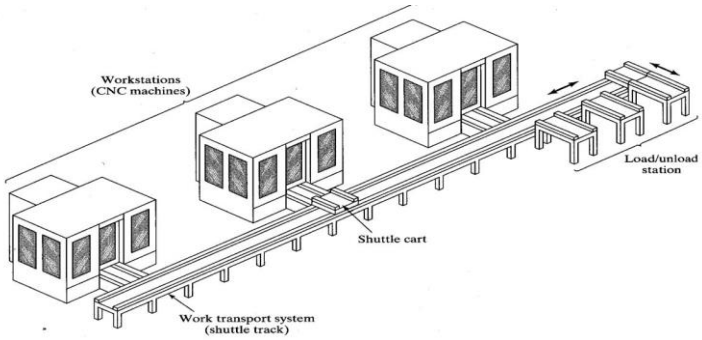


Figure 2.12 flexible manufacturing cell

Flexible Manufacturing System (FMS)

A flexible manufacturing system has four or more processing workstations connected mechanically by a common part handling system and electronically by a distributed computer system

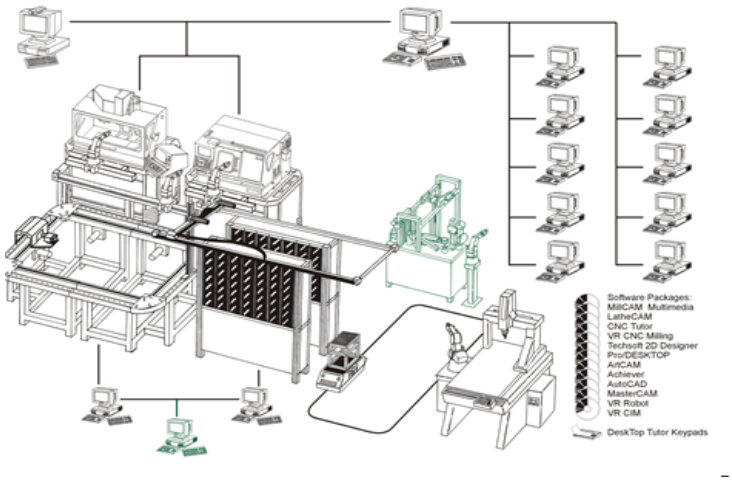


Figure 2.13 flexible manufacturing system

Self-Check 2

Instructions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. Write your answers in the sheet provided.

Part I. Choose the correct answer of the following questions

1. A system that data from the various production operation for direct communication to a central computer is called?
   - **a.** Data acquisition system
   - **b.** Radio frequency system
   - **c.** Magnetic strip
   - **d.** Process monitoring
2. Which of the follow is a bar cod class?
   - **a.** High density
   - **b.** Medium density
   - **c.** Low density
   - **d.** All
3. What are different types of coding structure used in part coding schemes?
   - **a.** Hierarchical codes
   - **b.** Attribute codes
   - **c.** Hybrid codes
   - **d.** All
4. What are the components of FMS?
   - **a.** Processing stations or workstations
   - **b.** Material handling and storage
   - **c.** Computer control system
   - **d.** human labour
5. a manufacturing technology and philosophy used to increase production efficiency is called?
   - **a.** Production planning
   - **b.** Group technology
   - **c.** Geometric modelling
   - **d.** CIM system

Part II: - for the following questions given bellow say true if the sentence is correct say false if the sentence is not correct.

1. A bar code reader used to read the code
2. Part family is collection of parts that are difference in process step
3. CIM system can have significant impact on sustainability.
4. Production planning is concerned with the logistic issue

5. Flexible manufacturing system is manually processing of process

Part III:- explain each of the following questions bellow

1. Define process planning.
2. What is group technology?
3. List out any four benefits of GT?
4. What is meant by part family?
5. Write the various methods of part family formation
6. What is the basis for forming groups in group Technology?

LAP Test 2
Practical Demonstration

Name: _____ Date: _____TVT Technical Layouts

Time started: _____ Time finished: _____

Instructions:

A certain part is produced in a batch size of 50 units and requires a sequence of eight operations in the plant. The average setup time is 3 h, and the average operation time per machine is 6 min. The average non operation time due to handling, delays, inspections, and so on, is 7 h.

Task 1: compute how many days it will take to produce a batch, assuming that the plant operates on a 7-h shift per day

Task 2: Calculate Production Rate (R_p)

Task 2: - Calculate Production Time ($\boldsymbol{T_P}$)

Task 3: Calculate Operation Time **($\boldsymbol{T_o}$)**

Instruction II
A production machine is operated 65 h/week at full capacity. Its production rate is 20 units/hr. During a certain week, the machine produced 1000 good parts and was idle the remaining time.

Task 1: Determine the production capacity of the machine.

Task 2: What was the utilization of the machine during the week under consideration?

Task 3: determine Availability

Task 4: determine Work-in-process

Task 5: determine Number of processing machine

Unit Three: Features of CIM system

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Production process plan and control
- Customer service or Consult
- Process plan implementation
- Documentation

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Plane conventional production processes in comparison to CIM design.
- provide documentation, drawings, specifications and instructions.
- Consult Client and stakeholders.
- Prepare approved drafted production process for implementation.

3.1 Computer Aided Process Planning

This is the planning strategy for manufacturing the part. It is defined as the activity that translates part design specifications from an engineering drawing into the manufacturing operation instructions required to convert a part from a rough to a finished state. It represents the link between engineering design and shop-floor manufacturing. It is a major determinant of manufacturing cost and profitability. The gap between CAD and CAM can be shortened considerably by developing better systems for process planning.

3.1.1 There are two levels of process planning

High-level planning'- The planner identifies the machine able features (surfaces) of the part, groups them into set-ups, and orders these set-ups. The features to be cut in each of the set-ups, and the tools for cutting each feature.

Low-level planning- Specifying the details of performing each step that results from the first level such as choosing machines, cutting conditions (speed and feed), type of fixture, cost and time estimates, etc.

3.1.2 Approaches of Process Planning

There are three approaches of process planning

- Manual approach
- Computer assisted variant approach
- Computer assisted generative approach

The latter two are known as Computer Aided Process Planning (CAPP)

The following are some of the drawbacks of manual approach

- The approach becomes rapidly inefficient and unmanageable when the number of process plans and revision to those plans increase. Consequently, inconsistent plans and large time requirements for planning often result.

- The plans by this approach reflect the personal experiences and preferences of the process planner. This is considered a poor use of engineering skills because of the high clerical content in most of its functions.

These limitations have logically lead to computerized approach to process planning.

3.1.3 Conventional Process Planning

Traditionally, skilled planners perform process planning. Planning is based on planner's decisions. The quality of the plan highly depends on individual skill, knowledge and experience. Planning is very time consuming, because of voluminous routine work and calculations. Only little time is left for creative work and updating planner's knowledge. The functions of process planning in the conventional manufacturing industry are shown in Fig. 3.3.

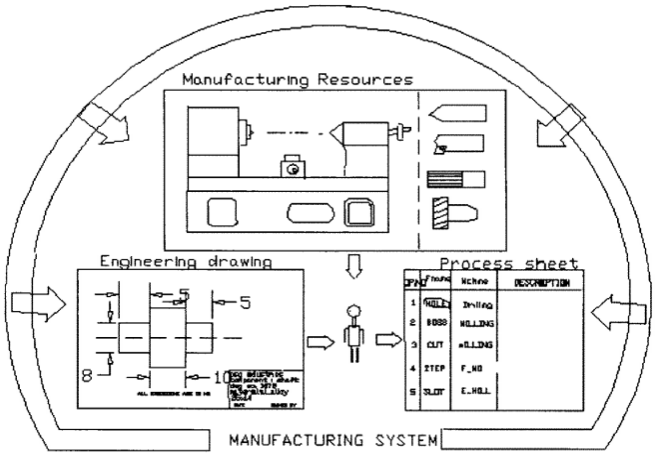


Figure 3.1 Conventional Process Planning

3.1.4 Importance of Computer Aided Process Planning

The importance of CAPP has already been identified by industries. Many companies in manufacturing sector have started developing CAPP for their internal use. The aim of Computer Aided Process Planning is to eliminate or at least reduce the manual intervention in process planning. The role of Process Planning from design to part is shown in Fig. 3.4. It is also found that there is generally a lack of consistency among process plans prepared by different individuals with varying manufacturing backgrounds and levels of skill. It is

therefore imperative to automate the process planning function and this makes CAPP important even in the absence of CAD and CAM.

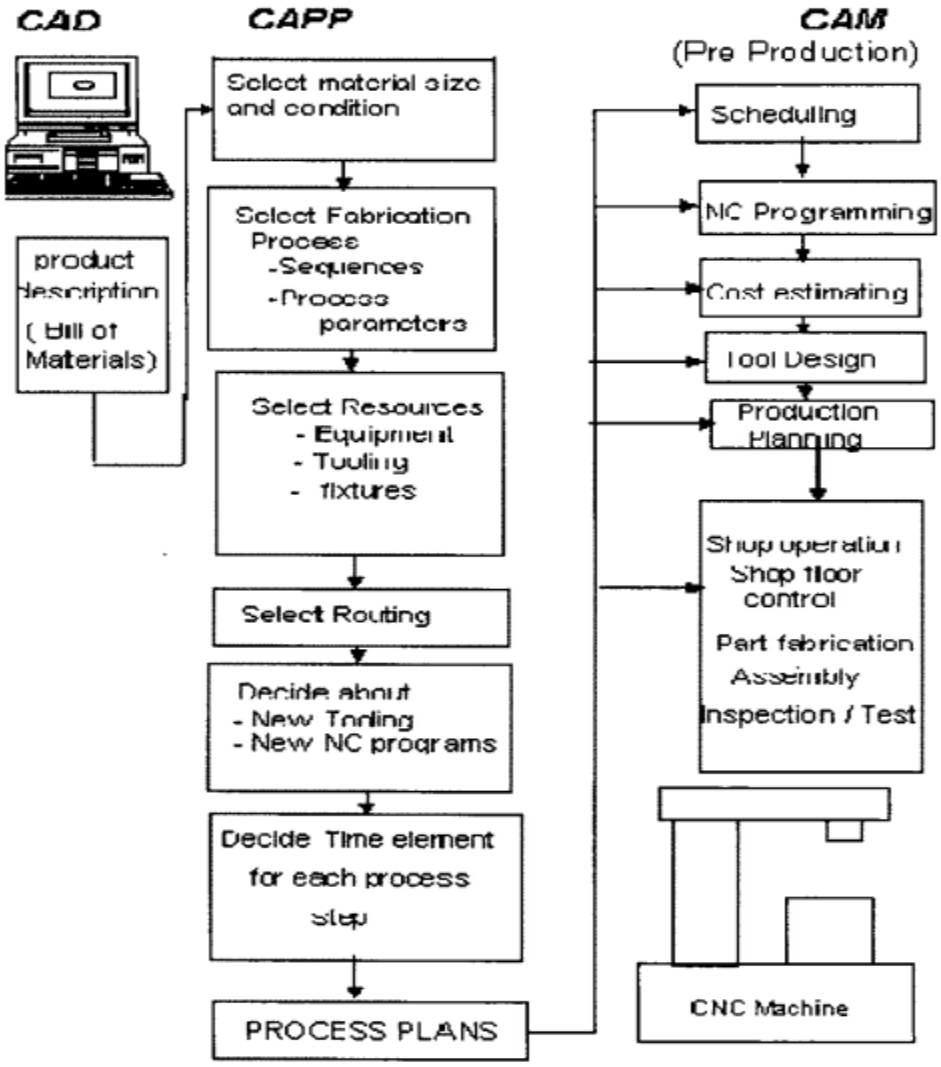


Figure 3.2 The role of CAPP in Integration of CAD/CAM

3.1.5 Conventional Process Planning versus CAPP

To manually plan processes for complicated parts, the process planners must be quite experienced persons. A Process planner usually spends considerable time to plan a process and complete the process documents depending the complexity of the part. It is thus evident that the development of a CAPP for the prismatic components is even more meaningful.

The aim of Computer Aided Process Planning is to eliminate or at least reduce the manual intervention in process planning.

The advantage of CAPP over conventional process planning is manifold.

- **It improves the quality and consistency of process plans.**
- **Savings in lead time**: In today's concepts of TQM and batch manufacturing lead time seriously effects the delivery time of the product which plays a major role in deciding the market share of any company.
- **Process rationalization:** CAPP generated process plan is more likely to be consistent (because the use of same software for all plants), logical and optimal (because the company has presumably incorporated the experience and judgement of its best manufacturing people into process planning software and computer can evaluate more number of alternatives in a less time).
- **Integration with manufacturing support functions:** These functions involve NC part program generation, computerized work standards etc., If done independently these functions involve duplication of clerical work.
- Increases the efficiency of process planning.
- Decreases the variety of tooling.
- **Error reduction:** Helps in overcoming the casual errors committed by human process planners. If the error goes unnoticed, it penalizes heavily from the cost point of view.
- It can reduce the skill required by planners.
- It can increase productivity.
- It can consider all available equipment while process planning.

3.2 Customer service or Consult approach in CIM system

A CIM system can play an important role in customer service in a number of ways. For example, a CIM system can help businesses to:

Improve product quality: By automating and coordinating the manufacturing process, CIM systems can help businesses to improve product quality. This can lead to fewer customer complaints and returns.

Reduce delivery times: CIM systems can help businesses to reduce delivery times by streamlining the manufacturing and shipping process. This can help businesses to meet customer expectations and improve customer satisfaction.

Provide better customer support: CIM systems can help businesses to provide better customer support by providing customer service representatives with access to real-time information about product availability, order status, and shipping information. This can help customer service representatives to answer customer questions quickly and accurately.

In addition to these specific benefits, CIM systems can also support customer service initiatives in a number of other ways. For example, CIM systems can be used to:

Collect and analyze customer feedback: CIM systems can be used to collect and analyze customer feedback from a variety of sources, such as surveys, social media, and customer service calls. This information can be used to identify areas where the company can improve its products and services.

Personalize customer interactions: CIM systems can be used to personalize customer interactions by providing customer service representatives with access to information about individual customer preferences and purchase history. This information can be used to provide customers with more relevant recommendations and offers.

Resolve customer issues quickly and efficiently: CIM systems can be used to resolve customer issues quickly and efficiently by providing customer service representatives with access to all of the information they need to resolve an issue, such as product information, order history, and customer support notes. This can help to reduce customer frustration and improve customer satisfaction.

Overall, CIM systems can play an important role in customer service by helping businesses to improve product quality, reduce delivery times, provide better customer support, and resolve customer issues quickly and efficiently.

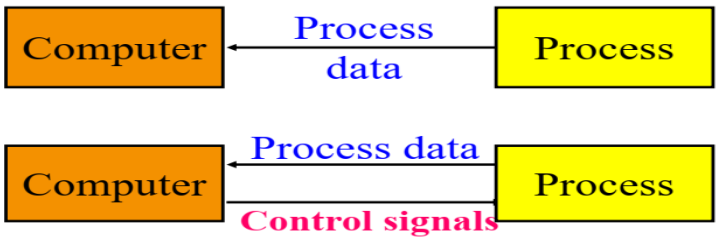
3.3 Implementation CAD/CAM

CAD/CAM = Computer Aided Design and Computer Aided Manufacturing. It is the technology concerned with the use of computers to perform design and manufacturing functions.

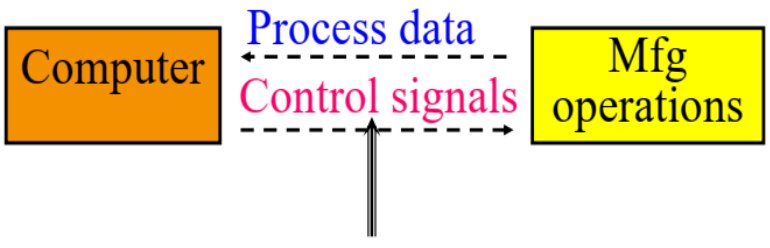
- CAD can be defined as the use of computer systems to perform certain functions in the design process.
- CAM is the use of computer systems to plan, manage and control the operations of manufacturing plant through either direct or indirect computer interface with the plant's production resources.

From CAM definition, the application of CAM falls into two broad categories:

a) Computer monitoring and control



b) Manufacturing support application.



3.1.1 The Product Cycle and CAD/CAM

In order to establish the scope and definition of CAD/CAM in an engineering environment and identify existing and future related tools, a study of a typical product cycle is necessary. The following Figure shows a flowchart of such a cycle.

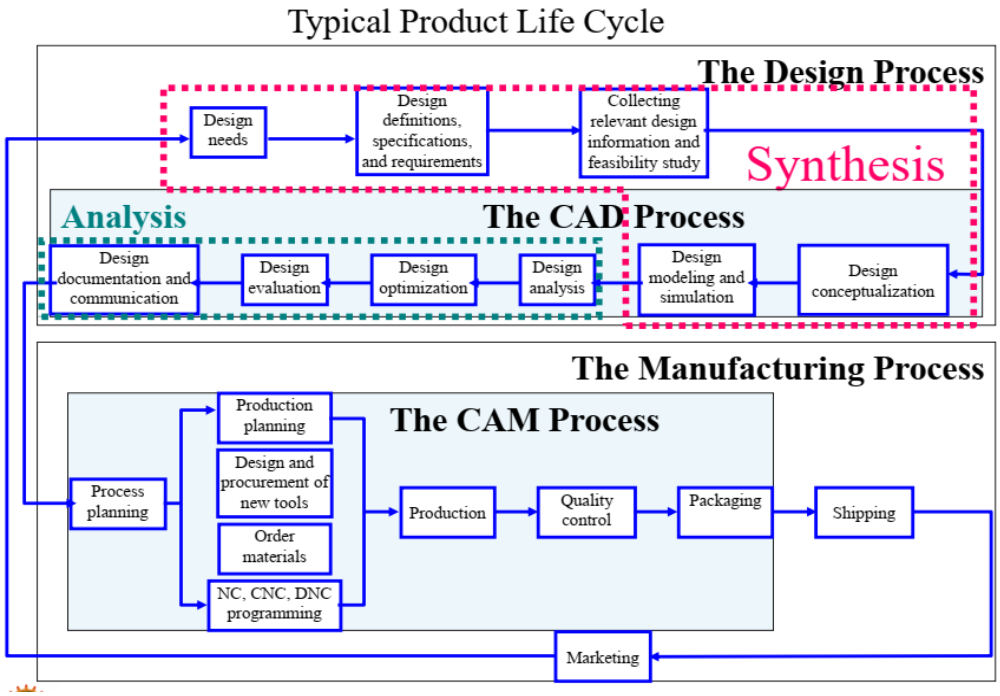


Figure 3.3 typical product life cycle

3.1.1 Reasons for Implementing a CAD System

I. To increase in the productivity of the designer

The CAD improves the productivity of the designer to visualize the product and its components, parts and reduces time required in synthesizing, analyzing and documenting the design.

II. To improve the quality of design

CAD system permits a more detailed engineering analysis and a large no. of design alternatives can be investigated.

o The design errors are also reduced because of the greater accuracy provided by system.

III. To improve communication in design

The use of a CAD system provides better engineering drawings, more standardization in drawing, better documentation of design, few drawing errors.

IV. To create a data base for manufacturing

In the process of creating the documentation for the product design, much of the required data base to manufacture the product can be created.

V. Improves the efficiency of design

It improves the efficiency of design process and the wastages at the design stage can be reduced.

3.1.1 Implementation of A Typical CAD Process On a CAD/CAM System

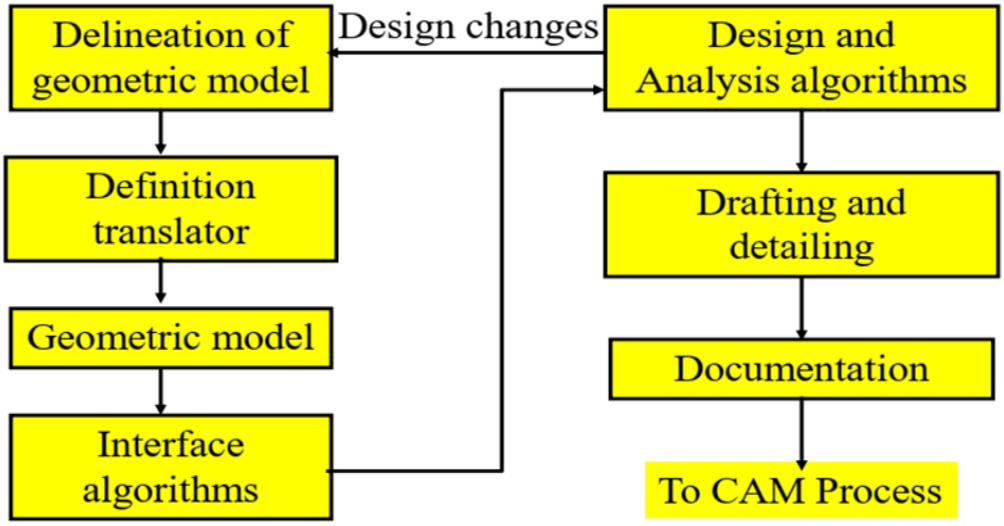


Table.3.1 CAD Tools Required to Support the Design Process

Design phase	Required CAD tools
Design conceptualization	Geometric modeling techniques; Graphics aids; manipulations; and visualization
Design modeling and simulation	Same as above; animation; assemblies; special modeling packages.
Design analysis	Analysis packages; customized programs and packages.
Design optimization	Customized applications; structural optimization.
Design evaluation	Dimensioning; tolerances; BOM; NC.
Design communication and documentation	Drafting and detailing…

3.1.1 Implementation of A Typical CAM Process On A CAD/CAM System

The product begins with a need which is identified based on customers' and markets' demands.

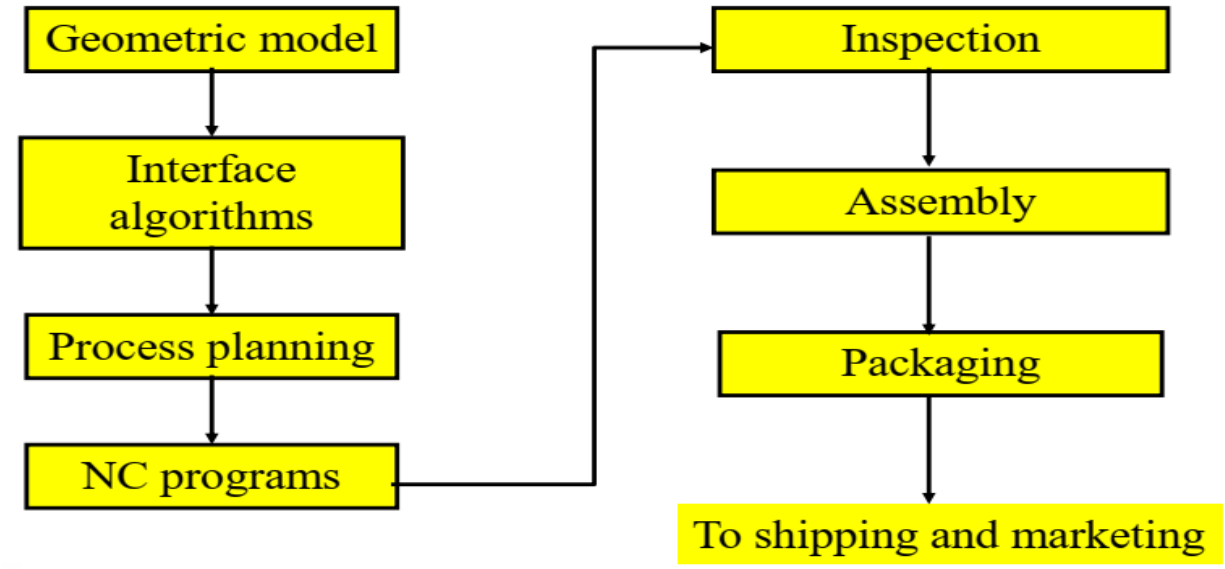
The product goes through two main processes from the idea conceptualization to the finished product:

- The design process.
- The manufacturing process.

The main sub-processes that constitute the design process are:

o Synthesis.

o Analysis.



3.4 Documentation of The Final Design

In the CIM (Computer Integrated Manufacturing) process, the final design documentation and evaluation procedure play a crucial role in ensuring the successful implementation of the manufacturing system. Here's an outline of a typical procedure for final design documentation and evaluation in CIM**:**

The documents provided are as follows:

- **Layout Drawings**: Describes the position of each machine and station.
- **Infrastructure Requirements**: Describes the requirements of the electric power line, LAN infrastructure, compressed air outlets and more.
- **PC and Table Requirements:** Describes the required computers and tables.
- **Test Application Description**: Describes the application to be performed for demonstration and acceptance test procedures.
- **Position Table:** Defines the positions used by the robotic program. Defined for each robot in each station.
- **I/O Table:** Describes the various input/output connections (digital I/O, RS-232) between different machines in a station (e.g., robot to CNC machine, etc).

If any of the documents listed here are missing, or if any further information is required, please contact Intelitek’s technical support.

Self-Check 3
Instructions

Given minutes 30 min provide what is asked.

- Enumerate the following. Use a separate sheet of paper for answering.
- For Short answers, write the answer for the questions on the provided space.

Part I. Choose the correct answer from the given alternatives

1. Which one of the following is levels of process planning?
    a. Single machine cell
    b. High level planning
    c. Group technology
    d. Flexible manufacturing
2. Which of the following is an approach of process planning that known as computer aide process planning?
    a. Manual process planning
    b. Computer assisted variant
    c. Computer assisted generative
    d. A and B are the answer
3. What is the importance of computer aided process planning?
    a. To reduce the manual intervention
    b. Save time
    c. Error reduction
    d. All
4. What is the advantage of CIM system in business?
    a. Improve quality
    b. Reduce delivery time
    c. Provide better customer service
    d. All
5. Which of the following is the reason of implementing CAD?
    a. To increase productivity
    b. To improve machine capacity
    c. To reduce quality

d. To improve supervision

Part II. For the following questions say True if the statement is correct and say false if the statement is incorrect

1. The CAD improves the productivity of the designer to visualize the product
2. A CIM system can play an important role in customer service
3. CAPP have no advantage in Savings lead time:
4. The product begins with a need which is identified based on customers' and markets' demands.
5. CIM system used to increase product quality

Part III. give brief and clear answer to the given questions given bellow

1. Explain in detail about the importance of computer process planning
2. Discuss in detail about the customer services quality in CIM system
3. Write the procedure of documentation in CIM system
4. What is the advantage of implementation of CAD/CAM?
5. Lis the procedure for final design documentation and evaluation in CIM:

Unit Four: Production process quality

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Standards and cods of CIM system

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Apply Production standards during the manufacturing process

4.1 Standards and cods of CIM system

The quality control (QC) function has traditionally been performed using manual inspection methods and statistical sampling procedures.

- Manual inspection is generally a time-consuming procedure which involves precise, yet monotonous work. If often requires that parts be removed from the vicinity of the production machines to a separate inspection area. This causes delays and often constitutes a bottleneck in the manufacturing schedule.
- Inherent in the use of statistical sampling procedures is acknowledgment of the risk that some defective parts will slip through. Indeed, statistical quality control attempts to guarantee that a certain expected or average fraction defect rate will be generated during the production/inspection process. The nature of traditional statistical QC procedures is that something less than 100% good quality must be tolerated.
- There is another aspect of the traditional QC inspection process which detracts from its usefulness. It is often performed after the fact. The measurements are taken and the quality is determined after the parts are already made. If the parts are defective, they must be scrapped or reworked at a cost which is often greater than their original cost to manufacture.

All of these various factors are driving the quality control function toward what we are calling computer-aided quality control (CAQC). Other terms that have been applied to describe this movement are "computer-aided inspection" (CAI) and "computer-aided testing" (CAT).

The objectives of computer-aided quality control are ambitious, yet straight forward. They are:

- To improve product quality
- To increase productivity in the inspection process
- To increase productivity and reduce lead times in manufacturing

The strategy for achieving these objectives is basically to automate the inspection process through the application of computers combined with advanced sensor technology. Wherever technically possible and economically feasible, inspection will be done on a 100% basis rather than sampling.

4.1.1 The Computer in Qc

Computer-aided inspection (CAI) and computer aided testing (CAT) are the two major segments of computer-aided quality control. Whereas these activities have been traditionally performed manually (with the help of gauges, measuring devices and testing apparatus), CAI and CAT are performed automatically using computer and sensor technology. Today, CAI and CAT can be well integrated into the overall CIM system

The following list summarizes the important benefits of CAQC

A. With Computer aided inspection and computer aided testing inspection and testing will typically be done on a 100% basis rather by the sampling procedures normally used in traditional QC. This eliminates any problem in assembly later and therefore is important in CIM.
B. Inspection is integrated into the manufacturing process. This will help to reduce the lead-time to complete the parts.
C. The use of non-contact sensors is recommended for computer aided inspection and CIM. With contact inspection devices, the part must be stopped and often repositioned to allow the inspection device to be applied properly. These activities take time. With non-contact sensing devices, the parts can be inspected while in operation. The inspection can thus be completed in a fraction of a second.
D. Sensor technology will not be the only manifestation of automation in CAQC. Intelligent robots fitted with computer vision and other sensors, as an integral part of completely automated test cells is also a feature of CIM.

E. An important feature of QC in a CIM environment is that the CAD/CAM database will be used to develop inspection plan.

Inspection methods:

a. contact method
b. non-contact method

Contact method:

In contact inspection, physical contact is made between the object to be inspected, and the measurement device. Typically contact is achieved using a mechanical probe or other device that touches the item, and allows the inspection procedure to occur. By its nature, contact inspection is concerned with some physical dimension of the part, and so contact methods are widely used in manufacturing and production industries to assess metal parts, and for electrical circuit testing.

a. Conventional instruments
b. Coordinate measuring machine
c. Stylus measuring system

Convention measuring instruments:

- scale
- gauge bars
- slip gauges
- Vernier calipers
- screw gauge

Coordinate Measuring Machine:

The coordinate measuring machine (CMM) is the most prominent example of the equipment used for contact inspection of parts. When used for CIM these machines are controlled by CNC. A typical three-dimensional measuring machine consists of a table, which holds the part in a fixed, position, and movable head, which holds a sensing, probe. The probe can be moved in three directions corresponding to the X, Y and Z Coordinates.

For manual operation, the control unit is provided with joysticks, or other devices which drive X, Y and Z servo motors (AC/DC).

Typical accuracies of these machines are in the neighborhood of +0.004 mm with are solution of 0.001 mm. The measuring accuracy of a typical CMM is quoted 2.6 +L/300 micrometers, where L is the measured length in mm

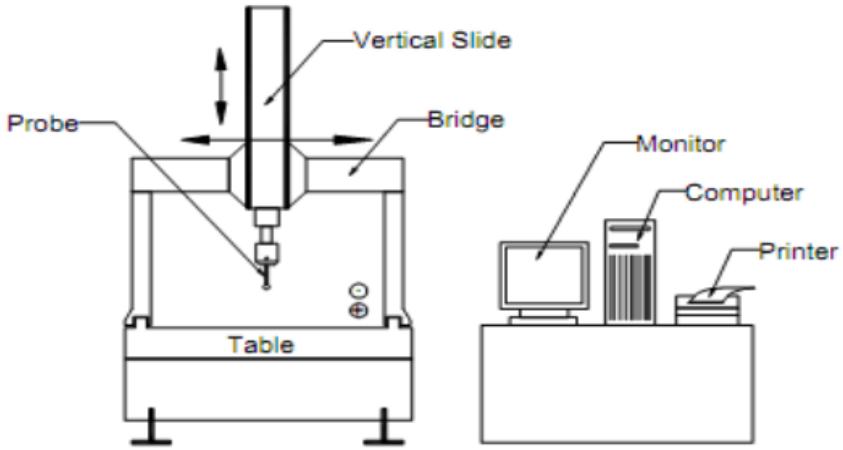


Figure 4.1 coordinate measuring machine

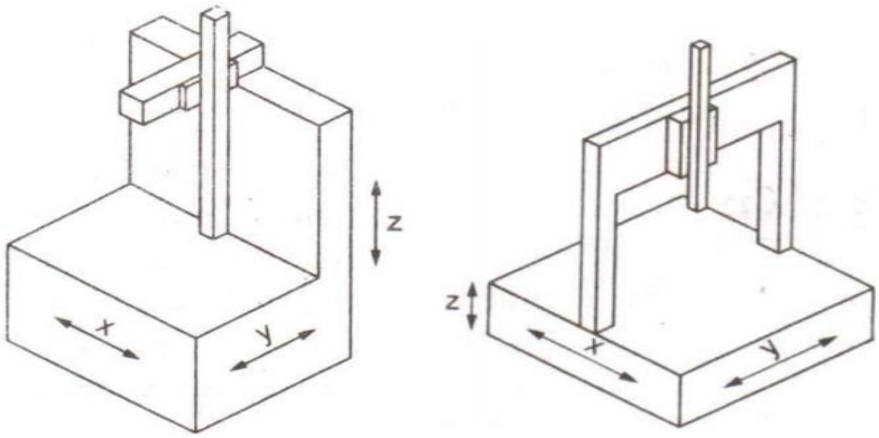
CMM consists of four main elements:

1. Main Structure:

The machine incorporates the basic concept of three coordinate axes so that precise movement in x, y, and z directions is possible. Each axis is fitted with a linear measurement transducer. The transducers sense the direction of Accordingly, there may be four types of arrangement:

Cantilever:

The cantilever construction combines easy access and relatively small floor space requirements. It is typically limited to small and medium sized machines. Parts larger than the machine table can be inserted into the open side without inhibiting full machine travel.



Cantilever type Bridge Type

Figure 4.2

Bridge Type:

The bridge arrangement over the table carries the quill (z-axis) along the x-axis and is sometimes referred to as a travelling bridge. It is claimed that the bridge construction provides better accuracy, although it may be offset by difficulty in making two members track in perfect alignment. This is by far the most popular CMM construction.

Column Type:

The column type machine is commonly referred to as a universal measuring machine rather than a CMM. These machines are usually considered gage room instruments rather than production floor machine. The constructional difference in column type with the cantilever type is with x and y-axes movements.

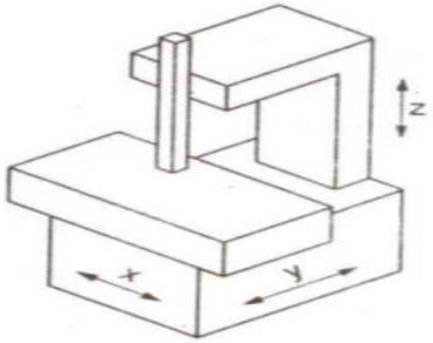


Figure 4.3 Column Type:

Gantry:

In a gantry type arrangement, arms are held by two fixed supports. Other two arms are capable of sliding over the supports. Movements of the x, y and z-axes. The gantry type construction is particularly suited for very large components and allows the operator to remain close to the area of inspection

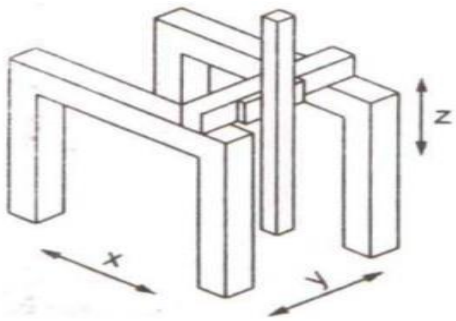


Figure 4.4 gantry

Horizontal:

The open structure of this arrangement provides optimum accessibility for large objects such as dies, models, and car bodies. Some horizontal arm machines are referred to as layout machines. There are some horizontal machines where the probe arm can rotate like a spindle to perform tramming operations. Tramming refers to accurate mechanical adjustment of instrument or machine with the help of tram.

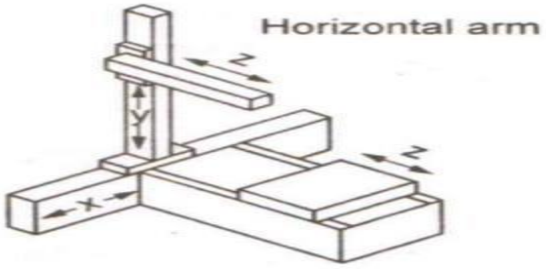


Figure 4.5 horizontal

Stylus instrument:

Stylus – type instruments are commercially available to measure surface roughness. These electronic devices have a cone shaped diamond stylus with point radius of about 0.005mm and a 90° tip angle that is traversed across the test surface at a constant slow speed. As the stylus head moves horizontally, it also moves vertically to follow the surface deviations. The vertical movements are converted in to an electronic signal that represents the topography of the surface along the path taken by the stylus. This can be displayed as either 1. a profile of the surface or 2. an average roughness value.

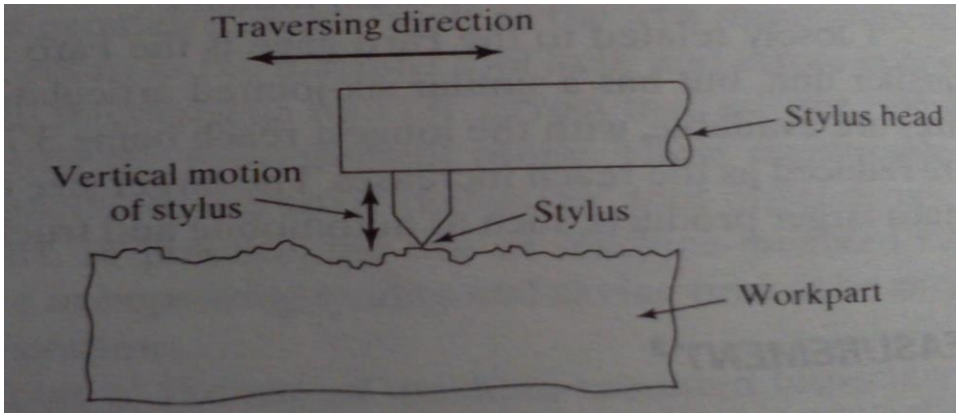


Figure 4.6 Stylus instrument

Non-contact inspection technologies:

Noncontact inspection methods utilize a sensor located at a certain distance from the object to measure or gage the desired features. The noncontact inspection technologies can be classified into two categories: 1. optical 2. Non optical Optical inspection technologies use light to accomplish the measurement or gaging cycle.

Non optical inspection technologies utilize energy forms other than light to perform the inspection. These other energies include various electrical fields, radiation and ultrasonic.

The main advantages of non-contact inspection are:

- It eliminates the need to reposition the workpiece.
- Non-contact inspection is faster than contact inspection.

- There is no mechanical wear encountered in the contact inspection probe.
- The possibility of damage to the surface of a part due to measuring pressure is eliminated.

Machine Vision:

Machine vision is the creation of an image and the collection of data derived from the image, and the subsequent processing and interpretation of the data by a computer from some useful application. Machine vision is also known as computer vision, and its principal application is in industrial inspection.

Machine vision exists in two-dimensional (2D) and three-dimensional (3D) formats, with 2D being most common in industrial applications. Examples of its usage include dimensional measuring and gauging, verifying the presence of components, and checking for features on a flat (or semi-flat) surface. 3D machine vision is used in applications where a 3D analysis of the scene is required. Here we focus on the simpler 2D machine vision system.

The operation machine vision system can be dived into the following three functions: 1. image acquisition and digitization. 2. image processing and analysis and 3. interpretation.

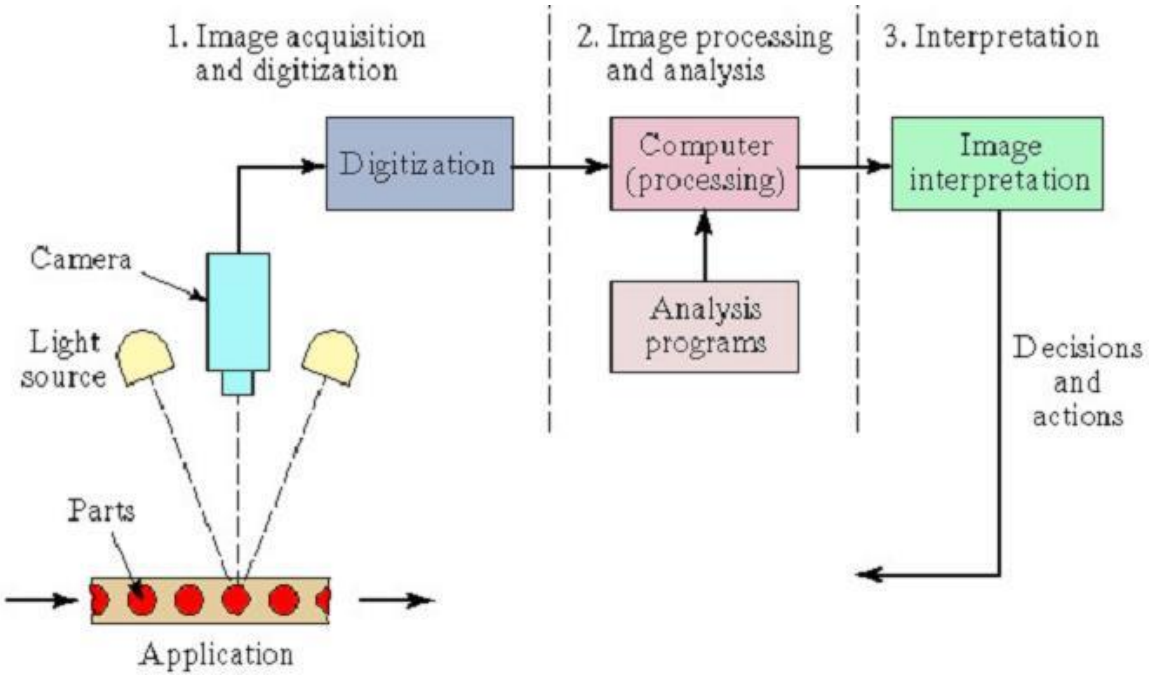


Figure 4.7 machine vision

Image Acquisition and Digitization:

Image acquisition and digitization is typically performed by deploying a video camera to capture the image, and the use of a digitizing system to store the image data for subsequent analysis. The camera is focused upon the surface of the item of interest, and an image consisting of discrete pixel elements is captured in the viewing area; each pixel has a value proportional to the light intensity of that portion of the scene. The intensity value of each pixel is converted into its equivalent digital value by an analogue-to-digital converter

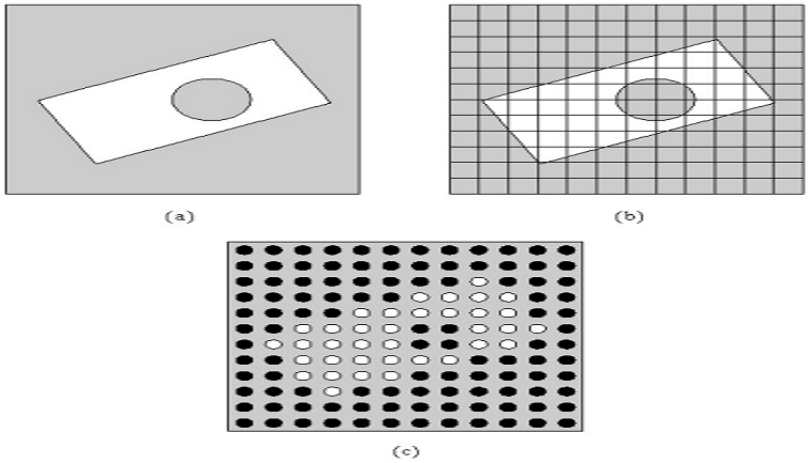


Figure 4.8 (a) scene presentation; (b) 12 x 12 matrix super-imposed; and (c) creation of pixelated scene and assignment of intensity values, in black or white

Image Processing and Analysis:

A number of techniques have been developed so that data produced during the first phase of machine vision may be processed and analyzed. These general techniques are called segmentation (a technique intended to define and separate regions of interest within the image), and feature extraction (which follows on from various segmentation processes).

Table 4.1. Image processing and analysis techniques

General category	Sub. category	Description
Segmentation	Thresholding	Involves the conversation of each pixel intensity level into a binary value (black and white); performed by comparing each pixel value to a defined threshold value
Segmentation	Edge detection	Concerned with determining the location of the boundaries between an object and its surrounding in an image. Accomplished by identifying the

		contrast in light intensity that exist between adjacent pixel at the boarders of the object.
Feature extraction		Method that are designed to determine an objects feature based on the area and boundary of the object (using the above segmentation technique).

Interpretation:

The extracted features of the image are guide from which interpretation of the image emerges; that is, interpretation is concerned with recognizing the object (object recognition), and/or recognizing the major features of the object (pattern recognition). Predefined models or standard values are used to identify the object in the image. Two commonly-used interpretation techniques are.

Bullet list

Template matching a method whereby the features of the image are compared against corresponding features of a model or template stored in the computer memory.

Feature weighting—a technique in which several features are combined into a single measure by assigning a weight to each feature according to its relative importance in identifying the object, and where the resultant score is compared against an ideal object score stored in computer memory, to achieve proper identification ENDLIST. [Ref.6]

Self – Check 4

Instructions:

- Given 30 minutes, provide to complete the question.
- Enumerate the following. Use a separate sheet of paper for answering.
- For Short answers, write the answer of the questions on the provided space.

Part I. Choose correct answer of the following questions

1. Which of the followings are not objective of CAQC?
   a. Improved product uality
   b. Increase productivity
   c. Reduce lead time
   d. Reduce production rate
2. CAI and CAT is performed using
   a. Manual technique
   b. Automation technique
   c. Modeling
   d. All
3. Wich of the following is inspection method
   a. Contact method
   b. Non-contact method
   c. A and B
   d. All
4. Which of the following if part of electrical circuit testing?
   a. Coordinate measuring machine
   b. Contact method
   c. Visual
   d. Mechanical
5. Which one is commonly-used interpretation techniques are
   a. Bullet list

b. Digitalization
c. Machine vision
d. Manual

Part II: - say True if the statement is true or else False

1. Inspection integrated into the manufacturing process will lead to reduce lead time
2. Coordinate measuring machine is the most important example of equipment used for contact inspection of machine
3. Predefined models or standard values are used to identify the object in the image
4. Manual inspection is generally a time-consuming procedure
5. The use of non-contact sensors is not recommended for computer aided inspection and CIM.

Part III: Explain the following questions briefly

1. Explain the Applying and advantages of integration of CAQC with CAD/CAM system
2. Discuss about CAQC
3. Explain in Detail about the various types of computer aided testing applied on computer-aided quality control systems.
4. With the help of schematic diagram
5. explain the operation of scanning laser beam system and explain its applying in CAQC systems.
6. Explain various non-Contact inspection methods optical with neat sketches

Reference

1. Article · January 2003, Planning and Design of Computer Integrated Manufacturing Systems Using an Expert System
2. www.bookspar.com
3. T.Manokaran ME,MBA, Computer Integrated Manufacturing.
4. Autonomous Institution – UGC, Govt. of India, Computer Aided Design and Computer Aided Manufacturing
5. July 2007, CIM System Installation Manual

Developer's Profile

No	Name	Qualification	Field of Study	Organization/ Institution	Mobile number	E-mail
1)	Abebe Hailiye	(MSc)	Manufacturing engineering	M/G Mulugeta Buli Polytechnic College	0913521369	Aabebe52@gmaile.com
2)	Tsegaye Mulat	(MSc)	Manufacturing technology	A.A tegbaried poly technic college	910411511	ttshgm97@gmail.com
3)	Boka Terefe	(MSc)	Manufacturing Technology	Ambo poly technic college	917038870	bokaterefe@gmaile.com
4)	Mesay Teshome	BSC	Manufacturing	Hawassa poly technic college	0905 456888	mesayy2018@gmail.com
5)	Mesret Woldemariam	MSC	Manufacturing technology	Wolkite poly technic college	912117416	bmesi2007@gmail.com
6)	Mohammed Bedri	MSC	Manufacturing Technology	Robe poly technic college	913897297	
7)	Mohammed Abdela	MSC	Manufacturing Technology	Ethio italy poly technic college	973794977	mehamed abdela 49@gmail.com