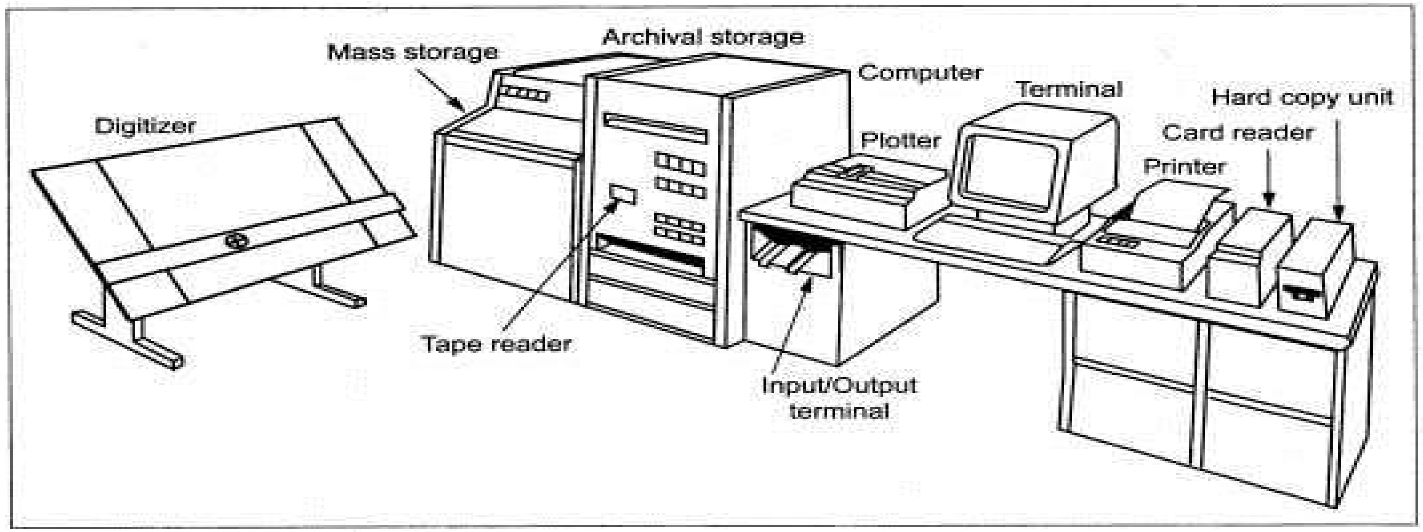
UNIT I
INTRODUCTION

CAD Hardware and Software

CAD hardware:

- Includes the computer, one or more graphical display terminals, keyboard and other peripheral equipment.
- In CAD, the drawing boards are replaced by electronic input and output devices, an electronic plotter, mass storage, an archival storage device, a tape reader, printer, card reader, and hard copy unit, as shown in Figure:



CAD Hardware and Software

CAD software:

- CAD software consists of

  (i) system software and

  (ii) application software.

(i) System software:

- It is used to perform/control the operation of the computer.
- Responsible for making the hardware components to work and interact with each others and the end user.
- Examples of system software are the operating systems, all kinds of hardware drivers, compilers and interpreters.

CAD Hardware and Software

(ii) Application software:

- It is also known as application programs,
- It is used for general or customised/specialized problems.
- Examples of application software are AutoCAD, Solid works, Pro-E, ANSYS, ADAMS, etc.

CAD Hardware and Software

Advantages of an Application Software

- Increased design productivity.
- Shorter lead time.
- Flexibility in design.
- Improved design analysis.
- Fewer design errors.
- Greater accuracy in design calculations
- Standardization of design, drafting and documentation procedures.
- Easier creation and correction of engineering drawings.
- Better visualization of drawings.
- Faster new products design.

CAD Hardware and Software

- The benefits of CAD in manufacturing can be realised in the following areas:

  (i)Tool and fixture design.

  (ii)Generation of NC (numerical control) part programming.

  (iii)CAPP (computer aided process planning).

  (iv)Models generated can be utilized for rapid prototyping.

  (v)Computer aided inspection.

  (vi)Preparation of assembly lists and bill of materials.

  (vii)Group technology (in coding and classification of parts).

  (viii)Robotics and materials handling equipment planning

  (ix) Assembly sequence planning.

Reasons for Implementing CAD

The four fundamental reasons for implementing a CAD system are as follows:

- **To increase the productivity of the designer.**

Using CAD, the designer can visualize quickly the product and its components, subassemblies and parts.

Reduces the time required for synthesis, analysis and documentation of the design.

Reduces product design time and cost.

- To improve the quality of design.

Design alterations can be done quickly without error.

Reasons for Implementing CAD

- **To improve communications.**

Provides better documentation of the design, fewer drawing errors with greater legibility.

- **To create a database for engineering.**

Design database consists of product geometries and dimensions, bill of materials, etc. which are essential input for manufacturing of the product.

Applications of CAD

Area	Application
Design	• Assembly layout • New-part design • Standard part library • Tolerance specification • Interface and clearance specification • Part relations in an assembly
Analysis	• Interference checking • Fit analysis • Weight and balance • Volume and area properties • Structural analysis • Kinematics analysis • Tolerance stacking

Applications of CAD

Area	Application
Documentation	• Drawing generation • Technical illustrations • Bill of materials • Image rending
Manufacturing	• Process planning • NC part program generation • NC part program verification • NC machine simulation • Inspection programming • Robot programming and verification • Factory layout

Applications of CAD

Area	Application
Management	• Review and release • Engineering changes • Project control and monitoring • Selection of standard parts and assemblies • Design standards

Design Process in a CAD System (Elements of CAD System)

The conventional design process has been accomplished on drawing boards with the design being documented in the form of detailed engineering drawing.

The conventional design process also known as Shigley model, consists of the following six steps/phases:

1. Recognition of need
2. Identification of problem
3. Synthesis
4. Analysis and optimization
5. Evaluation
6. Presentation

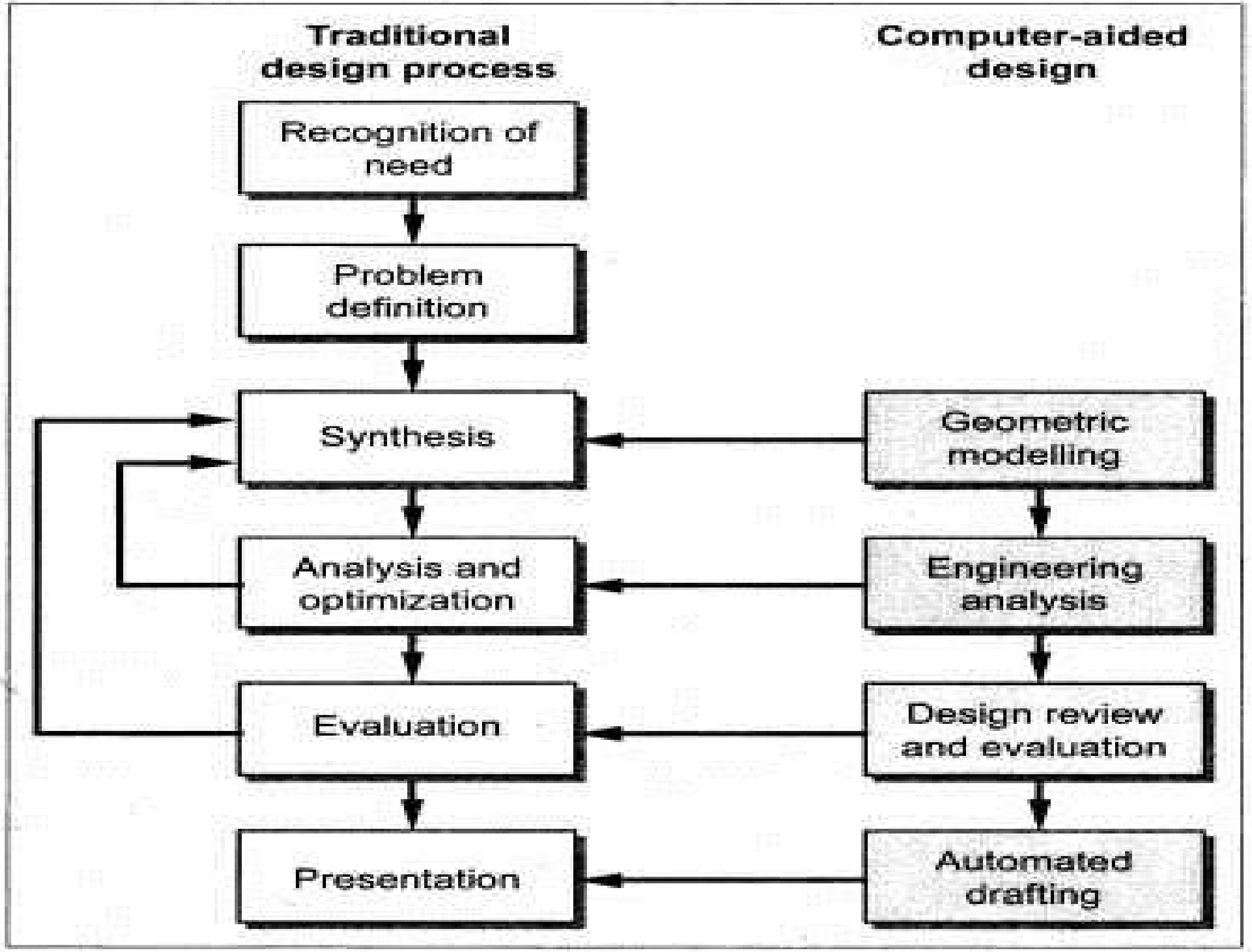
In CAD, the design related tasks are performed by a modern CAD system.

Four Stages of CAD Design Process

Four stages or functional areas of a CAD design process are:

1. Geometric modelling.
2. Design analysis and optimization.
3. Design review and evaluation.
4. Documentation and drafting.

Four Stages of CAD Design Process



Four Stages of CAD Design Process

- Geometric Modelling

Concerned with computer compatible mathematical description of geometry of an object.

The mathematic description of geometry should be such that:

(i) The image of the object can be displayed and manipulated in the computer terminals.

(ii) Modification of the geometry of the object can be done easily.

(iii) It can be stored in the computer memory.

(iv) It can be retrieved back on the computer screen for review, analysis or alteration.

Four Stages of CAD Design Process

- In geometric modelling, three types of commands are used. They are:

(i) Commands used to generate basic geometric entities like points, lines, circles, etc.

(ii) Commands used to do manipulation work like scaling, translation, rotation, etc.

- The models can be represented in three different ways:

(i)Wire-frame

(ii)Surface

(iii)Solid modelling

Four Stages of CAD Design Process

- Design Analysis and Optimization

Once the graphic model is created, the design is subjected to engineering analysis.

- This phase consist of analysing stresses, strains, deflections and other parameters.
- The analysis can be done either by using a specific program generated for it or by using general purpose software commercially available in the market.
- Nowadays sophisticated packages (such as ANSYS, Pro-E, CATIA) having capabilities are available to compute the various performance parameters accurately.
- Because of the relative ease with which such analysis can be made, designers are increasingly willing to thoroughly analyse a design before it moves into production.
- Experiments and field measurements may be necessary to determine the effects of loads, temperature and other variables.

Four Stages of CAD Design Process

- Design Review and Evaluation
  - The phase is to review and evaluate to check for any interference between various components in order to avoid difficulties during assembly or use of the part and whether the moving members such as linkages are going to operate as intended.
  - Using the layering procedure, every stage of production can be checked; by using animation, the working of the mechanism can be checked.

- Documentation and Drafting
  - After analysis and review, the design is reproduced by automated drafting machines for documentation and reference.
  - In this phase, detailed and working drawing are developed and printed.
  - Important features of automated drafting are automated dimensioning, scaling of the drawing, development of generating sectional views, enlargement of minute part details and ability to generate different views of the object (like orthographic, oblique, isometric and perspective views).

Computer Aided Manufacturing (CAM)

- Defined as an effective use of computers and computer technology in the planning management and control of the manufacturing function.

- The use of computers to assist in all the phases of manufacturing a product, including process and production planning, machining, scheduling, management and quality control.

Applications of CAM

- The applications of CAM can be divided into two broad categories:

1. Manufacturing planning.

2. Manufacturing control.

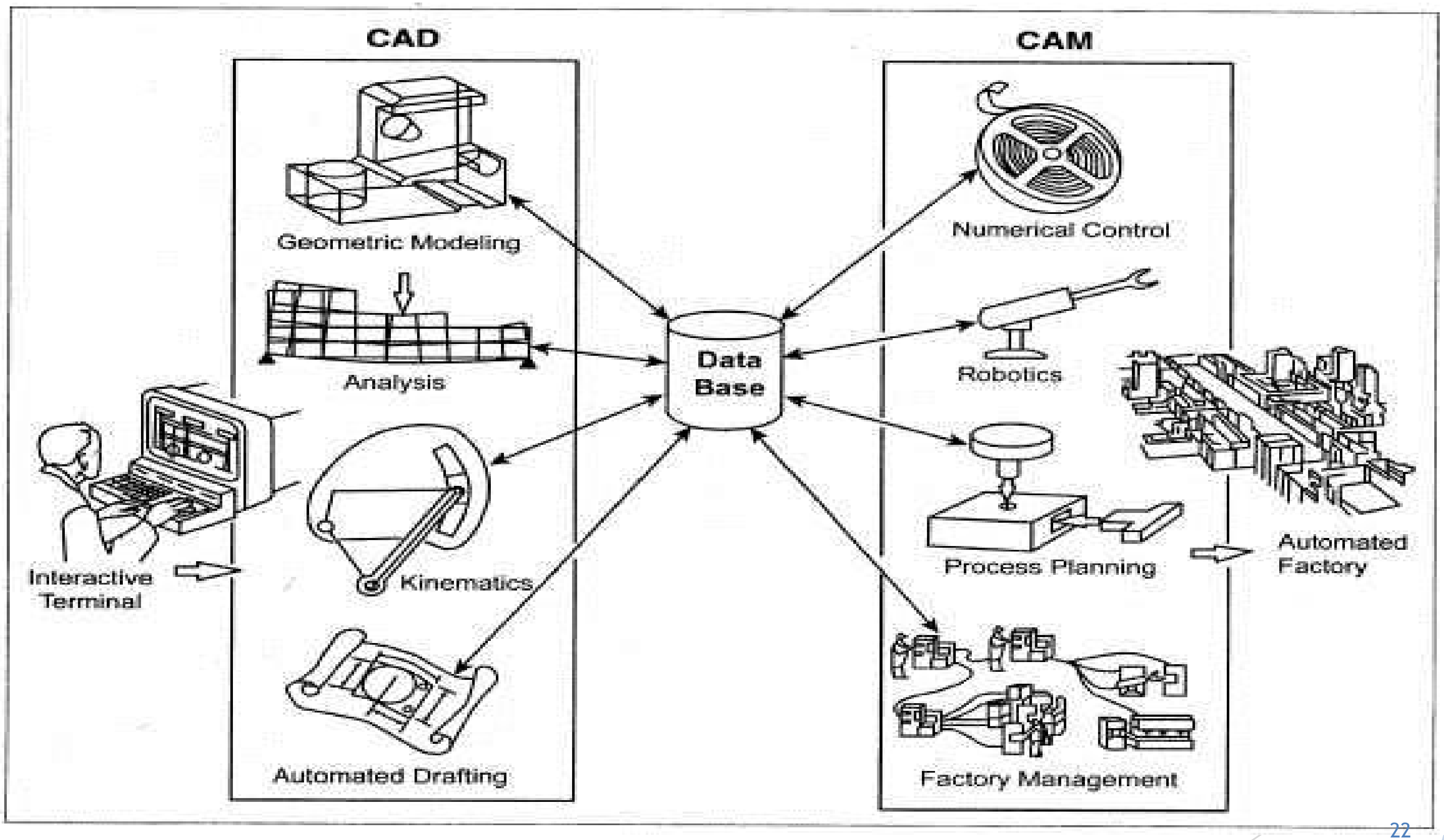
CAD/CAM Interface

- Computer-aided design and computer-aided manufacturing are often combined into CAD/CAM systems because of the benefits.

- By interfacing CAD/CAM technology, it is possible to establish a direct link between product design and manufacturing engineering.

- The user can interact with computer through a graphics terminal to accomplish all the design and manufacturing activities

CAD/CAM Interface

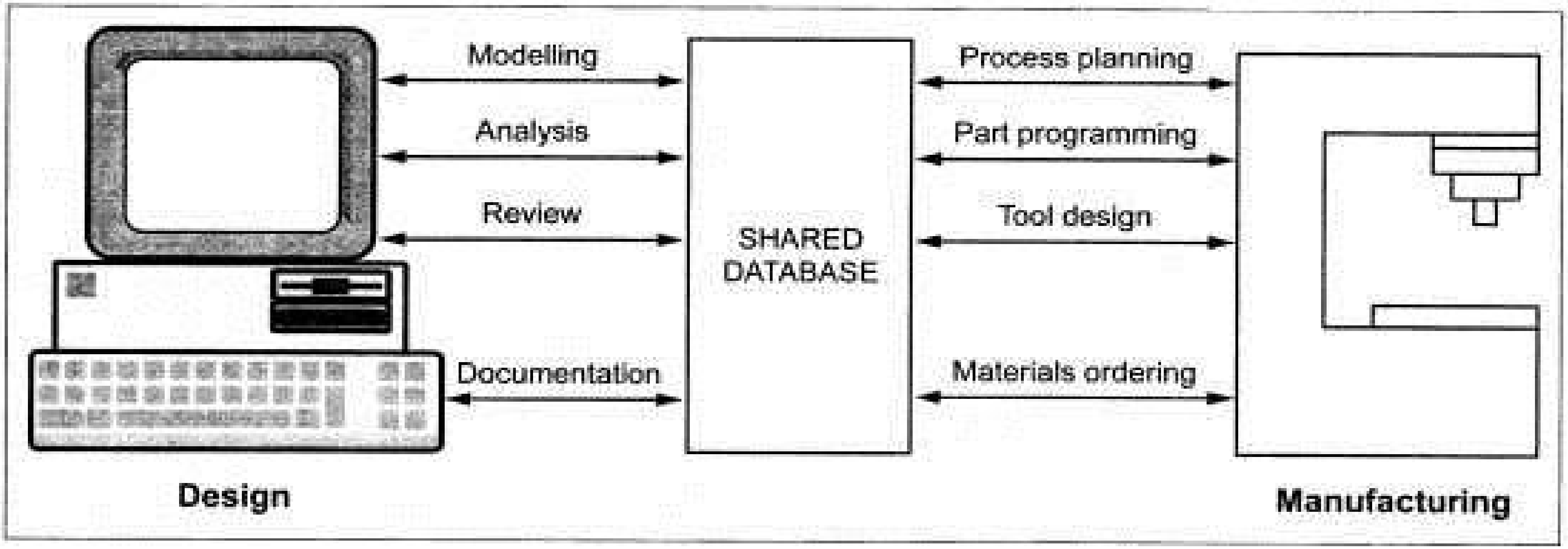


Elements of CAD/CAM interface

- CAD/CAM combination allows the transfer of information from the design stage into the stage of planning for the manufacture of a product without the need to re-enter the data on part geometry manually.

- Database developed during CAD is stored.

- It is processed further by CAM into the necessary data and instructions for operating and controlling production machinery, material-handling equipment and automated testing and inspection for product quality.



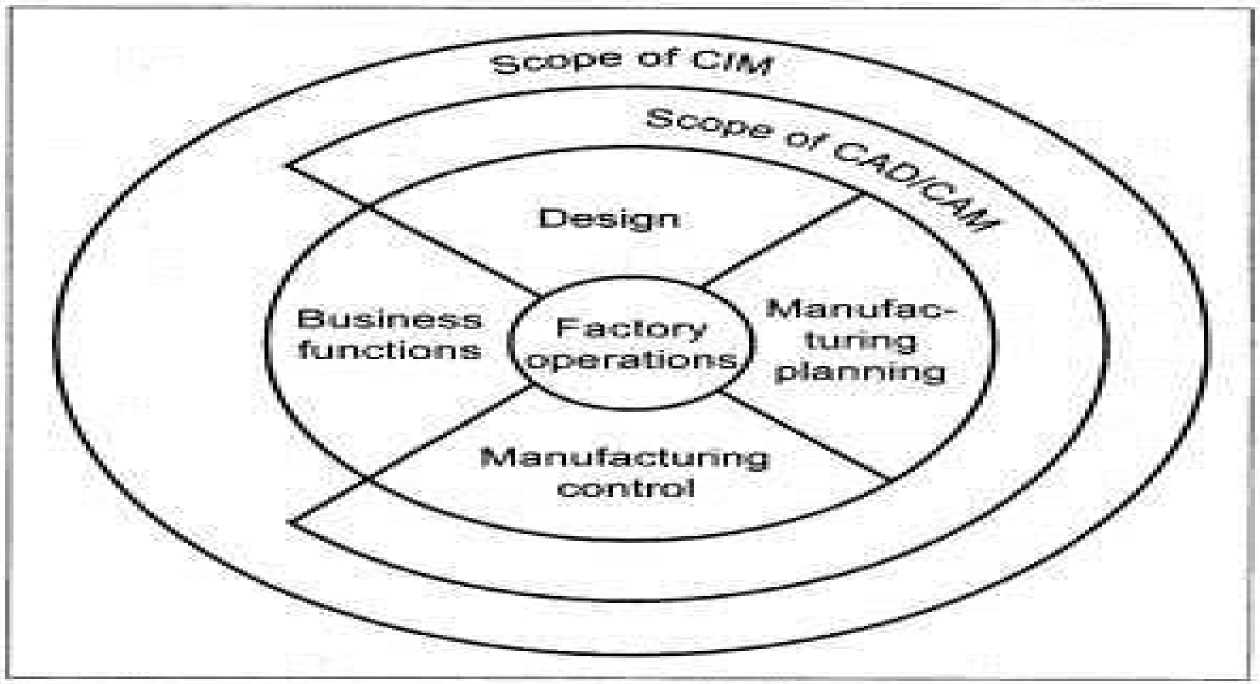
CAD/CAM Vs CIM

- The scope of CAD/CAM includes design, manufacturing planning and manufacturing control.
- Typical applications of CAD/CAM includes:

  - Programming for NC, CNC and industrial robots
  - Design of dies and moulds for casting
  - Dies for metal working operations
  - Design of tools
  - Quality control and inspection
  - Process planning and scheduling
  - Plant layout

CAD/CAM Vs CIM

- CIM
  - Computer Integrated Manufacturing (CIM) includes all of the engineering functions of CAD/CAM and the firm's business functions that are related to manufacturing.
  - CIM = CAD/CAM functions + Business functions
  - Figure below illustrates the scope of CAD/CAM and CIM presented by Groover.



Computer-Aided Drafting

- The process of preparing drawings with the aid of computer is known as computer-aided drafting or computer graphics.
- The computer graphics includes the methods of making plane and geometrical drawings . Plotting of points, drawing of lines, squares, circles, etc. and building up of simple blocks form the computer graphics activities in two dimensions.
- Pictorial views of a machine component, as viewed from different directions can be obtained by using computer graphics.
- In present days the availability of sophisticated computer hardware and computer programmes have enabled solid modelling, which is a 3D representation of a product.
- The entire computer graphics activities integrate the analysis, design, manufacturing and management aspects into one system that may be called computer-aided engineering (CAE).

Major function performed by a computer-aided drafting system

- Basic set-up of a drawing.
- Drawing the objects.
- Changing the object properties.
- Translating the objects.
- Scaling the objects.
- Clipping the object to fit the image to the screen.
- Creating symbol libraries for frequently used objects.
- Text insertion.
- Dimensioning.

Advantages of computer-aided drafting

- It is a fast and convenient method.
- Drawing can be stored in database.
- Changes in drawings can be done easily and quickly.
- Neat and clean drawings of good quality can be prepared.
- Accuracy can be maintained.

Features of CAD systems

- Modelling and drafting:
  - Majority of systems provide 2D and 3D modelling capabilities. Some low cost CAD systems are dedicated to 2D drafting only.
- Ease of use:
  - Users find CAD Systems very easy to learn and use.
- Flexibility:
  - Popular CAD systems provide greater flexibility when configuring the available hardware. Hundreds of computers, display devices, expansion boards, input and output devices are compatible and configurable with popular software.
- Modularity:
  - Standard input and output devices are attached to standard connectors thereby making the system modular in nature.
- Low maintenance cost:
  - Little maintenance is needed to keep the system functional.
  - Software Packages for Modelling (Popular CAD Packages).

CAD packages available for modelling

- Auto CAD
- Pro-E
- IDEAS
- Uni-graphics
- CATIA
- Solid Works
- Solid Edge

Characteristics of a CAD Package

- According to Newman and Sproull, any graphic package should have the following six basic characteristics.

  - Simplicity
  - Consistency
  - Completeness
  - Robustness
  - Performance
  - Economic

Manufacturing Planning

- Important manufacturing planning applications include:

  - Computer-aided process planning (CAPP)
  - Computer-assisted NC part programming
  - Computerised machinability data systems
  - Development of work standards
  - Cost estimation
  - Production and inventory planning
  - Computer-aided line balancing

Manufacturing control

- The manufacturing control applications of CAM are concerned with developing computer systems for implementing the manufacturing control function.
- Is concerned with managing and controlling the physical operations in the factory.

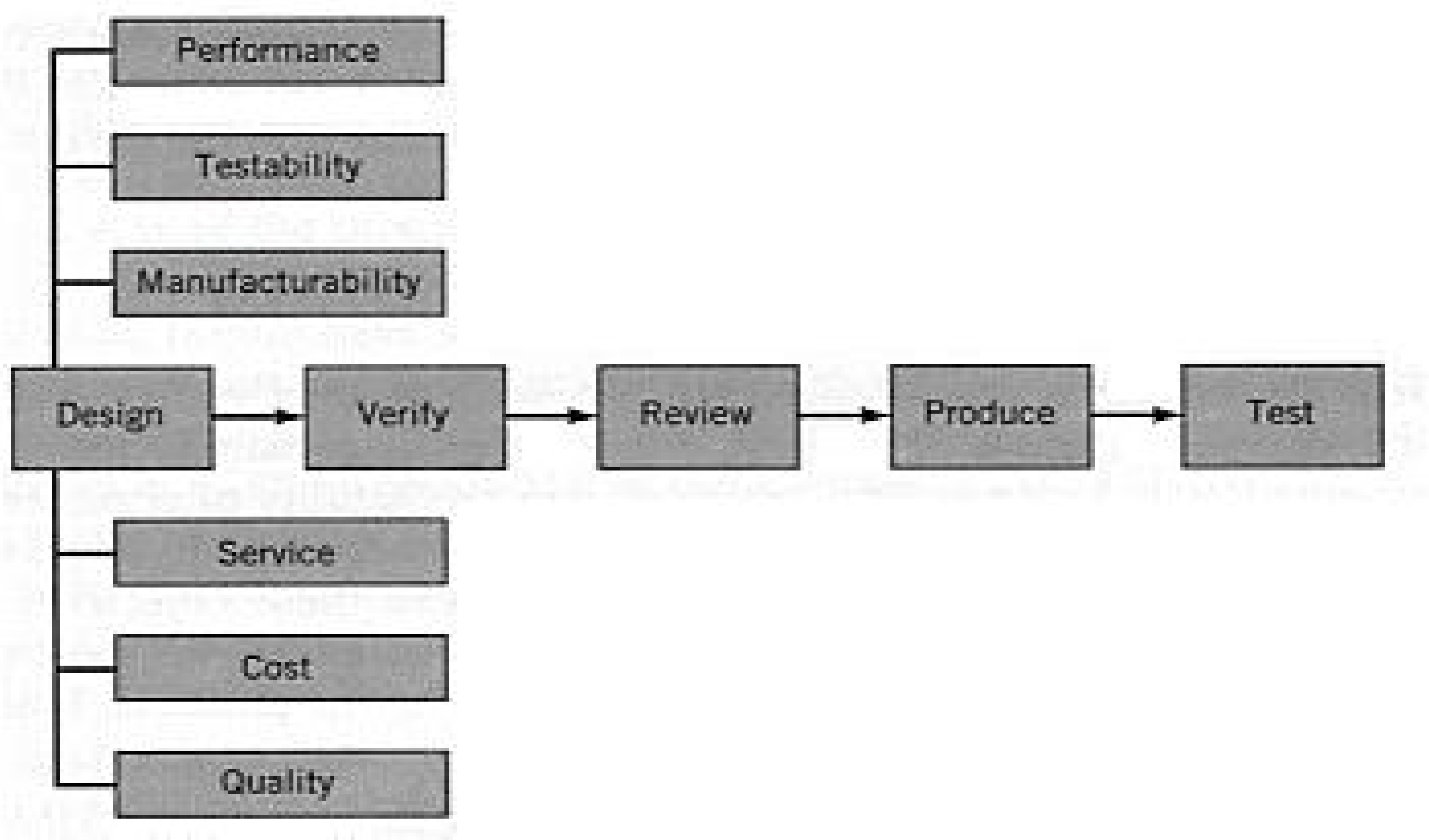
  - Some of the manufacturing control applications include:
    - Process monitoring and control
    - Quality control
    - Shop floor control
    - Inventory control
    - Just-in-time production systems

Concurrent Engineering

- A systematic approach to the integrated, concurrent design of products and their related processes including manufacture and support.

- It is intended to cause the developers from the outset, to consider all elements of the product life cycle from conception to disposal, including quality, cost, schedule and user requirements.

Concurrent Engineering



Concurrent Engineering Element

- Cross-functional teams
  - It Include members from various disciplines involved in the process including manufacturing, hardware and software design, marketing and so forth.
- Concurrent product realization
  - Process activities are at the heart of concurrent engineering.
  - Designing various subsystems simultaneously is critical to reduce design time.
- Incremental information sharing
  - As soon as new information becomes available, it is shared and integrated into the design.
  - It cross functional teams are important to the effective sharing of information in a timely fashion.
- Integrated project management
  - It ensures that someone is responsible for the entire project and that responsibility is not abdicated once one aspect of the work is done.

Applications of Concurrent Engineering

- The applications of concurrent engineering are as follows,
  - Development and production lead times
  - Measurable quality improvements
  - Engineering process improvements
  - Cost reduction

Applications of Concurrent Engineering

1. Development and production lead times

- Product development time is reduced up to 60%.
- Production spans are reduced 10%.
  - AT&T reduced the total process time for the ESS programmed digital switch by 46% in 3 years.
  - ITT reduced the design cycle for an electronic countermeasures system by33% and its transition-to-production time by 22%.

Applications of Concurrent Engineering

2. Measurable quality improvements

- Field failure rates reduced up to 83%.
  - AT&T achieved a fourfold reduction in variability in a poly silicon deposition process for very large scale integrated circuits and achieved nearly two orders of magnitude reduction in surface defects.
  - AT&T reduced defects in the ESS programmed digital switch up to 87% through a coordinated quality improvement program that included product and process design.
  - Degree reduced the number of inspectors by two-thirds through emphasis on process control and linking the design and manufacturing processes.

Applications of Concurrent Engineering

3. Engineering process improvements

- Engineering changes per drawing reduced up to 15 times.
- Early production engineering changes reduced by 15%.
- Inventory items stocked reduced up to 60%.
- Engineering prototype builds reduced up to three times.
- Scrap and rework reduced up to 87%.

Applications of Concurrent Engineering

4. Cost reduction

- McDonnell Douglas had a 60% reduction in life-cycle cost and 40% reduction in production cost on a short-range missile proposal.
- Boeing reduced a bid on a mobile missile launcher and realized costs 30 to 40% below the bid.
- IBM reduced direct costs in system assembly by 50%.
- ITT saved 25% in ferrite core bonding production costs .

CIM concepts

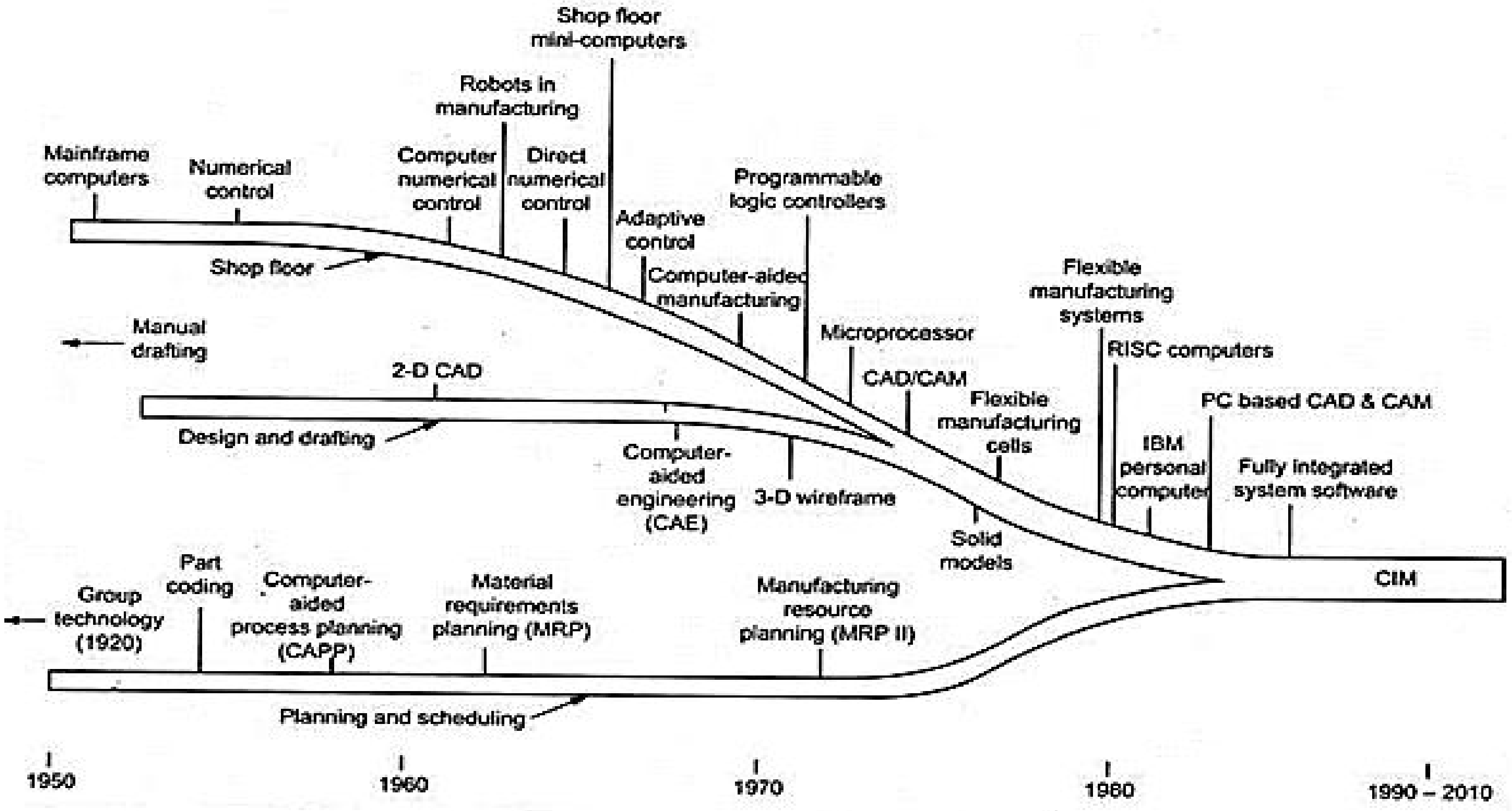
- It is a concept, an environment, an objective, a strategy.
- Modem technology is needed to implement/achieve the CIM environment.
- Thus CIM is also a technology.

Importance of CIM

Following factors have led to the development of the CIM concept and associated technologies:

1. Development of NC, CNC and DNC.
2. The advent and cost-effectiveness of computers.
3. Manufacturing challenges, such as
   - Global competition
   - High labour cost
   - Demand For quality products
   - Flexibility To meet the orders
   - Lower product cost
4. The capability-to-cost attractiveness of microcomputers.

Timeline of CIM



Activities of CIM

1. Evaluating and developing different product strategies.

2. Analysing markets and generating forecasts.

3. Analysing product/market characteristics and generating concepts of possible manufacturing system (i.e. FMS cells and FMS systems).

4. Designing and analysing components for machining, inspection, assembly and all other processes relating to the nature of the component and/or product.

Activities of CIM

5 . Evaluating and/or determining batch sizes, manufacturing capacity, scheduling and control strategies relating to the design and fabrication processes involved in the particular product.

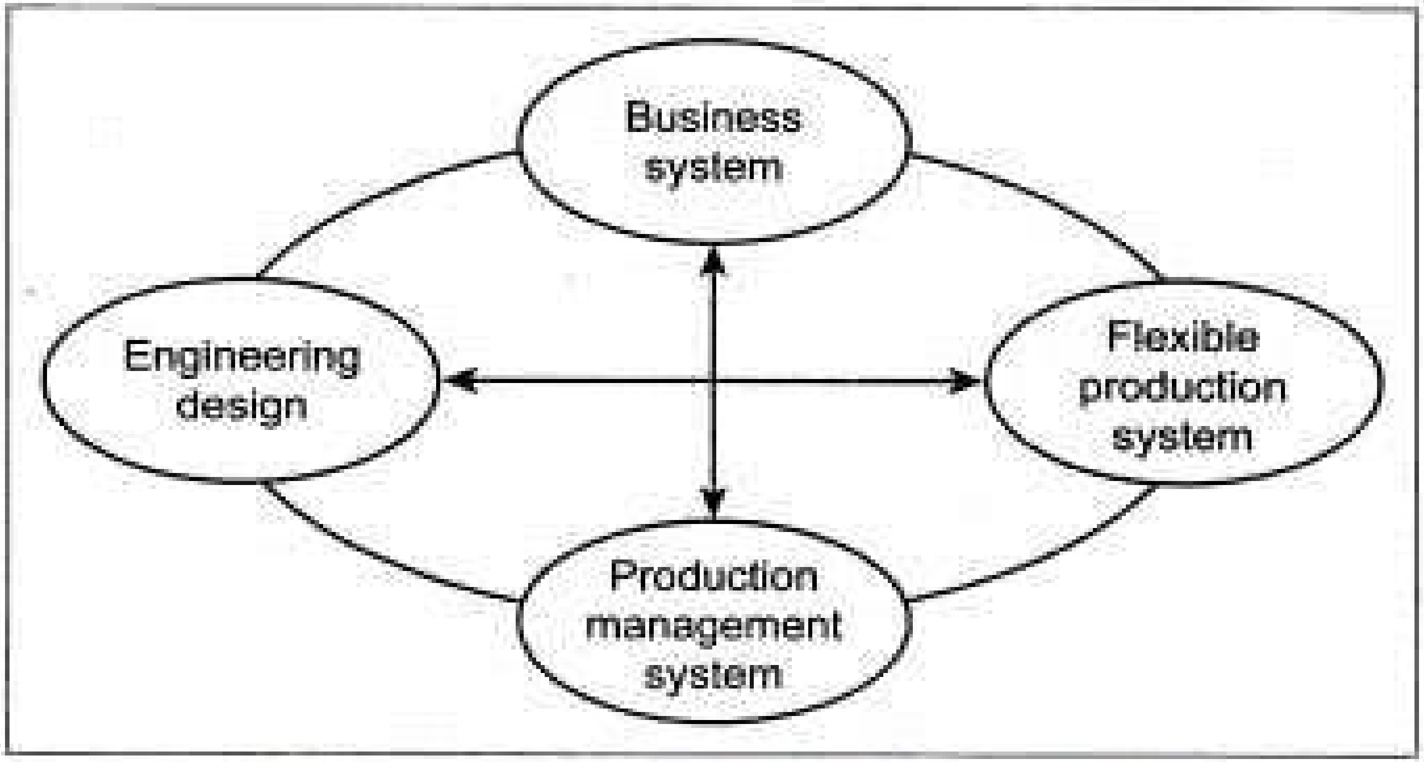
6. Analysis and feedback of certain selected parameters relating to the manufacturing processes, evaluation of status reports from the DNC system.

7. Analysing system disturbances and economic factors of the total system.

Elements of CIM System (Various Activities of CIM)

- CIM is a methodology and a goal rather than an assemblage of component and computers.
- The ideal CIM system applies computer technology to all of the operational functions and information processing functions in manufacturing from order receipt, through design and production to product delivery.

Elements of CIM System (Various Activities of CIM)



Elements of CIM System (Various Activities of CIM)

- At the broader level, CIM can be viewed as an integration of
  - Product and process design.
  - Production planning and control.
  - Production process.

Elements of CIM System (Various Activities of CIM)

- Computer integrated manufacturing is the automated version of the manufacturing process .

- Three major manufacturing functions are product and process design, production planning and control and production process—are replaced by the automated technologies CAD/CAM, CAPP and automated material handling systems , Automated guided vehicles (AGVs) and computerised business systems like order entry, payroll and billing.

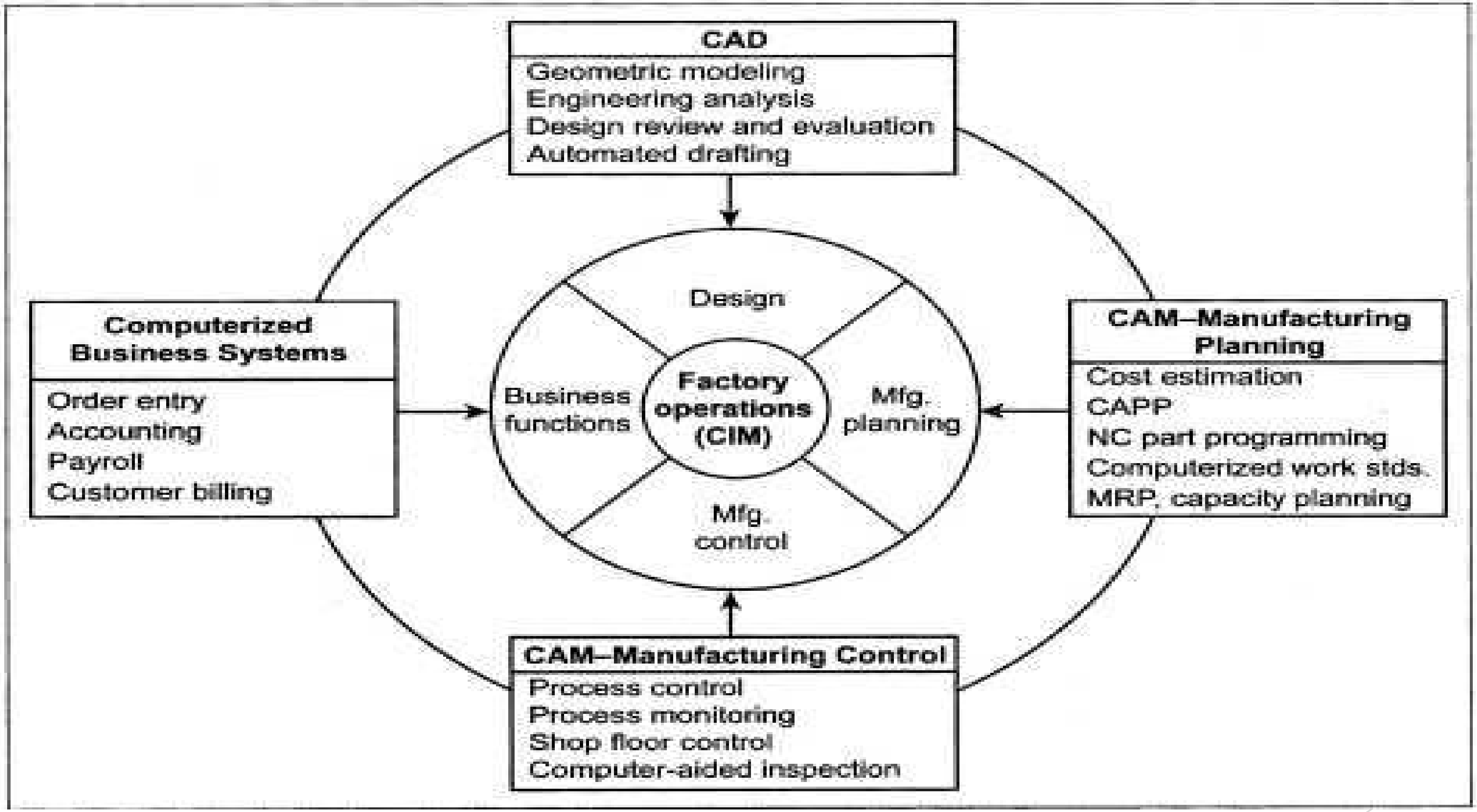
Elements of CIM System (Various Activities of CIM)

- CIM is also referred as completely automated factory with no human interference and factory of the future.

- CIM calls for the coordinated participation in all phases of manufacturing enterprises for the purpose of integration and supervision.

- Thus CIM includes:
  - Design of parts and components
  - Computer controlled flow of materials

Computerized elements of a CIM system



Subsystems of CIM

- CIM consists of subsystems that are integrated into a whole.
- These subsystems/elements consist of the following:

(i) Product design

(ii) Manufacturing planning

(iii) Manufacturing control

(iv) Business planning and support

Subsystems of CIM

- Subsystems are designed, developed and applied in such a manner that the output of one subsystem serves as the input of another system.

- These subsystems are usually divided into two functions as below:

  - Business planning functions

  - Business execution function

Subsystems of CIM

- 1. Business planning functions:

It Includes activities such as forecasting, scheduling, material-requirements planning, invoicing and accounting.

- 2. Business execution function:

It Includes production and process control, material handling, testing and inspection.

- Effectiveness of CIM depends greatly on the presence of a large-scale, integrated communications system involving computers, machines and their controls.

Islands of Automation

- The term 'islands of automation ’ represents the various technologies that facilitate manufacturing automation in isolation without having integrated with other manufacturing technologies.

- CIM represents the logical revolution of the islands of automation concept.

- As the ‘islands’ are not capable by themselves to bring out a ‘big picture’ of the entire manufacturing activities the evolution of CIM has become a natural evolution by the integration of these ‘islands of automation’.

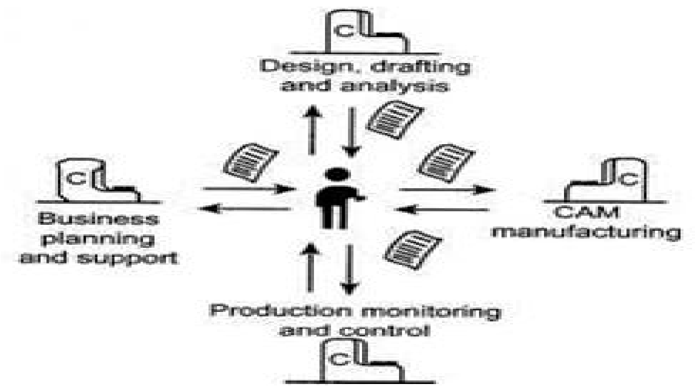
Islands of Automation

- The various ‘islands of automation which by integration forms computer integrated manufacturing, include:

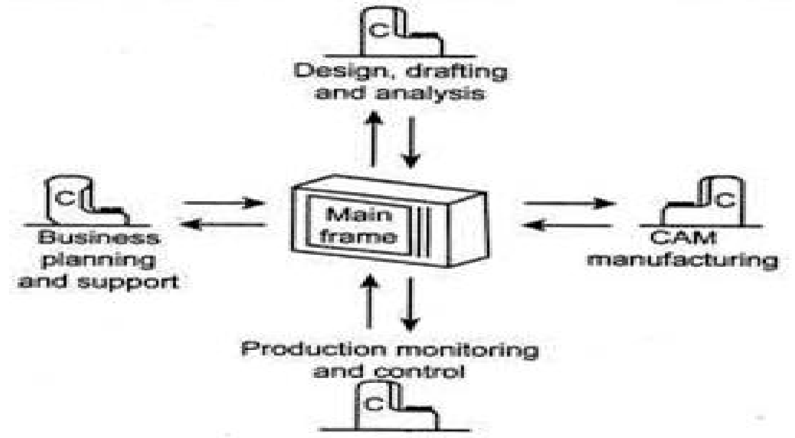
1. Computer-aided design (CAD)
2. Computer-aided manufacture (CAM)
3. Computer numerically controlled (CNC) machines
4. Flexible manufacturing systems (FMS)
5. Robotics
6. Automated material handling systems (AMHS)
7. Group technology (GT)
8. Computer aided process planning (CAPP)
9. Manufacturing resource planning (MRP II)
10. Computer control systems.

Islands of Automation

- CIM elements without mainframe computer and resulting islands of automation.



- Computer Integrated Manufacturing (CIM) through mainframe computer.



Types of Production

- Production activity is classified 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

- 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.
- Production equipment must be flexible and general purpose to allow for this variety of work.
- 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.
- Though these two activities involve the transformation of raw materials into finished products, the work is not performed in a factory.

Batch Production

- It involves the manufacture of medium-sized lots of the same item or product.
- Lots may be produced only once, or they may be produced at regular intervals.
- Purpose of batch production is often to satisfy continuous customer demand for an item.
- 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 moulding factories and press working shops.

Mass Production

- It involves continuous specialized manufacture of identical products.
- 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.
- Equipment is not only dedicated to one product, but the entire plant is often designed for the exclusive purpose of producing the particular product.
- Equipment is special purpose rather than general-purpose.
- Investment in machines and specialized tooling is high.
- Production skill has been transferred from the operator to the machine.
- The skill level of labour in a mass production plant tends to be lower than in a batch plant or job shop.

Manufacturing Models and Metrics

- Production Concepts and Mathematical Models

  Production rate, Rp

  Production capacity, PC

  Utilization, U

  Availability, A

  Manufacturing lead time, MLT

  Work-in-progress, WIP

Manufacturing Models and Metrics

- Operation Cycle Time
- Typical cycle time for a production operation:

$$T_c = T_o + T_h + T_{th}$$

where, T_c = cycle time

T_o = processing time for the operation.

T_h = handling time (e.g. loading and unloading the production machine).

T_{th} = tool handling time (e.g. time to change tools).

Manufacturing Models and Metrics

- Production Rate
- Batch production:

  batch time $T_b = T_{su} + QT_c$

  Average production time per work unit $T_p = T_b / Q$

  Production rate, $R_p = 60/ T_p$ (pieces/hr)

- Job shop production:

  For $Q = 1$, $T_p = T_{su} + T_c$

- For quantity high production:

  $R_p \rightarrow R_c = 60/ T_c$ since $T_{su}/ Q \rightarrow 0$

- For flow line production

  $T_c = T_r + \text{Max } T_o$ and $R_c = 60/ T_c$

Manufacturing Models and Metrics

- Production Capacity

Plant capacity for facility in which parts are made in one operation (no=1): PC w = n S w Hs Rp

Where, PC w = Weekly plant capacity, units/wk

Plant capacity for facility in which parts require multiple operations (n o >1):

$$PC_w = \frac{nS_wH_sR_p}{n_o}$$

where n o = Number of operations in the routing.

Manufacturing Models and Metrics

- Utilization and Availability

Utilization: $$U = \frac{Q}{PC}$$

where Q = Quantity actually produced and PC = plant capacity

Availability: $$A = \frac{MTBF - MTTR}{MTBF}$$

Where, MTBF = Mean time between failures and

MTTR = mean time to repair

Availability - MTBF and MTTR Defined

Manufacturing Models and Metrics

- Manufacturing Lead Time

$$MLT = n_o (T_{su} + QT_c + T_{no})$$

Where, MLT = Manufacturing lead time

n_o = Number of operations

T_{su} = Setup time

Q = batch quantity, T_c cycle time per part

T_{no} = Non-operation time

Manufacturing Models and Metrics

- Work-In-Process

$$WIP = \frac{AU(PC)(MLT)}{S_w H_{sh}}$$

Where, WIP = work-in-process, pc

A = Availability, U = utilization,

PC = plant capacity, pc/wk

MLT = Manufacturing lead time, hr

S w = shifts per week,

Hsh = hours per shift,hr/shift

Manufacturing Models and Metrics

- Costs of Manufacturing Operations
- Two major categories of manufacturing costs:

    1.Fixed costs - remain constant for any output level

    2. Variable costs - vary in proportion to production output level

Adding fixed and variable costs

$$TC = FC + VC (Q)$$

Where, TC = Total costs

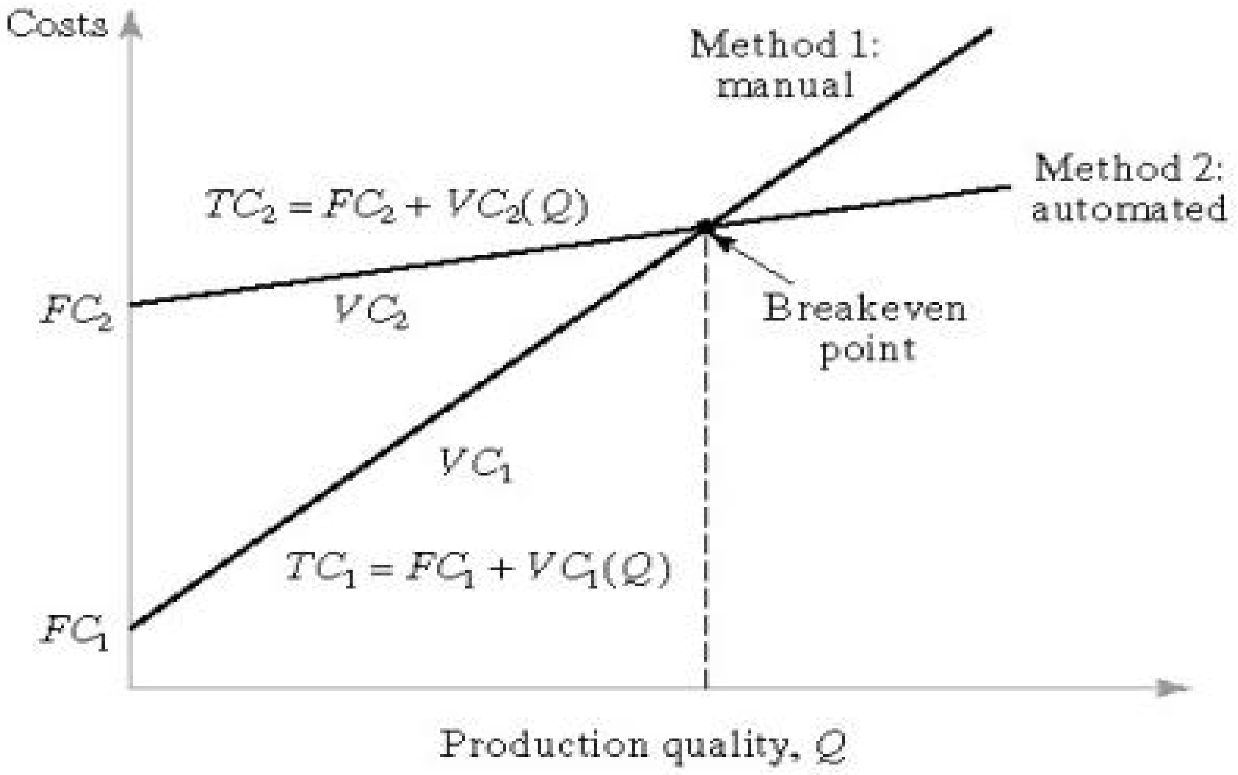
FC = Fixed costs (e.g. building, equipment, taxes)

VC = Variable costs (e.g. labor, materials, utilities)

Q = output level.

Manufacturing Models and Metrics

- Fixed and Variable Costs



Manufacturing Models and Metrics

- Manufacturing Costs
- Alternative classification of manufacturing costs:

    Direct labour -Wages and benefits paid to workers.

    Materials - Costs of raw materials.

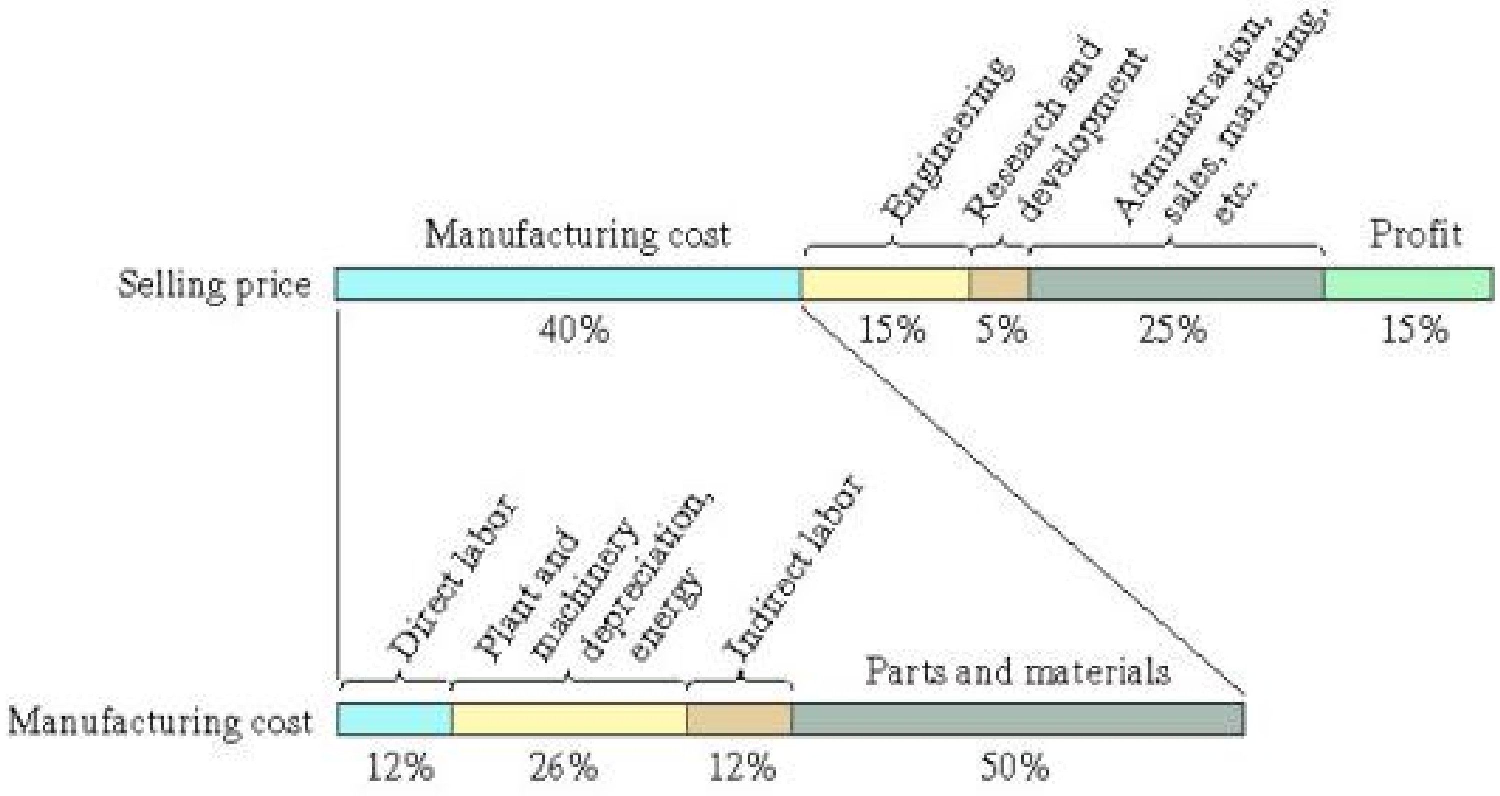
- Overhead - All of the other expenses associated with running the manufacturing firm.

    Factory overhead

    Corporate overhead

Manufacturing Models and Metrics

- Typical Manufacturing Costs



Manufacturing Models and Metrics

- Overhead Rates

- Factory overhead rate:

$$FOHR = \frac{FOHC}{DLC}$$

- Corporate overhead rate:

$$COHR = \frac{COHC}{DLC}$$

Where, DLC = Direct labour costs

Manufacturing Models and Metrics

- Cost of Equipment Usage
- Hourly cost of worker-machine system:

$$C_o = C_L(1 + FOHR_L) + C_m(1 + FOHR_m)$$

Where, C_o = hourly rate, S/hr.

C_L = labour rate, S/hr.

$FOHR_L$ = labour factory overhead rate,

C_m = machine rate, S/hr

$FOHR_m$ = machine factory overhead rate.

Manufacturing Planning & Control System

It includes the following functionalities:

- Restate business objectives in operations management terms.
- Ensure feasibility of plans.
- Identify gaps in current resources.
- Help formulate connective action-Suppliers.
- Prioritize activities - scheduling ,Facilitate feedback.

Production Plan

- It is the First step in the planning process.
- It is one of three high level plans namely Business Plan, Sales Plan and Production Plan.
- Difference between sales plan and production plan is the inventory plan.

Master Production Schedule

- A Document that defines the specific goods that specific shops will produce in definite quantities at definite times over a short-term horizon in accordance with the aggregate plan.

- The MPS represents an agreement between marketing and manufacturing.

Master Production Schedule

- A detailed aggregation of production plan tends to be:
  - Short time horizon
  - More detailed product information
  - More concern over capacity
  - Corporate plan
  - Quasi-contract
  - Updated regularly

Master Production Schedule

- MPS Problems:

  - Overloaded
  - Front end Loaded
  - Unstable
  - Incomplete
  - Short Horizon

Material Requirements Planning

- MRP Elements:

  - Gross Requirements
  - On-Hand Inventory
  - Allocations
  - Scheduled Receipts
  - Net Requirements
  - Planned and Order Releases
  - Time-phasing
  - Parent/Component

Material Requirements Planning

- Advantages of MRP

  - Forward looking when planning (visibility). Useful simulator.

  - Provides valid, credible priorities.

  - Priorities reflect actual needs, not implied needs.

  - Provides mangers with control over the execution system.

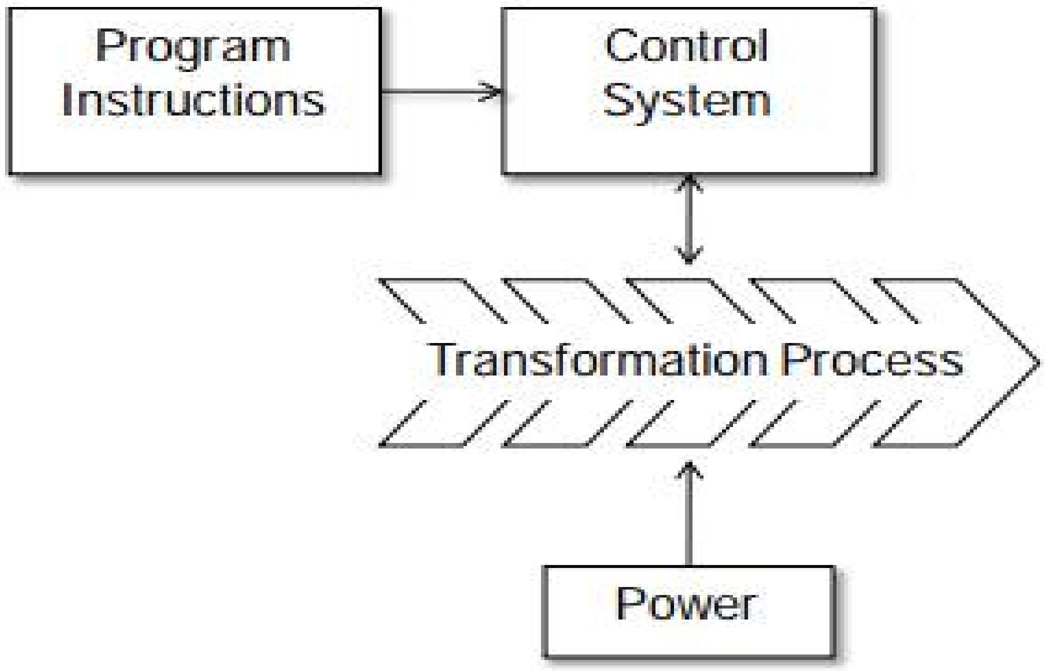
Material Requirements Planning

- Limitations of MRP
  - Looks at materials, ignores capacity, shop floor conditions.
  - Requires user discipline.
  - Requires accurate information/data.
  - Requires valid MPS.
  - High volume production.

Basic Elements of an Automated System

- Automation consists of three basic elements when applied to a particular transformation process:
  - Power to achieve the process and operate the system.
  - Programme of instructions to direct the process.
  - Control system to actuate the instructions.

Basic Elements of an Automated System



Basic Elements of an Automated System

- The programme of instructions used by the automated system is the series of controlled actions that are carried-out in the manufacturing or assembly process.

- Parts or products are usually processed as part of a work cycle and it is within this work cycle structure that programme steps may be defined, hence the term work cycle programmes.

- In numerical control work cycle programmes are called part programmes. The program of instructions can also be called software program.

- In complicated systems the work cycle consists of a number of work steps that are repeated with no deviation from one cycle to the next.

Basic Elements of an Automated System

- An example of this work cycle can be drawn from discrete-part manufacturing operation systems and consists of the following steps:

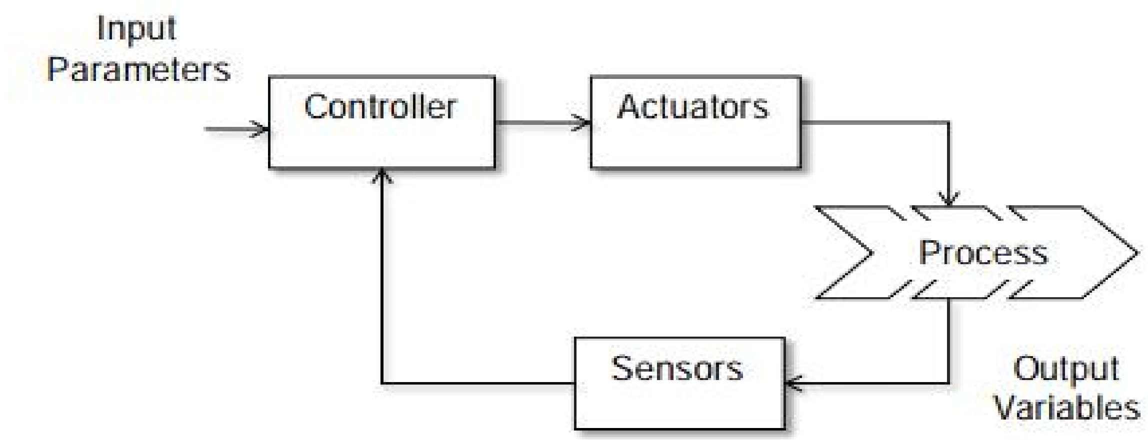
NUMLIST

- Load part into production machine.
- Perform process.
- Unload part from production machine.

Basic Elements of an Automated System

ENDLIST

- At each & every step, process parameters are being changed. A process parameters are inputs to the process, such as the initial process settings.
- Process parameters can be distinguished from process variables which are outputs from the process—these include actual process settings as the process is being performed.
- Different process parameters may be changed in each step.



Levels of Automation

- There are various levels at which automation can be applied in the context of the enterprise.
- A temperature sensor that feedback information to a regular in a shower is a reasonably low level of automation.
- On the other hand a high level automation system is required to run a train system in a city.

Levels of Automation

Five Level and Description:

- Device level:

The lowest level, it includes hardware components that comprise the machine level, such as actuators and sensors. Control loop devices are predominant here.

- Machine level :

Hardware at the device level is assembled into individual machines. Control functions at this level include performing the sequence of steps in the programme of instructions.

Levels of Automation

Cell or system level :

This operates under instructions from the plant level. Consists of a group of machines or workstations connected and supported by a material handling system, computers and other appropriate equipment, including production lines.

Plant level:

Factory or production systems level, it receives instruction from the corporate information system and translates them into operational plans for production.

Enterprise level :

The highest level, it consists of the corporate information system and is concerned with all the functions that are necessary to manage and coordinate the entire company.

Lean Production

- **It is also known as lean manufacturing. Also called as the Toyota Production System (TPS), as the concept was originated at Toyota motors.**

- It is Defined as an adoption of mass production in which workers and work cells are made more flexible and efficient by adopting methods that reduce waste in all forms.

Objectives of Lean Production

- The main benefits of lean production are lower production costs, increased output and shorter production lead times.

Some of the objectives of lean production are as follows.

- To reduce defects and unnecessary physical wastage, including excess use of raw material inputs, preventable defects, costs associated with reprocessing defective items.

- To reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages.

Objectives of Lean Production

- To minimize inventory levels at all stages of production, particularly works-in-progress between production stages.

- To improve labour productivity both by reducing the idle time of workers and ensuring that when workers are working they are using their effort as productively as possible.

- To use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production through existing equipment, while minimizing machine downtime.

Objectives of Lean Production

- To have the ability to produce a more flexible range of products with minimum changeover costs and change over time.

- Due to reduced cycle times, increased labour productivity and elimination of bottlenecks and machine downtime, companies can significantly increase the output from their existing facilities.

Key Principles of Lean Manufacturing

Key principles behind lean manufacturing can be summarized as follows:

- Recognition of waste:

The first step is to recognize what does not create value from the customers perspective. Any material process or feature which is not required for creating value from the customers perspective is waste and should be eliminated.

- Standard processes:

Lean requires the implementation of very detailed production guidelines called standard work, which clearly state the content, sequence, timing and outcome of all actions by workers. This eliminates variation in the way that workers perform their tasks.

Key Principles of Lean Manufacturing

- Continuous flow:

Lean usually aims for the implementation of a continuous production flow free of bottlenecks, interruption, detours, back flows or waiting.

- Pull-production:

Also called Just-In-Time (JIT), pull-production aims to produce only what is needed, when it is needed. Production is pulled by the downstream workstation so that each workstation should only produce what is requested by the next workstation.

Key Principles of Lean Manufacturing

- Quality at the source:

Lean aims for defects to be eliminated at the source and for quality inspection to be done by the workers as part of the in-line production process.

- Continuous improvement:

Lean requires striving for perfection by continually removing layers of waste as they are uncovered. This in turn requires a high level of worker involvement in the continuous improvement process.

Just-In-Time Production Systems

- **It is a management philosophy that strives to eliminate sources of manufacturing waste by producing the right part in the right place at the right time.**

- **It is also known as stockless production.** Improves profits and return on investment by:

  - Reducing inventory levels.
  - Reducing variability.
  - Improving product quality.
  - Reducing production and delivery lead times.
  - Reducing others costs such as machine setup cost and equipment breakdown cost.

Objectives of JIT

- The JIT is applied to achieve the following goals:

1) Zero defects
2) Zero setup time
3) Zero inventories
4) Zero handling
5) Zero breakdowns
6) Zero lead time
7) Lot size of one.

Elements of JIT

Some of he key elements of the JIT philosophy are:

- The Reduce or eliminate Setup times
- The Reduce manufacturing and purchasing lot sizes
- The Reduce production and delivery lead times
- The Preventive maintenance
- The Stabilize and level the production schedule with uniform plant loading
- The Flexible workforce
- The Require supplier quality assurance and implement a zero defects quality program
- The Small unit (single unit) conveyance

Kanban Production Control System

- Kanban means 'sign' or 'instruction card' in Japanese.
- Kanban is a card that is attached to a storage and transport container.
- Identifies the part number and container capacity, along with other information.

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Two Main Types of Kanban

- 1.Production Kanban (P-Kanban): Signals the need to produce more parts.
- 2.Transport or Conveyance Kanban (T-Kanban): Signals the need to deliver more parts to the next work centre. T-Kanban is also called as ‘more Kanban’ or ‘withdrawal Kanban'.

Pull Vs Push Systems

- A Kanban system is a pull system, in which the Kanban is used to pull parts to the next production stage when they are needed. Here product is made-to-order.

- A MRP system (or any schedule based system) is a push system in which a detailed production schedule for each part is used to push parts to the next production stage when scheduled. In a push system the product is made-to-stock.

- A weakness of a push system over a pull system is excess inventory, longer load time and more room for error.

Benefits of JIT

- JIT implementation leads to the following benefits:

  - Lower inventory cost.
  - Lower scrap and waste costs.
  - Improved quality and zero defect products.
  - Improved worker involvement.
  - Higher motivation and morale.
  - Increased productivity.
  - Reduced manufacturing lead time.
  - Improved product design and increased product flexibility.
  - Adherence to delivery time.