Tulsiramji Gaikwad Patil College of Engineering and Technology, Nagpur

Department of Mechanical Engineering

Computer Integrated Manufacturing

UNIT-I: INTRODUCTION OF CIM

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

This methodological approach is applied to all activities from the design of the product to customer support in an integrated way, using various methods, means and techniques in order to achieve production improvement, cost reduction, fulfilment of scheduled delivery dates, quality improvement and total flexibility in the manufacturing system. CIM requires all those associated with a company to involve totally in the process of product development and manufacture. In such a holistic approach, economic, social and human aspects have the same importance as technical aspects. CIM also encompasses the whole lot of enabling technologies including total quality management, business process reengineering, concurrent engineering, workflow automation, enterprise resource planning and flexible manufacturing. The challenge before the manufacturing engineers is illustrated in Fig.

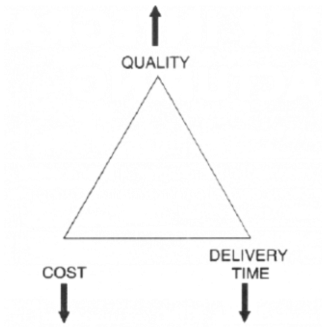

Figure Challenges in manufacturing

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

1. Reduction in inventory
2. Lower the cost of the product
3. Reduce waste
4. Improve quality
5. Increase flexibility in manufacturing to achieve immediate and rapid response
6. Product changes
7. Production changes
8. Process change
9. Equipment change
10. Change of personnel CIM technology is an enabling technology to meet the above challenges to the manufacturing.

EVOLUTION OF COMPUTER INTEGRATED MANUFACTURING

Computer Integrated Manufacturing (CIM) is considered a natural evolution of the technology of CAD/CAM which by itself evolved by the integration of CAD and CAM. Massachusetts Institute of Technology (MIT, USA) is credited with pioneering the development in both CAD and CAM. The need to meet the design and manufacturing requirements of aerospace industries after the Second World War necessitated the development these technologies. The manufacturing technology available during late 40's and early 50's could not meet the design and manufacturing challenges arising out of the need to develop sophisticated aircraft and satellite launch vehicles. This prompted the US Air Force to approach MIT to develop suitable control systems, drives and programming techniques for machine tools using electronic control. The first major innovation in machine control is the Numerical Control (NC), demonstrated at MIT in 1952. Early Numerical Control Systems were all basically hardwired systems, since these were built with discrete systems or with later first generation integrated chips. Early NC machines used paper tape as an input medium. Every NC machine was fitted with a tape reader to read paper tape and transfer the program to the memory of the machine tool block by block. Mainframe computers were used to control a group of NC machines by mid 60's. This arrangement was then called Direct Numerical Control (DNC) as the computer bypassed the tape reader to transfer the program data to the machine controller. By late 60's mini computers were being commonly used to control NC machines. At this stage NC became truly soft wired with the facilities of mass program storage, offline editing and software logic control and processing. This development is called Computer Numerical Control (CNC). Since 70's, numerical controllers are being designed around microprocessors, resulting in compact CNC systems. A further development to this technology is the distributed numerical control (also called DNC) in which processing of NC program is carried out in different computers operating at different hierarchical levels - typically from mainframe host computers to plant computers to the machine controller. Today the CNC systems are built around powerful 32 bit and 64 bit microprocessors. PC based systems are also becoming increasingly popular. Manufacturing engineers also started using computers for such tasks like inventory control; demand forecasting, production planning and control etc. CNC technology was adapted in the development of co-ordinate measuring machine's (CMMs) which automated inspection. Robots were introduced to automate several tasks like machine loading, materials handling, welding, painting and assembly. All these developments led to the evolution of flexible manufacturing cells and flexible manufacturing systems in late 70's. Evolution of Computer Aided Design (CAD), on the other hand was to cater to the geometric modelling needs of automobile and aeronautical industries. The developments in computers, design workstations, graphic cards, display devices and graphic input and output devices during the last ten years have been phenomenal. This coupled with the development of operating system with graphic user interfaces and powerful interactive (user friendly) software packages for modelling, drafting, analysis and optimization provides the necessary tools to automate the design process. CAD in fact owes its development to the APT language project at MIT in early 50's. Several clones of APT were introduced in 80's to automatically develop NC codes from the geometric model of the component. Now, one can model, draft, analyze, simulate, modify, optimize and create the NC code to manufacture a component and simulate the machining operation sitting at a computer workstation. If we review the manufacturing scenario during 80's we will find that the manufacturing is characterized by a few islands of automation. In the case of design, the task is well automated. In the case of manufacture, CNC machines, DNC systems, FMC, FMS etc provide tightly controlled automation systems. Similarly computer control has been implemented in several areas like manufacturing resource planning, accounting, sales, marketing and purchase. Yet the full potential of computerization could not be obtained unless all the segments of manufacturing are integrated, permitting the transfer of data across various functional modules. This realization led to the concept of computer integrated manufacturing. Thus the implementation of CIM required the development of whole lot of computer technologies related to hardware and software.

THE COMPONENTS OF CIM SYSTEM

Manufacturing firms must organize themselves to accomplish the five functions described above. Figure 7 illustrates the cycle of information-processing activities that typically occur in a manufacturing firm which produces discrete parts and assembles them into final products for sale to its customers. The factory operations described in the preceding section are pictured in the centre of the figure. The information-processing cycle, represented by the outer ring, can be described as consisting of four functions:

1. Business functions

2. Product design

3. Manufacturing planning

4. Manufacturing control

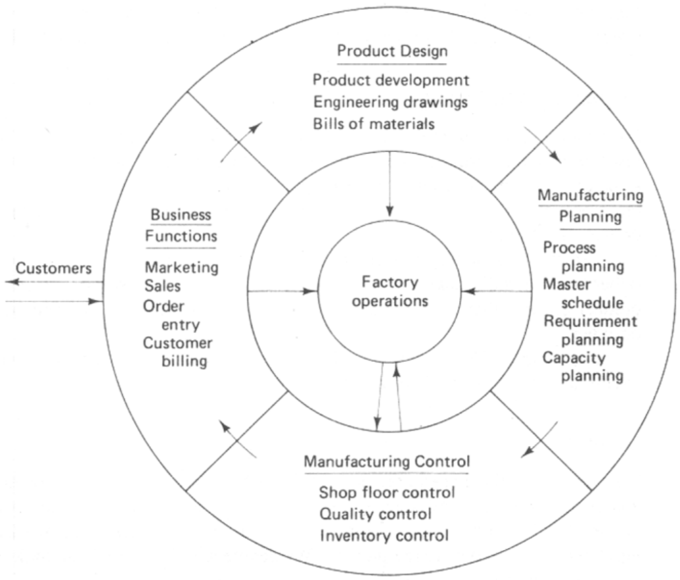

Figure CIMS cycle in a typical manufacturing firm

SCOPE OF COMPUTER-INTEGRATED MANUFACTURING

When all of the activities of the modern manufacturing plants are considered as a whole, it is impossible to think that a small portion might be automated, let alone trying to envisage automation of the whole. In systems approach, a large and complex system with interacting components are analyzed and improved. Anyone vested with the responsibility of implementation of automation for complex system is advised to implement a technique similar to the traditional systems approach.

Following steps are involved in the systems approach:

(a) Objectives of the system are determined.

(b) Structuring the system and set definable system boundaries.

(c) Significant components for a system are determined.

(d) A detailed study of the components is carried out

(e) Analyzed components are synthesized into the system.

(f) On the basis of the performance criteria, predetermined system is evaluated.

(g) For continuous improvement, Step „b‟ to Step „f‟ are constantly repeated.

No task, however small, should be tackled without knowledge of the task objective. This is the key ingredient which, when lacking, causes members of the same team to pull in different directions. In considering factory automation, there could be many possible objectives. One might be to improve the performance of a specific process. Boundary conditions would then be limited to that process (as well as other processes that might be affected by increased output, such as material supply and assembly after production). Another objective might be to minimize cost in a segment of the operation, while a third might be profit maximization; obviously it is rare that such multiple objectives can all be optimized, even though politicians seem to think so when it comes close to election day. When considering moving to a computer integrated manufacturing operation, the objective would probably be related to being competitive, a problem that manufacturing plants are having at the micro level and a situation that is almost catastrophic for the nation at the macro level. Setting system boundaries for a CIM project might at first appear to be concerned only with the engineering design and actual manufacture of the products. While the integration of these two components is a major task which is not satisfied in most of the facilities, CIM goes beyond these activities. Figure shows graphically what is involved in computer integrated manufacturing

CIMS activities include product design, engineering analysis and drafting whereas the process planning and NC part programming come in the manufacturing functions. The literal meaning of CAM is the manufacturing of the products with the aid of computers. Manufacturing is defined as a chain of interrelated activities that comprises designing, material selection, planning, production, quality assurance, management and marketing of discrete consumer and durable goods. CAM includes these aforementioned manufacturing functions

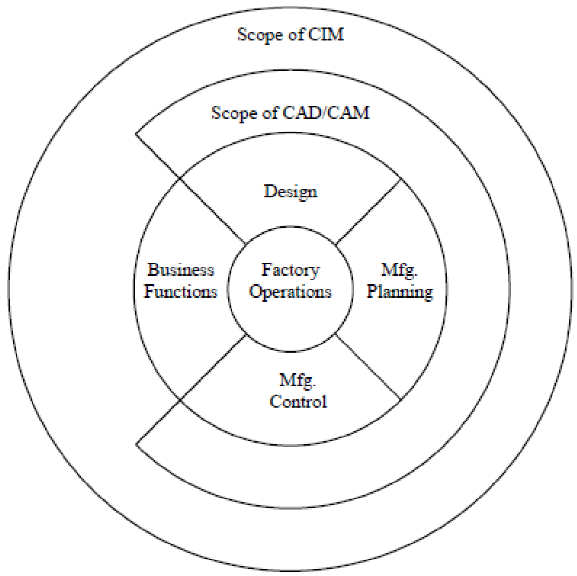

Figure: Scope of CIMS

CAD/CAM signifies an integration of design and manufacturing activities with the aid of computers. The conventional method of manufacturing a product which involves two separate procedures – designing the product and process planning – is a time consuming one and also involved duplication of effort by design and manufacturing personnel. These conventional methods are replaced by CAD/CAM. The direct link between product design and manufacturing is established with the help of CAD/CAM. While considering ideal CAD/CAM system, it takes the specific design of the product because it remains in the database and is converted into a process plan for manufacturing a product. CAD/CAM system automatically converts design of a product into a process plan. On a numerically controlled machine tool, a large portion of the processing can be completed. CAD/CAM automatically generates NC part programming. Using telecommunication network, NC program is directly downloaded to the machine tool in CAD/CAM system. Thus under CAD/CAM system, computer implements all the functions such as Product design, NC programming and Physical Production.

BENEFITS AND LIMITATIONS OF CIM

CIM plays a vital role in the economy of the manufacturing system or enterprise. The benefits of CIM are indicated as follows:

1. Products quality improvement.
2. Shorter time in launching new product in the market.
3. Inventory level reduced.
4. Improved scheduling performance.
5. Shorter lead time.
6. Improved customer service.
7. Increase in flexibility and responsiveness.
8. Total cost minimized.
9. Long term profitability increases.
10. Manufacturing productivity increases.

Limitations of CIM as follows:

1. High Initial Cost
2. Skilled manpower required
3. Unemployment
4. Degradation of Skills
5. High maintenance cost

DIFFERENCE BETWEEN AUTOMATION AND CIM

Automation	Computer Integrated Manufacturing (CIM)
1. Automation is a technology concerned with the application of mechanical, electronic, and computer-based systems to operate and control production.	1. CIM is a technology concern with the application and integration of all factions like business function, product development, manufacturing planning and manufacturing control for informational control to operate production.
2. It includes components like NC,CNC, Industrial Robots, Material Handling system, automated inspection system, feedback system and data base system	2. It includes components like Computer Base Business Function, CAD, CAM, CAPP, CAQC and FMS.
3. It is a physical activity performed in industry automation like processing, manufacturing, assembling, material handling, inspections etc.	3. It is communicative process of all integrated enterprise of industry like Business database communicate to product development, and product development to manufacturing planning and manufacturing control.
4. It is involve in actual activities in manufacturing	4. It is for supporting the manufacturing activities
5. It is human less programmed activity of production	5. it is information processing activity which starts from customer and goes on continuously

CONCURRENT ENGINEERING CONCEPT

Concurrent engineering, also known as simultaneous engineering, is a method of designing and developing products, in which the different stages run simultaneously, rather than consecutively. It decreases product development time and also the time to market, leading to improved productivity and reduced costs.

Concurrent Engineering was first implemented by Japanese companies in the late 80's and early 90's. According to total lead time of Japanese product projects at that time was 43 months as it correspondingly was 63 months in Europe. There were of course many things affecting but one of them was sc. Simultaneous Engineering nowadays called Concurrent Engineering (sometimes term Parallel Engineering also used). Concurrent Engineering presented a new team-based approach and implementation of certain technologies and methods that aimed to shorten total lead time with also improved quality and market entrance capability. As in traditional sequential engineering the engineering results are usually poured "finalized", non-changeable, to next step, Concurrent Engineering approach tries to capture need for change in early phases using constant interaction between departments. Concurrent Engineering collects many features of engineering philosophies and technologies under one umbrella. Methods like Quality Function Deployment and Taguchi method or technologies of CAD/CAM integration and Collaborative Engineering are examples of elements or "tools" in Concurrent Engineering. Concurrent Engineering should be seen as business strategy facilitator. In world today, it is not enough to make excellent products. You have to be in the market at the right time – and market is changing. Therefore companies must adapt to change in their processes – the faster they are the less time there is for market change. Concurrent Engineering aims to optimize the resource use in the product process providing an environment for agile product introduction.

Concurrent Engineering can be used with differing focus and using different elements to build the system. The focus can consist of one or more (adapted and fulfilled) :

1. Shorter total lead time
2. Products improved overall quality
3. Decreased manufacturing costs
4. Earlier break-even point
5. Life-cycle cost reduction
6. Better customer satisfaction
7. Reduced changes / changes earlier / less changes after ramp-up
8. Less risk of failure

9. Lower risk to flop with product in general

10. More predictable / accurate results / process (e.g. in feasibility)

11. Global engineering environment development

Common elements to all Concurrent Engineering environments are interaction between different functional departments (sales/marketing, design, production, purchase and also main suppliers). Typical for Concurrent Engineering is that there is more time used to define the product. This increased allocation of resources in the beginning of the process but decreases needs for changes later in the process where they are expensive to perform. When e.g. manufacturing sees also the first sketch manufacturing function can comment issues requiring manufacturing knowledge and start relevant preparations earlier. Also when marketing sees that same sketch, they can respond with market knowledge e.g. about the possible prize or volume – cross department issues definitively affecting to design issues. Basically this is done through cross border interactions – overlapping of functions. One must though be careful with overlapping. It must be remembered that use of resources is to be optimized – not wasted. The essential is not to assign marketing and manufacturing to all design meetings. Essential is to link knowledge domains of different functions, which can happen for example through team involvement. Concurrent Engineering requires constant monitoring and management following with enhancing changes to environment. Actually, there is quite much freedom in creating a Concurrent Engineering environment. E.g. Japanese auto manufacturers have their own solutions. Honda introduced sc. SED method that introduced “guest engineer” – an engineer from supplier taking part in the product team and acting as knowledge domain link. The features to deploy depend on focus and organization. CAD/CAM technologies, providing today sc. digital mock-ups, are today a key element of Concurrent Engineering. Virtual products and collaborative environments allow different expertise’s to contribute to product design. As one of the principles was to share information early in the project the three-dimensional geometry is unambiguous to all participants and therefore central part of interaction.

Concurrent Engineering benefits an extensive list of Concurrent Engineering benefits is available at.

1. Faster time to market which results in increased market share.

2. Lower manufacturing and production costs.
3. Improved quality of resulting end products.
4. Increased positioning in a highly competitive world market.
5. Increased accuracy in predicting and meeting plans, schedules, timelines, and budgets.
6. Increased efficiency and performance.
7. Higher reliability in the product development process.
8. Reduced defect rates.
9. Increased effectiveness in transferring technology.
10. Increased customer satisfaction.
11. Ability to execute high level and complex projects while minimizing the difficulties.
12. Shorter design and development process with accelerated project execution.
13. Higher return on investments.
14. Reduction or elimination of the number of design changes and reengineering efforts at later phases in the development process.
15. Reduced labour and resource requirements.
16. Ability to recognize necessary design changes early in the development process.
17. Increased innovation by having all players participate in the concept development phase.
18. Ability to design right the first time out / First time capabilities.
19. Overlapping capabilities and the ability to work in parallel.
20. Increased cohesiveness within the firm.
21. Improved communication between individuals and departments within the firm.
22. Lower implementation risks.
23. Faster reaction time in responding to the rapidly changing market.

24. Lower product and process design and development costs.

25. Improved inventory control, scheduling and customer relations. Concurrent

Engineering process In Figure a normal sequential engineering process is described. In sequential engineering each functional phase goes through reviews or gates in which the phase is locked and next phase is allowed to start. This approach has three deficiencies

1) Communication between expertises throughout the process is not supported

2) Total time used per product is long

3) Possibility to change is locked in gates.

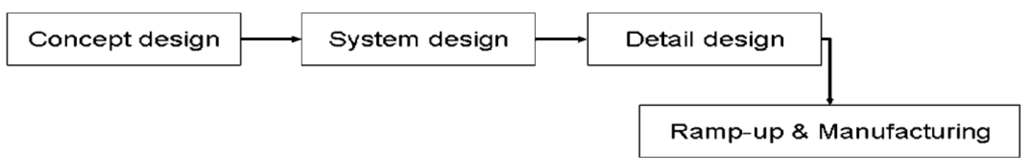

Figure In sequential engineering different phases follows each other – the text in boxes may vary or more phases can be included e.g. sales, quality or testing)

QUESTION BANK

1) Explain the various components of computer integrated manufacturing system?(W-03)

3) What is the difference between CIM and Automation? (W-03, W-06, W-11)

4) What is the difference between CIM and Automation? Explain the various segments of CIMS. (W-04, S-05, W-05, S-11) OR

Explain the various segments of CIMS with the help of CIM wheel. (S-06, W-06, S-07, W-09, S-10, W-10, W-11)

5) Explain the evolution of CIM. Discuss any one CIM software. (W-09, S-11)

6) Write a Short Note on:

a) Difference between Automation & CIMS (S-06, W-10, W-11)

7) What is concurrent Engineering? Explain in brief.

COMPUTER INTEGRATED MANUFACTURING

1. INTRODUCTION:

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    - Production changes
    - Process change
    - Equipment change
    - Change of personnel

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

2. EVOLUTION OF CIM:

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If we review the manufacturing scenario during 80's we will find that the manufacturing is characterized by a few islands of automation. In the case of design, the task is well automated. In the case of manufacture, CNC machines, DNC systems, FMC, FMS etc provide tightly controlled automation systems. Similarly computer control has been implemented in several areas like manufacturing resource planning, accounting, sales, marketing and purchase. Yet the full potential of computerization could not be obtained unless all the segments of manufacturing are integrated, permitting the transfer of data across various functional modules. This realization led to the concept of computer integrated manufacturing. Thus the implementation of CIM required the development of whole lot of computer technologies related to hardware and software.

3. DEFINITION OF CIM:

CIM is defined differently by different users, and can be implemented in varying an increasing degree of complexity. For many companies, improving shop-floor communications is the primary goal. Others extend the degree of integration to encompass communication between engineering and manufacturing functions. The ultimate benefit of CIM is the improvement of communication and control of information flow to all aspects of an enterprise.

The computer and automated systems association of the society of Manufacturing Engineers (CASA/SEM) defines CIM is the integration of total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency.

CIM is recognized as Islands of Automation. They are

1. CAD/CAM/CAE/GT
2. Manufacturing Planning and Control.
3. Factory Automation
4. General Business Management

CASA/SME's CIM Wheel is as shown in figure 1

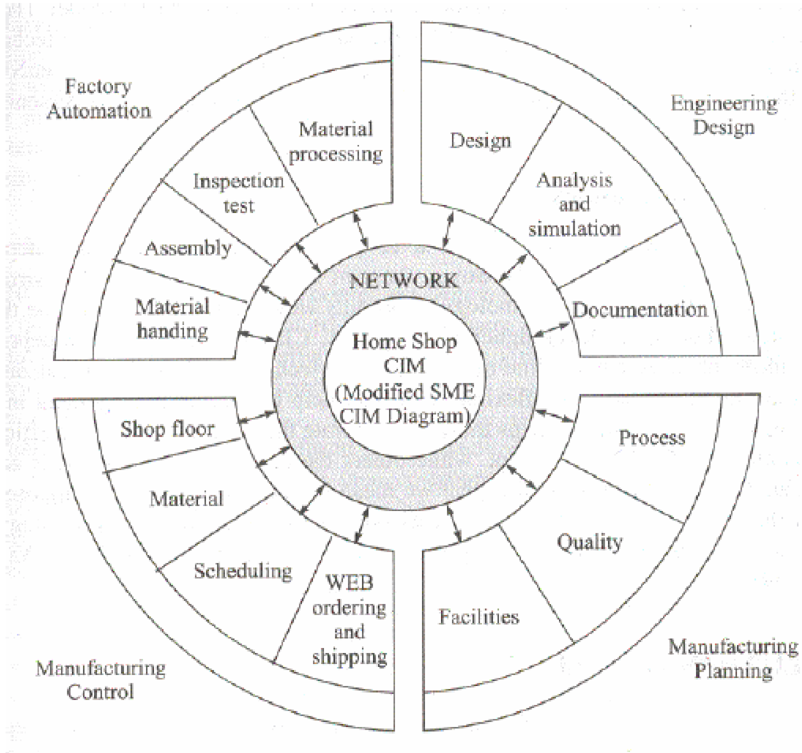

Figure 1 CASA/SME's CIM Wheel

4. CIM HARDWARE AND CIM SOFTWARE:

CIM Hardware comprises the following:

I. Manufacturing equipment such as CNC machines or computerized work centers, robotic work cells, DNC/FMS systems, work handling and tool handling devices, storage devices, sensors, shop floor data collection devices, inspection machines etc.

II. Computers, controllers, CAD/CAM systems, workstations / terminals, data entry terminals, bar code readers, RFID tags, printers, plotters and other peripheral devices, modems, cables, connectors etc.,

CIM software comprises computer programs to carry out the following functions:

- Management Information System
- Sales
- Marketing
- Finance
- Database Management
- Modeling and Design
- Analysis
- Simulation
- Communications
- Job Tracking
- Inventory Control
- Shop Floor Data Collection
- Order Entry
- Materials Handling
- Device Drivers
- Process Planning
- Manufacturing Facilities Planning
- Work Flow Automation

5. ROLE OF THE ELEMENTS OF CIM SYSTEM:

Nine major elements of a CIM system are in Figure 2 they are,

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

Figure 2 Major elements of CIM systems

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

ii. Product Design: The design department of the company establishes the initial database for production of a proposed product. In a CIM system this is accomplished through activities such as geometric modeling and computer aided design while considering the product requirements and concepts generated by the creativity of the design engineer.

Configuration management is an important activity in many designs. Complex designs are usually carried out by several teams working simultaneously, located often in different parts of the world. The design process is constrained by the costs that will be incurred in actual production and by the capabilities of the available production equipment and processes. The design process creates the database required to manufacture the part.

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

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

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

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

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

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

ix. *Information Management:* Information Management is perhaps one of the crucial tasks in CIM. This involves master production scheduling, database management, communication, manufacturing systems integration and management information systems.

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Computer Integrated Manufacturing
Unit –II

Introduction to Numerical Control of Machines

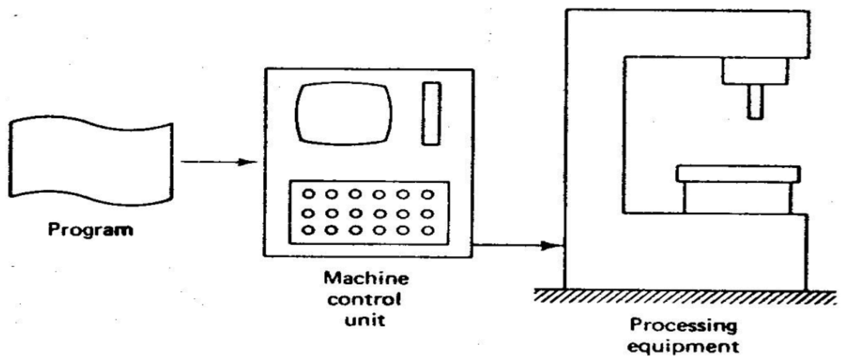
*** Why NC machines?**

1) Automation and mass production are associated with advancement in technology.
2) In today world of globalization and Industrialization cut throat compition increases for productivity, time & quality to satisfy this all industries are going for automation.
3) Automation means special purpose automation m/cs, automatic transfer lines and material handling robots etc. which are controlled by a digital electronics unit.
4) In conventional large variety of components and product manufactured by general purpose machine tools & skilled operators who was responsible for many inputs to the machine for example reading drawing, dimensions, material loading, unloading and inspection for quality.
5) Although the general purpose machines are very flexible but this flexibility on the cost of time, productivity & quality.
6) As the degree of complexity of component increases the tolerances of time and productivity become closer.
7) The process was totally dependent on operators, the mistakes on the part of operator due to in attention and tiredness, result in production of defective components.
8) To over come these problems of job & batch production several improvements had been made in conventional m/cs by reducing the manual control element
9) At the age of second world war the special purpose machine like copying machine had been evolved for producing similar component in mass level. It is also called tracer machines, a model or template called master was used to manufactured first then a tracer or stylus scans the model r template and controls the motion of cutting tool by mean of servo motor, mechanism.
10) The main disadvantage of copying machine is time spent on producing the master, as master is made without automation and it has to be produced to high degree of accuracy. Since this operation is very time consuming.
11) After copying machine automated lathe machine had been evolved but this type of setup of the required dimensions of the parts are established by micro switches and stoppers.
    The disadvantage of this setup is to setting of the limit switches and stoppers for every new product.
12) So all these problems of automation of medium and small volume production have been overcome by numerically controlled machine tools where the machining opera hens/processes are controlled with the help of coded instructions given to the machine tools.
    The simplest definition of numerical control (NC) given by Electronic industries Association (EIA) USA is :
    "A system in which the actions are controlled by direct in section of numerical data at some point. The system must automatically interpret at least some portion of this data".
13) This definition elaborated as machine tools controlled by means of a prepared programme, which consists of blocks or series of numbers, alphabets or alpha numerics.
    These codes define the required position of each machine slide, feed, cuttings speed & depth of cut. In addition the codes are used to control other functions like codeant ON /OFF, tool change, etc. The data for preparing the coded instructions, called part programming.

NC machines :

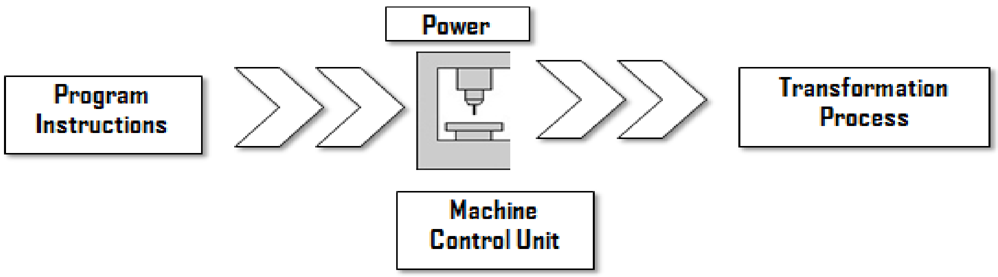
What is the concept of NC machines?

1) Combining control system with coded programmed and machine tools is formed Numerical controlled machine tools (NC machines)
2) NC machines having variety of complexities & capabilities. Conventionally NC control units added to machine tools which were used to control the position of work piece and relative motion of cutting tool. But the operator was required to select the cutting tolls, speed & feeds etc.



3) But As time passes the capabilities of machines tools improved and in addition to maintaining cutting tools & work piece relationship, the material removal was also controlled by the numerical control system.
4) NC machines consisting of following types of components.
   1) Program of instruction (paper tape or magnetic tape)
   2) Machine control Unit.
   3) Machine tool or processing equipment.

Diagram:



NC Machine System

1) **Program of instruction**: The instructions to NC machines are fed through an external medium i.e. paper tape or magnetic tape. The information coded on the paper tape and magnetic tap inform of coded punter with specific position. Which defines, cutting tool position with respect to the work piece.
2) **Machines control Unit** :- The information read through an external medium i.e., paper tap or magnetic tape processed and decoded in for m of digital signals which converts these digital signals into analog signals and control the motion of cutting tool with respect to work piece. This read information stored into the memory of the control system called "buffer storage" and is processed by the machine is working on one instructions block, the next block read from the tape and stored in the memory of machine control system.
3) **Machine tool or processing unit :-** Since the part cannot be produced without a tape being run through the control unit these type of NC machines called tape controlled machines. The machine tool. reads the digital signals inform of analog and transmit inform of mechanical motion for producing components. The tape has to be run repeatedly to be produced. Also if there is minor change inhering of component, the tape has to be discarded and new tape with changed programme has to be produced.

CNC Machines:

***What is the concept of CNC machines?**

1) In case of computer is used to perform all basic NC functions to control the machine tolls this type of machine tool system is called CNC machine (computer numerical controlled machine)
2) The complete part program to produce a component is input and stored in the computer memory and the information for each operation is fed to the machine tools i.e. motors, etc.
3) The programs can be stored in memory of the computer and used in future.

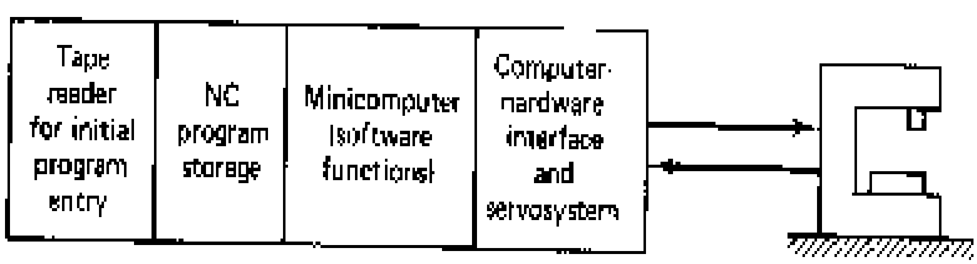
Some of important features available for CNC m/c:-

1) The part program can be input to the controller unit through keyboard
2) The part program can be input to the computer memory can be used again and again.
3) The part program can be edited and optimized at m/c tool itself if there is any change in the design of the component the part program can be changed according to the requirements.
4) The input information can be reproduced by developing sub program favor putative operations. For example, for making holes on pitch circle etc. Subroutines can be retrieved and used any number of times within a part program only certain parameters have to be specified.
5) The CNC machines have the facility for providing the part program without actually running it on the machine tool. Each operation we can execute actual running of machine tool with we can see the video of operation on monitor screen.
6) CNC control unit allows compensation for any changes the dimension of cutting tool. Because according to part program particular type & size of cutting tool in mind. But in actual use that cutting may not available. So in this regard CNC can provide compensation to made difference between the programmed cutter and the actual cutter used.
7) CNC machines system, useful to the management also like control system can provide the information such as number of components produced, time per component time for setting up a job, time for which a particular toll has been use, time for which machine has not been working and fault diagnosis etc.

CNC machine consist of following component;-

1) Program instruction
2) Machine control unit
3) Machine tool or processing equipment.

Diagram:-



CNC Machine system

1) Program instruction: The program of CNC machine in two type's manual part programming & APT manual part programming use in special coded instructions for different machining operation 'G' code & 'H' code form. After the completion of part program it is allow to execute without actual operation and check where her it is correct or not in control unit of CNC machine.
2) Machine Control Unit (MCU):- The machine control unit through which reading of the part programming and convert these coded instruction to the main operation instruction in digital mode and transmit the coded digital signal of instruction to the machine tool.
   MCU also provides the actual working interface of the actual operation without machine tool running which can be helpful to find out defects an part programming.
   MCU work as a management unit of CNC machine tool for managing various operational activities and store the information like program and sort of instruction for future use.

Direct Numerical control (DNC machine):-

What is the concept of DNC machines?

1) Direct Numerical control (DNC) machine is a new generation manufacturing system in which large number of machines is controlled by a computer through the direct connections.
2) All machines linked to a main frame computer which sends information to individual machines when required.
3) The part programming for all the components, which are to be manufactured on DNC system, are stored in the memory of the computer.
4) There are two types of system configuration for linking the computer with machine tool.

The 1st configuration in which main computer is directly linked to the machine but in this type there can be delay in communicating the instruction in between computers. 2nd configuration the main computer is connected to machine tool through a minim computer called satellite computer. The main computer stores the part programmes for all the components to be mechanical on a particular machine. The satellite computer receives and stores the part program. The satellite computer controls the machines tool operation. The advantage of this system is that the machine can be used independent of the main computer as the main computer is not actively involved in operation of machine tool.

Advantage DNC machine that we can give the instruction of complier manufacturing unit from very long distance.

There are various components of DNC machines as follows :-

1) Central main frame satellite computer with bulk memory.
2) Satellite minicomputer with memory buffer
3) Tele communication lines
4) Machine tolls.

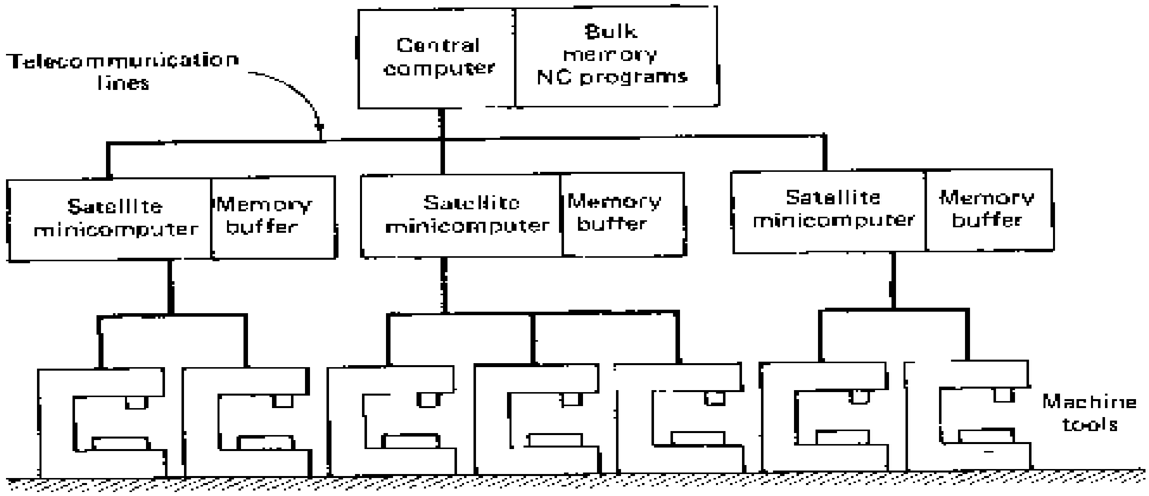


Diagram:

1) **Central Computer:-** It is the master computer which consist or execute the part program and transmit the command or instruction directly or through satellite to mini subsystem through the telecommunication system.
   The control computer consists of main Bulk memory for storing different part program and sort of instruction.
2) **Satellite mini computers**:- Satellite mini computers are the sub systems which are linked to their machine tool. There computer taking signals in form of instruction from the central computer directly or through satellite these instruction transmit to the machine tool for operation. These computers having. Buffer memory for storing the program and instruct.
3) **Telecommunication lines:-** Telecom.- communication lines through which the central mainframe computer linked with satellite minicomputer directly or through satellite.
4) **Machine tool:-** Machine tools receives the digital signal from minicomputers inform of instruction and convert that digital signals into the analog signals and perform different machining operations.

Advantages of CNC machines:

***What are the advantages of CNC M/C?**

There are following advantages of CNC machine:-

1) Reducing Lead Time :- It is the time there receipt of a design drawing by production department and manufacturer getting ready to start production including the time needed for planning, design or Jigs & Fixtures etc. is called lead time.
   Since special Jigs and fixtures are often entirely eliminated CNC machines, the whole of the time needed for their design and manufacturing saved.
   CNC machine can start production within a short period of the work being planned and material being available.
2) Elimination of operator Errors: - The machine is controlled by program of instructions stored in memory. The program is checked before goes on machine so no errors will occur in job Fatigue boredom or in attention by a operator will not effect the quality or duration of the machining.
3) Operator Activity:- The operator is relieved of talks readily performed like pre-setting of tools, setting of components and preparation of planning so man factor totally eliminated in CNC systems.
4) Lower Labour cost:- CNC machine requires lower operation time hence one operator can room two or more machines or multiple parallel machines at a time resulting reduced of labour cost.
5) Smaller Batches:- In CNC machines pre-setting of tolls and work piece is minimum 80 we can produce different design of product with smaller batches.

6) Longer tool Life :-Tools can be used at optimum speed and feed because this functions are controlled by part program so we can get Longer tool life.
7) Elimination of special Jigs & Fixtures:- Special Jig & Fixtures are often not used on CNC and cost and storage space required for it totally eliminated because CNC having all these facilities in built.
8) Flexibility in changes of component Design:- The modification or changes in component design can be readily accommodated by re programming.
9) Reduced inspection:- The time spent on inspection and in waiting for inspection to being greatly reduced. Normally it is required to inspect only 1st component in place of inspection in batch wise.
10) Less scrap:- Since the operator error eliminated results the proper planning of raw material use and tool setting which avoids raw material & tools wastage. Which result into less scrap.
11) Accurate costing & scheduling:-In CNC machine the time fell in maching is predictable, consist and result in greater accuracy of costing & scheduling and more predictable output.

Disadvantages of CNC machines

Explain various disadvantages of CNC m/c[3]

There are four main disadvantages of CNC m/c are as follows:-

1) Higher Investment Cost: - CNC machine tolls represent a more sophisticated and complex technology. This technology costs more to buy than its non CNC counterpart, higher cost requires manufacturing management, erection & operation.

2) Higher Maintenance Cost: - CNC machines are more sophisticated and complex then maintenance problem occur more frequency and it required skilled manpower for maintenance which cost is very high.

3) Costlier CNC personnel:- Certain aspects of CNC machine operations requires a higher skill level than conversional operations. Part program & CNC maintenance with required skill are in short supply. Hence cost of CNC personnel hiring is very high.

4) Planned Support facility:- CNC operations is done which required a vast planned support facility for different planning of work, time, cost & material which much costlier as compaire to conversional one.

Classification of CNC machines.

***What are different type of control system ?**

Ans : I) Based on the motion type point to point, straight line & contouring system.

a) Point to Point control system :-

1) point to point control is one where accurate positional slides only to place the machine slides in fixed position & the machine tool slide is required to reach a particular fixed to co-ordinate point in the shortest possible time.

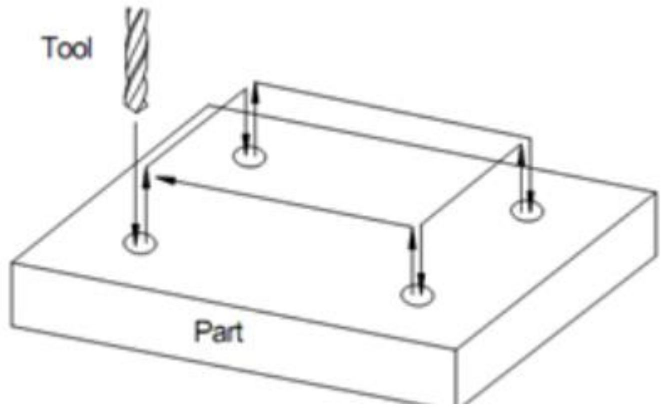
2) The machining operating are performed at specific points and there is no machining while the machine table/slide move from one point to the next. No machining takes place until the machine slides have reached the programmed co-ordinate point and slide movement ceases. Since there is no machining when the machine slides move from one point to other point.

3) Here path of movement of tool is not important but care must be taken to ensure that the costing tool should not hit the work piece while moving from one position to the next.

4) The movement along different axis may be sequential or simultaneous. The sequential or simultaneous movement reducing machining time.

5) Point to point system is suitable for drilling, boring, tapping, punch presses and jig boring machines.

Diagram :



Point - to – point system

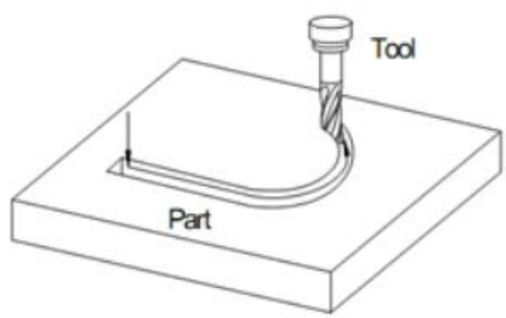
b) Straight line control system :-

1. It is extension of point to point control system in which special provision for maching along a straight line as in case of milling, turning & facing.
2. In this control system controlled feed provides along the axis in line motion.
3. In this control system it is capable of calculating and displacing the slides simultaneously at suitable feed rates to reach the desired points.

C) Continuous path or contouring control system

1. The contouring system is a high technology and most versatile control system. The control system generates continuous motion of tool and work piece along different co-ordinate axis.
2. This system enables the machining of profile, contours and curved surfaces.
3. This system designed for continuous path machining hence in it we can perform point to point & straight line machining also
4. In this system the machine tool, tool & work piece movement control simultaneously relative positions and velocities at every point throughout the operation.

Diagram :



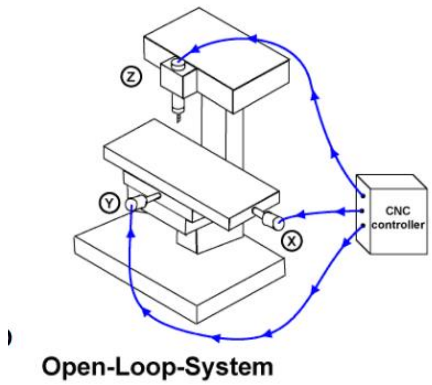
Contouring System

***Explain the open loop & close loop control system:**

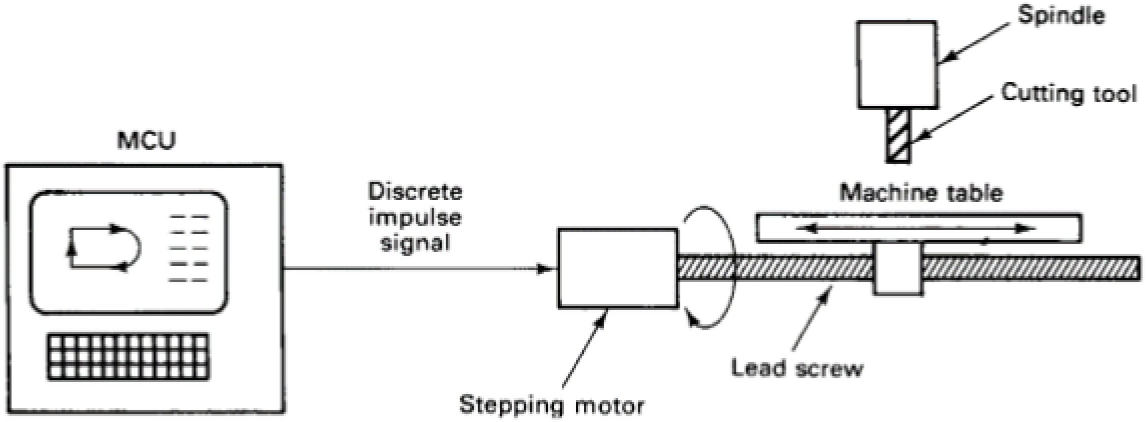
II) Based on Feedback control

a) Open-loop control System :

Diagram



Open loop control system



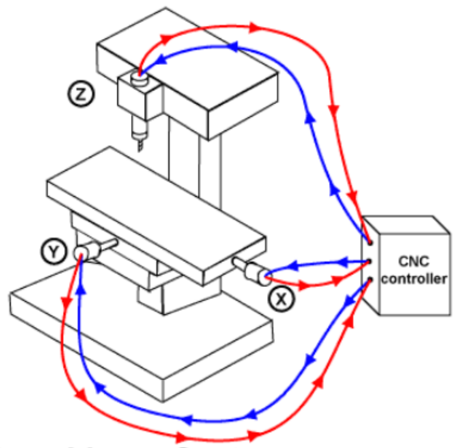
Configuration for an open loop system.

Block diagram of an open-loop system.

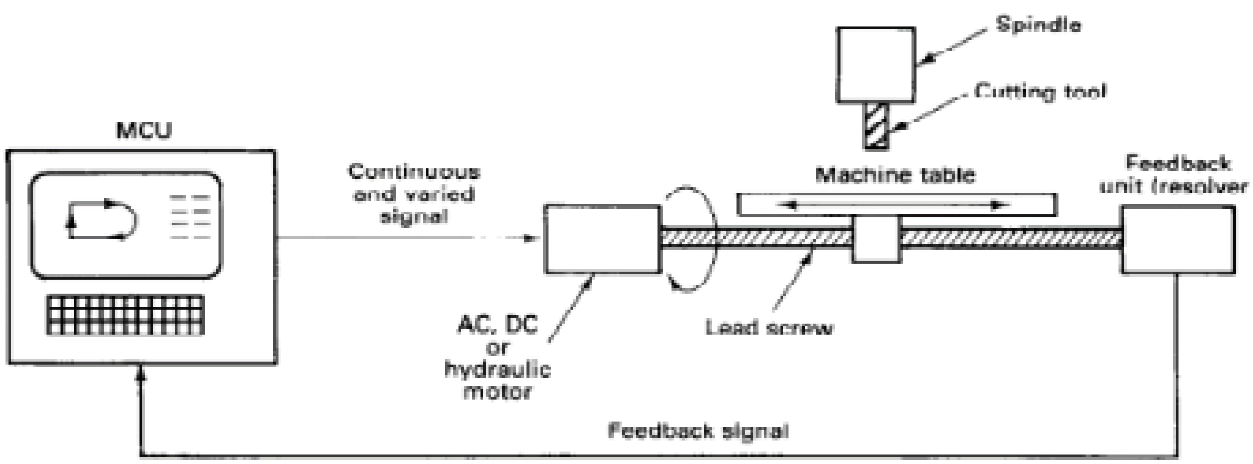
1) Machine toll control in which there is no provision to compare the actual position of cutting tool or work piece are called open-loop systems.
2) Programmed instructions are fed into the controller through an input device. These instructions are then convert to electrical pulses (signals) by the controller and sent to the servo amplifier to energize the servo motors.
3) The primary drawback there is not monitoring of the actual displacement of the machine slide.
4) For these reasons the open-loop system is generally used in point-to-point systems. Where the accuracy requirements are not critical.
5) In open –loop control system the actual displacement of the slide way vary with change in external conditions and wear of components of the drive mechanism. Since there is no provision of feed back in the control system periodical adjustment are required to compensate for the changed due to various factors.

b) Closed –loop control system :

Diagram :



Closed-Loop-System

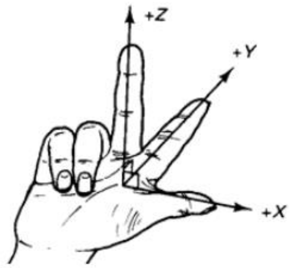


Configuration of a closed loop system.

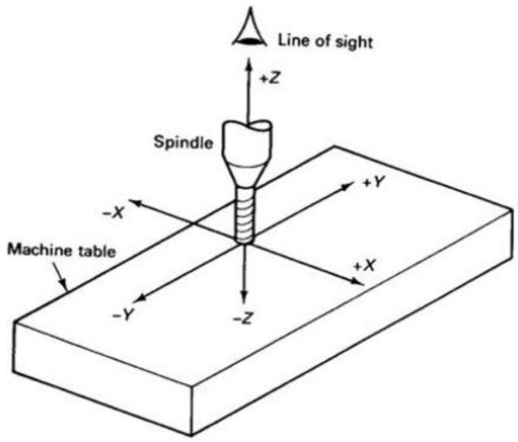
1) In a closed –loop control system i.e. actual displacement of the machine slide, is compared with the input signal. The closed loop control systems are characterized by the presence of feed-back devices in the system.
2) In the closed –loop control system the displacement can be achieved by a very high degree of accuracy because a measuring or monitoring devices is used to determine the displacement of the slide.
3) The feedback from the monitoring device is then compared with the input. Signal and slide position is regulated by the servo system until it agrees with desired position a closed loop control system with a provision for feed back for the displacement of position of machining slide. In order to measure the speed of the motor and compare the actual speed with the programmed speed, a velocity feed backs system is added to the system.

III) Based on the number of axes 2,3,4, & 5 axes CNC machines

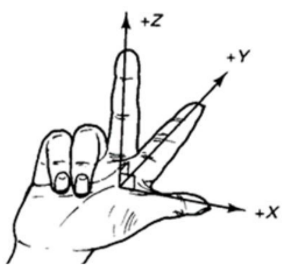
1) **2 & 3 lathes will be coming under 2 axes machines**. There will be two axes along which motion takes place. The saddle will be moving



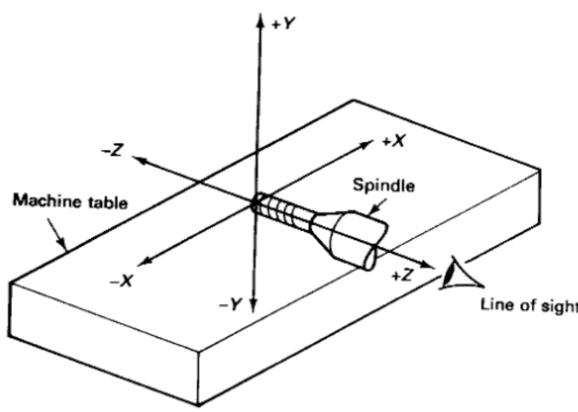
The right-hand rule for linear motion.



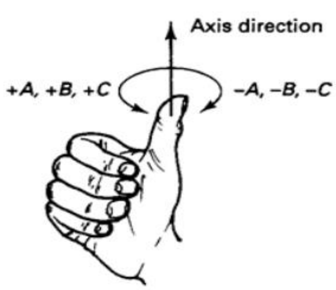
Machine axis for a three-axis vertical CNC machine (machine axis defined as spindle movement).



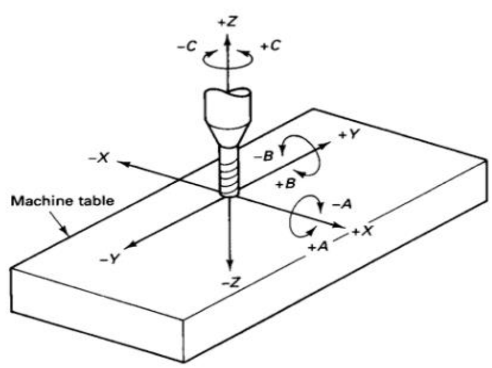
The right-hand rule for linear motion.



Machine axis for a three-axis horizontal CNC machine (machine axis defined as spindle movement).



The right-hand rule for rotary motion.

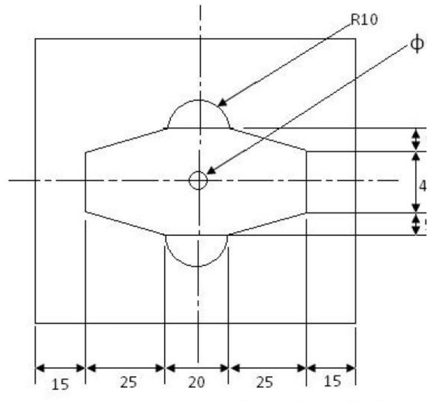


Machine axes for six-axis vertical CNC machine (machine axis defined as spindle movement).

M-word	*Function*
M00	Program stop; used in middle of program. Operator must restart machine.
M01	Optional program stop; active only when optional stop button on control panel depressed.
M02	End of program. Machine stop.
M03	Start spindle in clockwise direction for milling machine (forward for turning ma
M04	Start spindle in counterclockwise direction for milling machine (reverse for turn
M05	Spindle stop.
M06	Execute tool change, either manually or automatically. If manually, operator mu machine. Does not include selection of tool, which is done by T-word if automa operator if manual.
M07	Turn cutting fluid on flood.
M08	Turn cutting fluid on mist.
M09	Turn cutting fluid off.
M10	Automatic clamping of fixture, machine slides, etc.
M11	Automatic unclamping.
M13	Start spindle in clockwise direction for milling machine (forward for turning ma turn on cutting fluid.
M14	Start spindle in counterclockwise direction for milling machine (reverse for turn and turn on cutting fluid.
M17	Spindle and cutting fluid off.
M19	Turn spindle off at oriented position.
M30	End of program. Machine stop. Rewind tape (on tape-controlled machines).

G-word	Function
G00	Point-to-point movement (rapid traverse) between previous point and endpoint defined in current block. Block must include *x-y-z* coordinates of end position.
G01	Linear interpolation movement. Block must include *x-y-z* coordinates of end position. Feed rate must also be specified.
G02	Circular interpolation, clockwise. Block must include either arc radius or arc center; coordinates of end position must also be specified.
G03	Circular interpolation, counterclockwise. Block must include either arc radius or arc center; coordinates of end position must also be specified.
G04	Dwell for a specified time.
G10	Input of cutter offset data, followed by a P-code and an R-code.
G17	Selection of *x-y* plane in milling.
G18	Selection of *x-z* plane in milling.
G19	Selection of *y-z* plane in milling.
G20	Input values specified in inches.
G21	Input values specified in millimeters.
G28	Return to reference point.
G32	Thread cutting in turning.
G40	Cancel offset compensation for cutter radius (nose radius in turning).
G41	Cutter offset compensation, left of part surface. Cutter radius (nose radius in turning) must be specified in block.
G42	Cutter offset compensation, right of part surface. Cutter radius (nose radius in turning) must be specified in block.
G50	Specify location of coordinate axis system origin relative to starting location of cutting tool. Used in some lathes. Milling and drilling machines use G92.
G90	Programming in absolute coordinates.
G91	Programming in incremental coordinates.
G92	Specify location of coordinate axis system origin relative to starting location of cutting tool. Used in milling and drilling machines and some lathes. Other lathes use G50.
G94	Specify feed per minute in milling and drilling.
G95	Specify feed per revolution in milling and drilling.
G98	Specify feed per minute in turning.
G99	Specify feed per revolution in turning.

Q.5.Write a manual part program for machining the profile as shown in figure. Assume the depth of slot to be 2 mm. Assume appropriate speed and feed. Take the billet size as 100 x 100 x 10 mm. Briefly explain each program statement.



All dimensions are in mm.

Answer: - Program

N001 G21 G92 X0 Y0 Z0;

N002 G00 X15 Y30;

N003 G01 X40 Y25 Z-2 F40;

N004 G01 X60;

N005 G01 X85 Y30;

N006 G01 Y70;

N007 G01 X60 Y75;

N008 G01 X40;

N009 G01 X15 Y70;

N010 G01 Y30;

N011 G00 X0 Y0 Z0;

N012 G00 X40 Y25;

N013 G03 X60 Y25 R10; 27

N014 G00 X0 Y0 Z0;

N015 G00 X40 Y75;

N016 G02 X60 Y75 R10 F40;

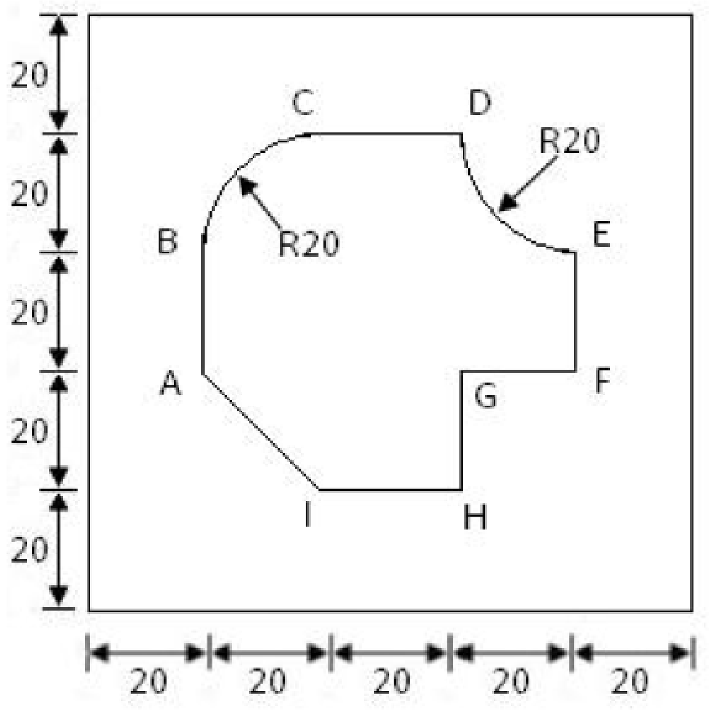
N017 G00 X0 Y0 Z0;

N018 G00 X47.5 Y50;

N019 G02 X47.5 Y50 Z-2 R2.5;

N020 M30;

Q.6.Write a manual part program to mill a slot as shown in figure.1 on an aluminum billet of size 100 x 100 x 10 mm. the depth of the slot should be 2 mm by using a drill bit of φ 5 mm. Assume suitable machining data wherever necessary.



All dimensions are in mm.

Answer: - Program

N001 G21 G92 X0 Y0 Z0;

N002 G00 X20 Y40;

N003 G01 X40 Y20 Z-2 F40;

N004 G01 X20;

N005 G01 Y40;

N006 G01 X80;

N007 G01 Y60;

N008 G02 X60 Y80 R20;

N009 G01 X40; 28

N010 G03 X20 Y60 R20;

N011 G01 Y40;

N012 G00 X0 Y0 Z0;

N013 M30;

Group Technology

Introduction

As early as in the 1920ies it was observed, that using product-oriented departments to manufacture standardized products in machine companies lead to reduced transportation. This can be considered the start of ***Group Technology*** (GT). Parts are classified and parts with similar features are manufactured together with standardized processes. As a consequence, small "focused factories" are being created as independent operating units within large facilities.

More generally, Group Technology can be considered a theory of management based on the principle that *"similar things should be done similarly"*. In our context, "things" include product design, process planning, fabrication, assembly, and production control. However, in a more general sense GT may be applied to all activities, including administrative functions.

The principle of group technology is to divide the manufacturing facility into small groups or *cells* of machines. The term ***cellular manufacturing*** is often used in this regard. Each of these cells is dedicated to a specified family or set of part types. Typically, a cell is a small group of machines (as a rule of thumb not more than five). An example would be a machining center with inspection and monitoring devices, tool and Part Storage, a robot for part handling, and the associated control hardware.

The idea of GT can also be used to build larger groups, such as for instance, a department, possibly composed of several automated cells or several manned machines of various types. As mentioned in Chapter 1 (see also Figure 1.5) pure item flow lines are possible, if volumes are very large. If volumes are very small, and parts are very different, a functional layout (job shop) is usually appropriate. In the intermediate case of *medium-variety, medium-volume* environments, group configuration is most appropriate.

GT can produce considerable improvements where it is appropriate and the basic idea can be utilized in all manufacturing environments:

- To the *manufacturing engineer* GT can be viewed as a role model to obtain the advantages of flow line systems in environments previously ruled by job shop layouts. The idea is to form groups and to aim at a product-type layout within each group (for a family of parts). Whenever possible, *new parts* are designed to be compatible with the processes and tooling of an existing part family. This way, production experience is quickly obtained, and standard process plans and tooling can be developed for this restricted part set.
- To the *design engineer* the idea of GT can mean to standardize products and process plans. If a new part should be designed, first retrieve the design for a similar, existing part. Maybe, the need for the new part is eliminated if an existing part will suffice. If a new part is actually needed, the new plan can be developed quickly by relying on decisions and documentation previously made for similar parts. Hence, the resulting plan will match current manufacturing procedures and document preparation time is reduced. The design engineer is freed to concentrate on optimal design.

In this GT context a typical approach would be the use of composite Part families. Consider e.g. the parts family shown in Figure 3.1.

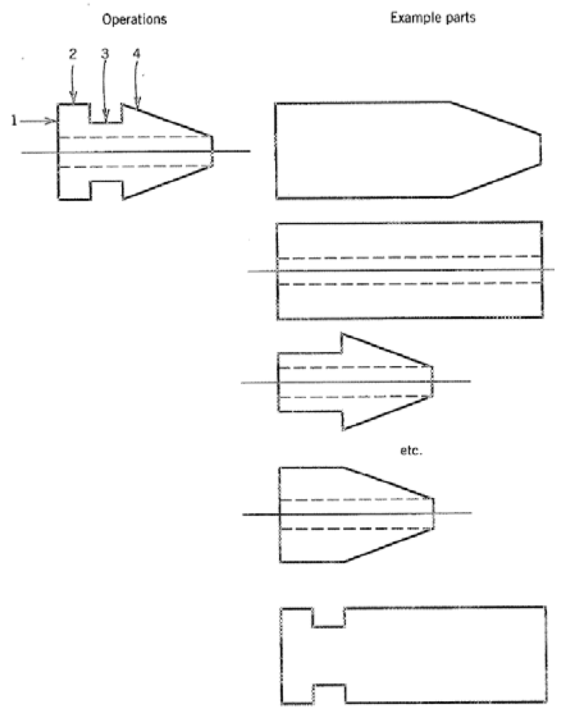


Figure 3.1. Composite Group Technology Part (Askin & Standridge, 1993, p. 165).

The parameter values for the features of this single part family have the same allowable ranges. Each part in the family requires the same set of machines and tools; in our example: turning/lathing (Drehbank), internal drilling (Bohrmaschine), face milling (Planfräsen), etc.

Raw material should be reasonably consistent (e.g. plastic and metallic parts require different manufacturing operations and should not be in the same family).

Fixtures can be designed that are capable of supporting all the actual realizations of the composite parts within the family.

Standard machine setups are often possible with little or no changeover required between the different parts within the family (same material, same fixture method, similar size, same tools/machines required).

In the *functional process* (job shop) layout, all parts travel through the *entire shop*. Scheduling and material control are complicated. Job priorities are difficult to set, and large WIP inventories are used to assure reasonable capacity utilisation. In *GT*, each part type flows only through its specific group area. The reduced setup time allows faster adjustment to changing conditions.

Often, workers are cross-trained on all machines within the group and follow the job from Start to finish. This usually leads to higher job satisfaction/motivation and higher efficiency.

For smaller-volume part families it may be necessary to include several such part families in a machine group to justify machine utilization.

One can identify three *different types group layout*:

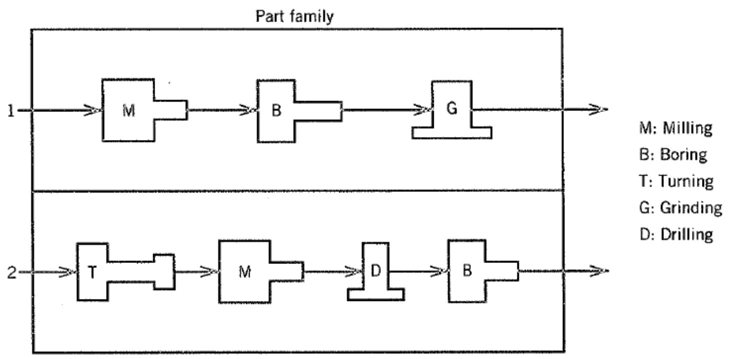


Figure 3.2a. GT flow line (Askin & Standridge, 1993, p. 167).

In a ***GT flow line*** concept all parts assigned to a group follow the same machine sequence and require relatively proportional time requirements on each machine.

The GT flow line operates as a *mixed-product assembly line* system; see Figure 3.2a. Automated transfer mechanisms may be possible. See also Chapter 4 for mixed-product assembly lines.

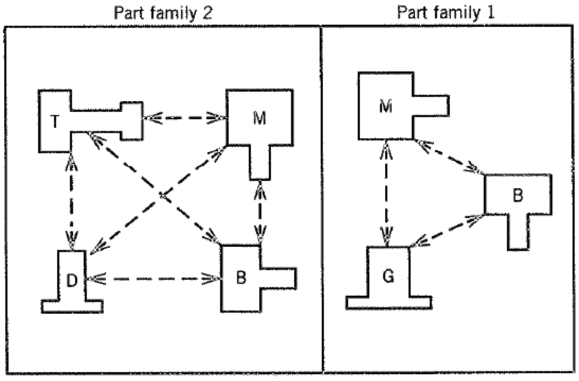


Figure 3.2b. GT cell
(Askin & Standridge, 1993, p. 167).

The *classical **GT cell*** allows parts to move from any machine to any other machine. Flow is not unidirectional. However, since machines are located in close proximity short and fast transfer is possible.

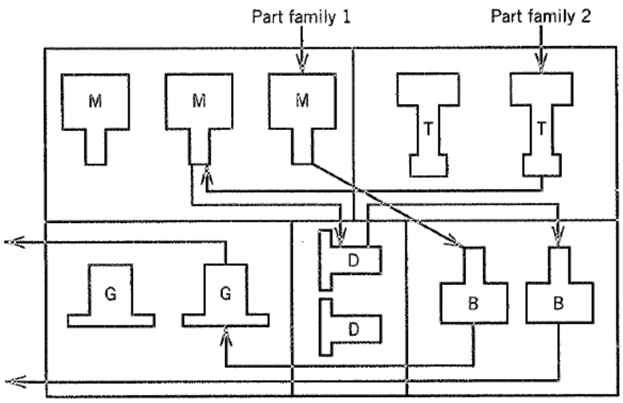


Figure 3.2c. GT center
(Askin & Standridge, 1993, p. 167).

The ***GT center*** may be appropriate when

- large machines have already been located and cannot be moved, or
- product mix and part families are dynamic and would require frequent relayout.

Then, machines may be located as in a process layout by using functional departments (job shops), but each machine is dedicated to producing only certain Part families. This way, only the tooling and control advantages of GT can be achieved. Compared to a GT cell layout, increased material handling is necessary.

GT offers numerous benefits w.r.t. throughput time, WIP inventory, materials handling, job satisfaction, fixtures, setup time, space needs, quality, finished goods, and labor cost; **read also Chapter 6.1 of Askin & Standridge, 1993.**

In general, GT simplifies and standardizes. The approach to simplify, standardize, and internalize through repetition produces efficiency.

Since a workcenter will work only on a family of similar parts generic fixtures can be developed and used. Tooling can be stored locally since parts will always be processed through the same machines. Tool changes may be required due to tool wear only, not part changeovers (e.g. a press may have a generic fixture that can hold all the parts in a family without any change or simply by changing a part-specific insert secured by a single screw. Hence ***setup time*** is reduced, and tooling cost is reduced. Using queuing theory (M/M/1 model) it is possible to show that if setup time is reduced, also the throughput time for the system is reduced by the same percentage.

How to form groups

Askin & Standridge, 1993, Chapter 6.2 provides a list of seven characteristics of successful groups:

Characteristic	Description
Team	specified team of dedicated workers
Products	specified set of products and no others
Facilities	specified set of (mainly) dedicated machines equipment
Group layout	dedicated contiguous space for specified facilities
Target	common group goal, established at start of each period
Independence	buffers between groups; groups can reach goals independently
Size	Preferably 6-15 workers (small enough to act as a team with a common goal; large enough to contain all necessary resources)

Clearly, also the organization should be structured around groups. Each group performs functions that in many cases were previously attributed to different functional departments. For instance, in most situations employee bonuses should be based on group performance.

Worker empowerment is an important aspect of manned cells. Exchanging ideas and work load is necessary. Many groups are allocated the responsibility for individual work assignments. By cross-training of technical skills, at least two workers can perform each task and all workers can perform multiple tasks. Hence the there is some flexibility in work assignments.

The group should be an independent profit center in some sense. It should also retain the responsibility for its performance and authority to affect that performance. The group is a single entity and must act together to resolve problems.

There are three basic steps in group technology planning:

1. coding

2. classification
3. layout.

These will be discussed in separate subsections.

Coding schemes

The knowledge concerning the similarities between parts must be coded somehow. This will facilitate determination and retrieval of similar parts. Often this involves the assignment of a symbolic or numerical description to parts (part number) based on their design and manufacturing characteristics. However, it may also simply mean listing the machines used by each part.

There are four major issues in the construction of a coding system:

- part (component) population
- code detail
- code structure, and
- (digital) representation.

Numerous codes exist, including Brisch-Birn, MULTICLASS, and KK-3. One of the most widely used coding systems is OPITZ. Many firms customize existing coding systems to their specific needs. Important aspects are

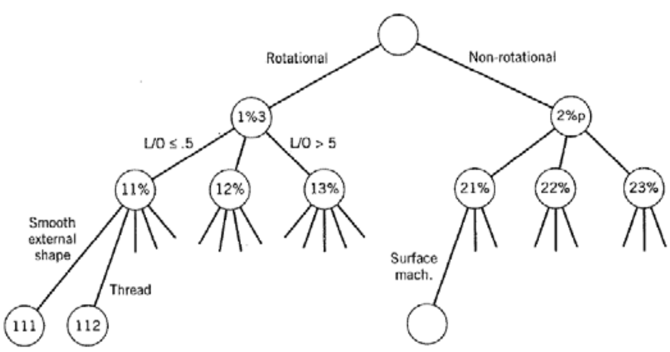
- The code should be sufficiently flexible to handle future as well as current parts.
- The scope of part types to be included must be known (e.g. are the parts rotational, prismatic, sheet metal, etc.?)
- To be useful, the code must discriminate between parts with different values for key attributes (material, tolerances, required machines, etc.)

Code detail is crucial to the success of the coding project. Ideal is a short code that uniquely identifies each part and fully describes the part from design and manufacturing viewpoints,

- Too much detail results in cumbersome codes and the waste of resources in data collection.
- With too few details and the code becomes useless.

As a general rule, all information necessary for grouping the part for manufacturing should be included in the code whenever possible. Features like outside shape, end shape, internal shape, holes, and dimensions are typically included in the coding scheme.

code structure, codes are generally classified as, hierarchical (also called monocode), chain (also called polycode), or hybrid. This is explained in Figure 3.3 (taken from Askin & Standridge, 1993).



Hierarchical code structure: the meaning of a digit in the code depends on the values of preceding digits. The value of 3 in the third place may indicate

- the existence of internal threads in a rotational part: "12**3**2"
- a smooth internal feature: "21**3**2"

Hierarchical codes are efficient; they only consider relevant information at each digit. But

Figure 3.3a. Hierarchical structure.

Code Digit Feature	1 Outside shape	2 Inside shape	3 Holes	4 Surface Machining	...
Value 1	None	None	No	None	
2	Smooth	Smooth	Smooth axial	External groove	
3	Stepped ends	Stepped ends	Smooth radial	External spline	
4	Stepped and threads	Stepped and threads	Axial and radial	Internal curved	
⋮					

Figure 3.3b. Chain structure.

they are difficult to learn because of the large number of conditional inferences.

***Chain code*:** each value for each digit of the code has a consistent meaning. The value 3 in the third place has the same meaning for all parts.

They are easier to learn but less efficient. Certain digits may be almost meaningless for some parts.

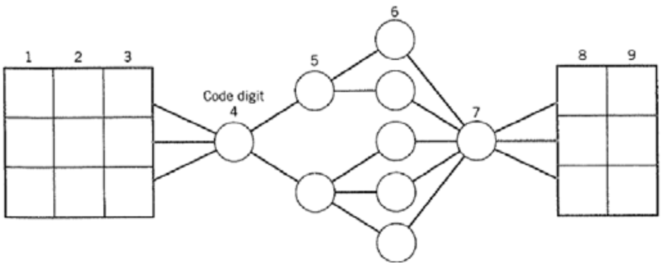


Figure 3.3c. Chain structure.

Since both hierarchical and chain codes have advantages, many commercial codes are ***hybrid***: combination of both:

Some section of the code is a chain code and then several hierarchical digits further detail the specified characteristics. Several such sections may exist. One example of a hybrid code is OPITZ.

The final decision is, ***code representation.*** The digits can be

- *numeric* or even *binary*; for direct use in computer (storage and retrieval efficiency)
- *alphabetic*; humans are more comfortable with a coding like "S" for smooth or "T" for thread (*Gewinde*) than with digits

The proper decision process involves the design engineer, manufacturing engineer, and Computer scientist working together as a team.

A well known coding system is OPITZ. It can have 3 sections:

- it starts with a five-digit "geometric form code"
- followed by a fourdigit "supplementary code."
- This may be followed by a company-specific four-digit "secondary code" intended for describing production operations and sequencing.

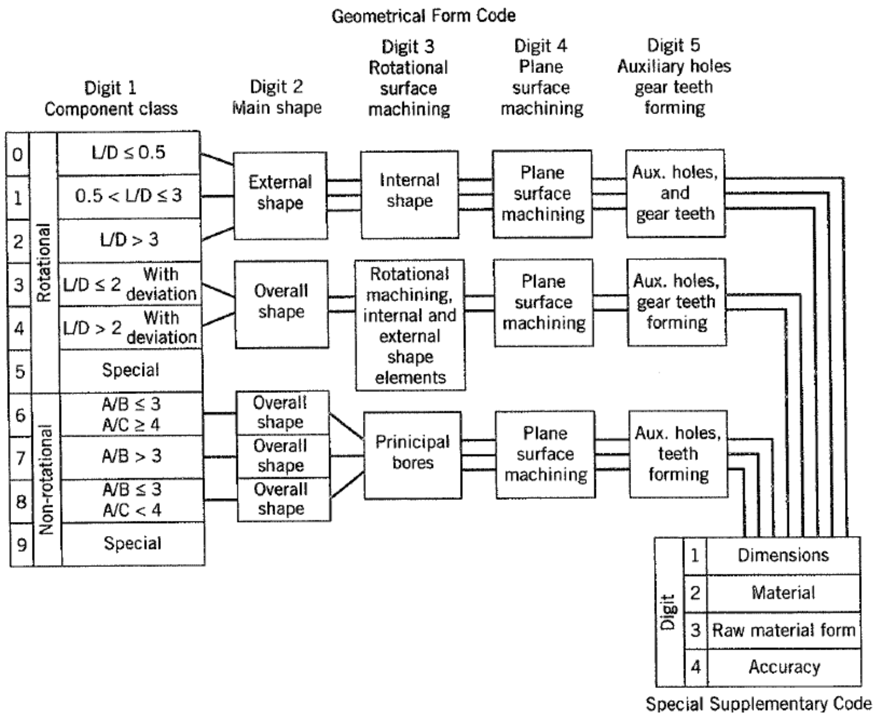


Figure 3.4. Overview of the Opitz code (Askin & Standridge, 1993, p. 167).

Digit 1: shows whether the part is rotational and also the basic dimension ratio (length/diameter if rotational, length/width if nonrotational).

Digit 2: main external shape; partly dependent on digit 1.

Digit 3: main internal shape.

Digit 4: machining requirements for plane surfaces.

Digit 5: auxiliary features like additional holes, etc.

For more details on the meaning of these digits see Figure 6.6 in Askin & Standridge, 1993.

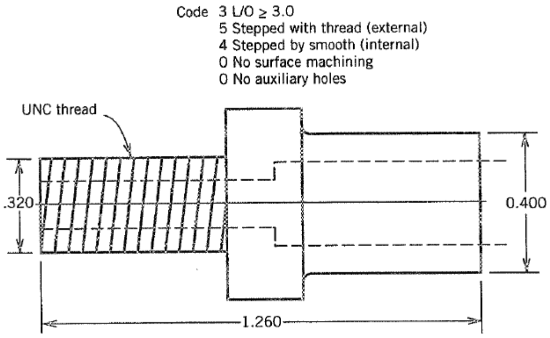


Figure 3.4. Opitz code for sample part (Askin & Standridge, 1993, p. 167).

An example for a coded Part is shown in Figure 3.5.

Correct code: 2 2 4 0 0

Part coding is helpful for design and group formation. But, the time and cost involved in collecting data, determining part families, and rearranging facilities can be seen as the major disadvantage of GT. For designing new facilities and product lines, this is not so problematic: Parts must be identified and designed, and facilities must be constructed anyway. The extra effort to plan under a GT framework is marginal, and the framework facilitates standardization and operation thereafter. Hence, GT is a logical approach to product and facility planning.

Classification (group formation)

Here, part codes and other information are used to assign parts to families. Part families are assigned to groups along with the machines required to produce the parts. A variety of models for forming part-machine groups are available in the literature, as can be seen from the following figure:

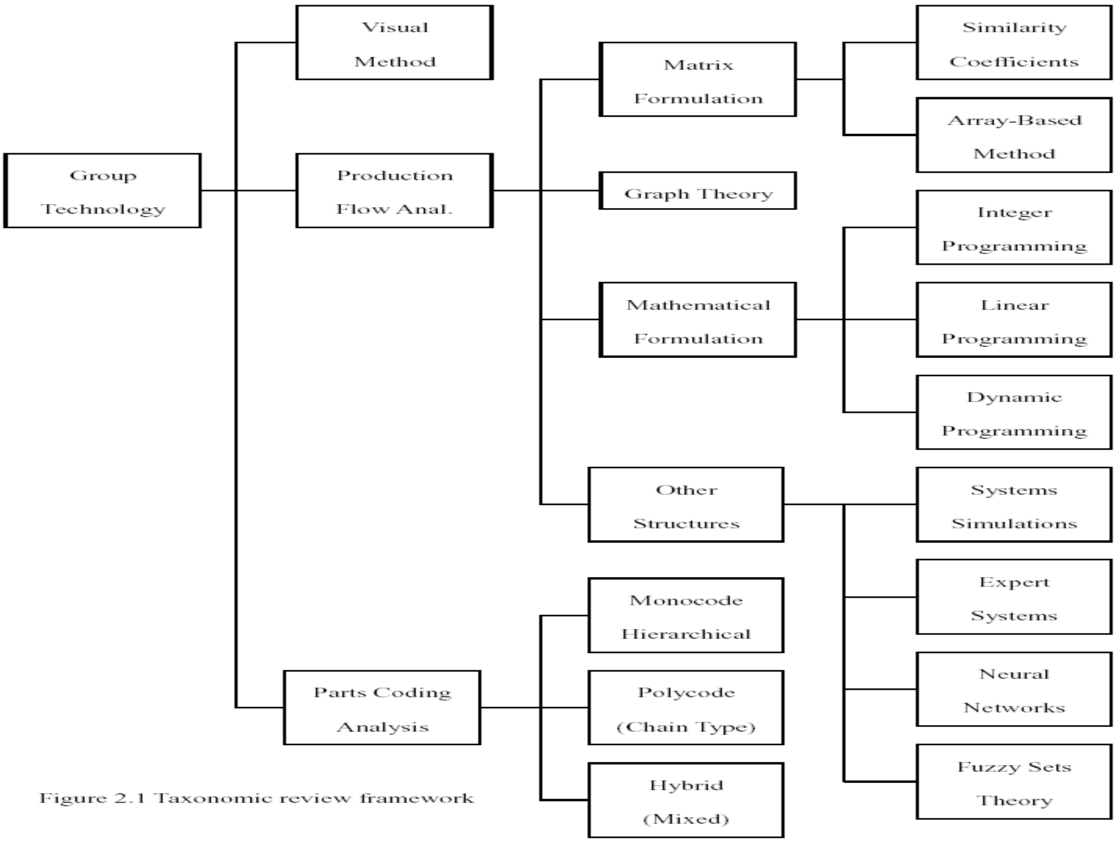


Figure 3.5. Methods of group formation

Production Flow Analysis (PFA)

Method of grouping part into families

- Used to analyze the operation steps and machine routes for the parts produced groups parts with similar or identical routings together
- These groups can be used to form logical machine cells in a gt layout
- Uses manufacturing data rather than design data to make groups, so takes care of the problem of:
- Parts whose basic geometry may differ but might take same or similar process routes
- Parts whose basic geometry may be same or similar but require different process routings

Disadvantage:

- Takes the route details the way they are, no check for optimal, consistent or logical routing

Production Flow Analysis: Procedure

1 Data Collection

- Define the population of the parts to be analyzed
- Study a sample or the whole population
- Minimum data needed is the part number and routing sequence of each part (route sheets)
- additional data as lot size, annual production rate, can be used to design cells of the desired productivity

2 Sorting of Process

- Routings
- Arrange the parts according to the similarity of their process routings
- Sorting procedure is used to arrange the parts into “packs”
- “pack: is a group of parts with identical process routings
- each pack is given a pack identification number or letter

3 PFA Chart

- Processes used for each pack are displayed graphically on a PFA chart
- Plot of the process code numbers for all the packs that have been determined

4 Analysis

- Most difficult and crucial step
- From the PFA chart, similar groups are identified
- Minimum data needed is the part number and routing sequence of each part (route sheets)
- Additional data as lot size, annual production rate, can be used to design cells of the desired Productivity

Example (Matrix Form)

Before Grouping

Pump Machining Production Flow Analysis		Broach	HMC	Lathe-Chuck	Hob	Lathe-Manual	Hob	Lathe-Bar	Lathe-Vert
61354	Cover Bearing			X					
70852	Gear Driven 8P,56T, RH	X		X	X		X		
52594	Spacer,cplg Shaft							X	
81357-T	Impellor	X		X					
50547-D	Gland, MU, 6"					X			
70935	Gear,Driven,8P,26T,LH	X		X	X		X		
51171	Retainer Bushing							X	
81176	Body Volute		X						X
72298	Elbow, Relief Valve		X						
50763	Spacer, Bearing							X	
71972-8	Adapter, Intake, 8"		X			X			X
62575	Shaft Shift							X	
63160	Seat, Spring							X	
62966	Generator, Tach Pulse			X	X				
71928	Head, Pump					X			X

Pump Machining Production Flow Analysis		Lathe-Manu	Lathe-Vert	HMC	Lathe-Chuck	Broach	Hob	Lathe-Bar
50547-D	Gland, MU, 6"	X						
71928	Head, Pump	X	X					
71972-8	Adapter, Intake, 8"	X	X	X				
81176	Body Volute		X	X				
72298	Elbow, Relief Valve			X				
81357-T	Impellor				X	X		
62966	Generator, Tach Pulse				X		X	
70852	Gear Driven 8P,56T, RH				X	X	X	
70935	Gear,Driven,8P,26T,LH				X	X	X	
61354	Cover Bearing				X			
52594	Sp[acer,cplg Shaft							X
62575	Shaft Shift							X
63160	Seat, Spring							X
51171	Retainer Bushing							X
50763	Spacer, Bearing							X

Turn-Mill Cell

Chucking Lathe Cell

Barfeed Lathe Cell

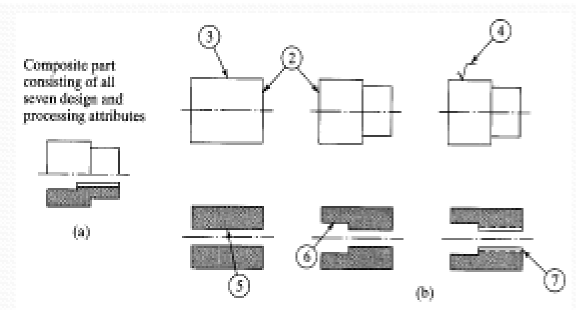
Production Flow Analysis: Procedure

1) There will be packs that do not fit into similar groupings
2) These parts can be analyzed to determine if a revised process sequence can be developed which fits to one of the groups
3) If not possible, then these parts continue to be manufactured through a conventional process
4) Type plant layout
5) weakness of PFA is that the data used in the analysis is derived from route sheets, prepared by different process planners
6) Routings may contain unnecessary and non-optimal steps
7) Final groupings may be sub-optimal
8) Requires less time to perform than a complete parts classification and coding Procedure

Group Technology: Machine Cell Design

Composite Part Concept

- A Composite Part for a given family, which includes all of the design and manufacturing attributes of the family
- An individual part in the family will have some of the features that characterize the family but not all of them
- Composite part possesses all of the features



Label	Design Feature	Corresponding Manufacturing Operation
1	External cylinder	Turning
2	Cylinder face	Facing
3	Cylindrical step	Turning
4	Smooth surface	External cylindrical grinding
5	Axial hole	Drilling
6	Counterbore	Counterboring
7	Internal threads	Tapping

Machine Cell Designs: Types

Term “cellular manufacturing” is used to describe the operations of a GT machine cell _ can be classified, based on number of machines and the degree to which the material f low is mechanized between the machines:

1. single machine cell
2. group machine cell with manual handling
3. group machine cell with semi-integrated handling
4. flexible manufacturing system (FMS)

Machine Cell Designs: Type 1

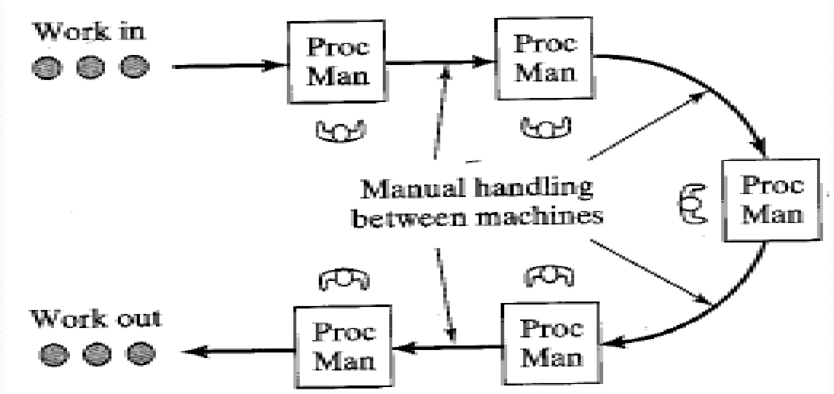
Single machine cell

1. It consists of 1 machine plus supporting fixtures and tooling to make one or more part families
2. It can be applied to work parts that is made by one type of process, such as turning or milling

Machine Cell Designs: Type 2

Group machine cell with manual handling using a U-shaped layout

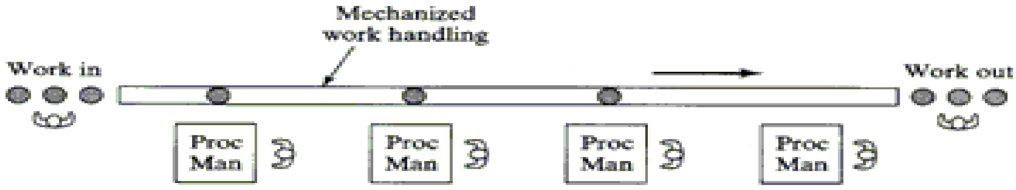
1. It consists of more than one machine used collectively to make one or more part families
2. There no provision for mechanized part movement between machines
3. Human operators running cell, perform material handling; if size of the part is huge or arrangement of machines in cell is large, regular handling crew may be required
4. It may organized in a U-shape layout when there is variation in work f low in parts; also useful in movement of multi functional workers
5. Design is often achieved without rearranging the process-type layout; simply include certain machines in group and restrict their work to specified part family
6. Saves cost of rearranging but many material handling benefits of GT are not realized



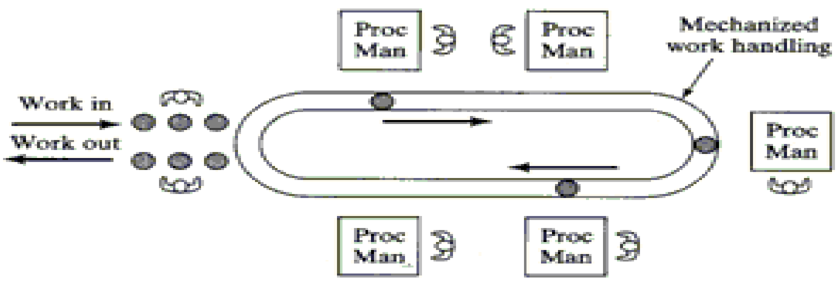
Machine Cell Designs: Type 3

Group machine cell with semi-integrated handling

1. Uses a mechanized handling system, such as a conveyor, to move parts between machines in the cell
2. Parts made in the cell have identical or similar routing – in-line layout (a)
3. Machines are laid along a conveyor to match the processing sequence
4. P routings vary in parts – loop layout (b)
5. Allows parts to circulate in the handling system
6. Permits different processing steps in the different parts in the system



(a)



(b)

Machine Cell Designs: Type 4

Flexible Manufacturing System (FMS)

1. highly automated machine cells in GT

2. combines automated processing stations with a fully integrated material handling system

Best Machine Arrangement

Depends on the work processing requirements important factors are:

1. Volume of the work to be done by the cell includes the number of parts per year and the work required per part

2. Influences number of machines to be used in cell, cost of operating a cell, amount of money to be spent in establishing a cell

• Variations in process routings of the part determines the work flow; for identical routings- in-line flow, significant variation in routing – a U-shape or loop layout

• Part size, shape, weight, and other physical attributes determine the size and type of material handling and processing equipment that can be used

Opitz Classification System

One of the first published and best known classification and coding schemes for mechanical parts uses the following digit sequence

12345 6789 ABCD

1. basic code consists of 9 digits
2. digits 1 through 5 (12345) -> form code
3. primary shape and design attributes (hierarchical structure)
4. digits 6 through 9 -> supplementary code – attributes that are useful in manufacturing (e.g., dimensions, starting material)
5. digits 10 through 13 (ABCD) ->secondary code – identify production operation type and sequence very complex system

Benefits of Group Technology

1. Product design
- Derived from coding and classification
- If new part design is required -> code of the required part is figured out matched with the existing part designs
- Design standardization
2. Material handling is reduced
- parts are moved within a machine cell rather than the entire factory
3. Process planning and production scheduling are simplified
4. Work-in-process and manufacturing lead time are reduced
5. Improved worker satisfaction in a GT cell
6. Higher quality work

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Department of Mechanical Engineering

Computer Integrated Manufacturing

UNIT-IV

Introduction To Flexible Manufacturing System

Manufacturing Industries are facing vigorous threats by inflation in market needs, corporate lifestyle and globalization. Hence, in current situation, Industries which are responding rapidly to market fluctuations with more competitiveness will have great capabilities in producing products with high quality and low cost. In the view of manufacturers, production cost is not at all a significant factor which affects them. But, some of the factors which are important to the manufacturer are flexibility, quality, efficient delivery and customer satisfaction.

Hence, with the help of automation, robotics and other innovative concepts such as just-in-time (JIT), Production planning and control (PPC), enterprise resource planning (ERP) etc., manufacturers are very keen to attain these factors.

Flexible manufacturing is a theory which permits production systems to perform under high modified production needs. The problems such as minimum inventories and market-response time to bump into customer needs, response to adjust as per the deviations in the market. In order to sweep market by reducing the cost of products and services will be mandatory to various companies to shift over to flexible manufacturing systems. FMSs as a possible way to overcome the said issues while making reliable and good quality and cost effective yields. Flexible manufacturing system has advanced as a tool to bridge the gap between high mechanized line and CNC Machines with efficient mid- volume production of a various part mix with low setup time, low work- in-process, low inventory, short manufacturing lead time, high machine utilization and high quality FMS is especially attractive for medium and low-capacity industries such as automotive, aeronautical, steel and electronics.

Flexible manufacturing system incorporates the following concepts and skills in an automated production system

1. Flexible automation
2. Group technology
3. Computer numerical control machine tools
4. Automated material handling between machines

TYPES OF FMS

Flexible manufacturing systems can be separated into various types subject to their natures:

1. **DEPENDING UPON KINDS OF OPERATION**

Flexible manufacturing system can be illustrious subject to the kinds of operation performed:

a. Processing operation.

It performs some activities on a given job. Such activities convertthe job from one shape to another continuous up to the final product. It enhances significance by altering the geometry, features or appearance of the initial materials.

b. Assembly operation. It comprises an assembly of two or more parts to make a new component which is called an assembly/subassembly. The subassemblies which are joined permanently use processes like welding, brazing, soldering , adhesive bonding, rivets, press fitting.

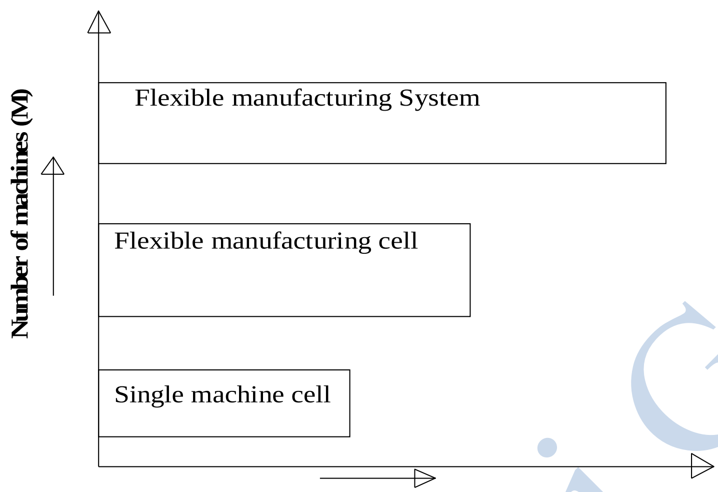
2. BASED ON NUMBER OF MACHINES

There are typical varieties of FMS based on the number of machines in the system:

a. **Single machine cell (SMC).** It consists of completely automated machines which are capable of performing unattended operations within a time period lengthier than one complete machine cycle. It is skilful of dispensing various part mix, reacting to fluctuations in manufacture plan, and inviting introduction of a part as a new entry. It is a sequence dependent production system.

b. **Flexible manufacturing cell (FMC).** It entails two or three dispensing workstations and a material handling system. The material handling system is linked to a load/unload station. It is a simultaneous production system.

c. **An Flexible Manufacturing System (FMS).** It has four or more processing work stations (typically CNC machining centers or turning centers) connected mechanically by a common part handling system and automatically by a distributed computer system. It also includes non-processing work stations that support production but do not directly participate in it e.g., part / pallet washing stations, co-ordinate measuring machines. These features significantly differentiate it from Flexible manufacturing cell (FMC).



Comparison for three categories of FMS

In this research, authors focused on Flexible manufacturing system

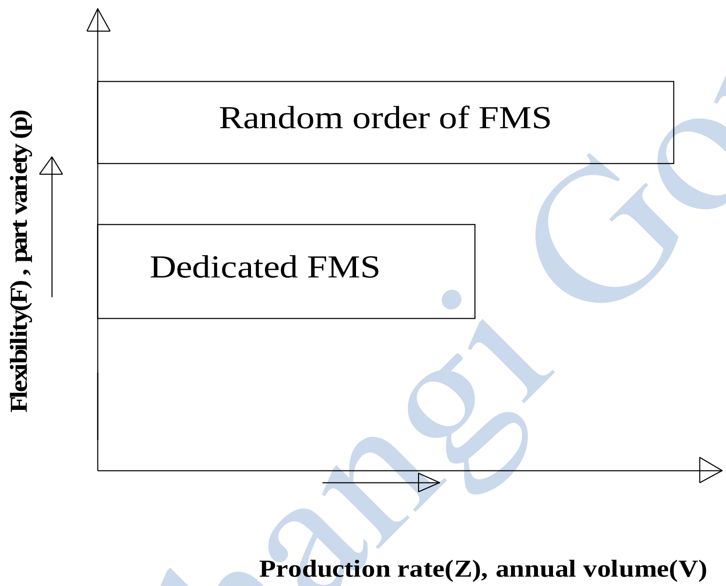
3. BASED ON LEVEL OF FLEXIBILITY

FMS is further classified based on the level of flexibility related to the manufacturing system. Two categories are depicted here:

a. **Dedicated FMS.** It is made to produce a certain variety of part styles. The product design is considered fixed. So, the system can be designed with a certain amount of process specialization to make the operation more efficient.

b. **Random order FMS.** It is able to handle the substantial variations in part configurations. To accommodate these variations, a random order FMS must be more flexible than the dedicated FMS. A random order FMS is capable of processing parts that have a higher degree of complexity. Thus, to deal with these kinds of complexity, sophisticated computer control system is used for this FMS type.

In this research, authors consider Random order FMS



Differences between dedicated and random-order FMS types

Flexibility is an attribute that allows a mixed model manufacturing system to cope up with a certain level of variations in part or product style, without having any interruption in production due to changeovers between models. Flexibility measures the ability to adapt “to a wide range of possible environment”. To be flexible, a manufacturing system must posses the following capabilities:

- ❖ Identification of the different production units to perform the correct operation
- ❖ Quick changeover of operating instructions to the computer controlled production machines

Quick changeover of physical setups of fixtures, tools and other working units

The different types of flexibility that are exhibited by manufacturing systems are given below:

1. **Machine Flexibility.** It is the capability to adapt a given machine in the system to a wide range of production operations and part styles. The greater the range of operations and part styles the greater will be the machine flexibility. The various factors on which machine flexibility depends are:

- Setup or changeover time
- Ease with which part-programs can be downloaded to machines
- Tool storage capacity of machines
- Skill and versatility of workers in the systems

2. **Production Flexibility.** It is the range of part styles that can be produced on the systems. The range of part styles that can be produced by a manufacturing system at moderate cost and time is determined by the process envelope. It depends on following factors:

- Machine flexibility of individual stations
- Range of machine flexibilities of all stations in the system

3. **Mix Flexibility.** It is defined as the ability to change the product mix while maintaining the same total production quantity that is, producing the same parts only in different proportions. It is also known as process flexibility. Mix flexibility provides protection against market variability by accommodating changes in product mix due to the use of shared resources. However, high mix variations may result in requirements for a greater number of tools, fixtures, and other resources. Mixed flexibility depends on factors such as:

- Similarity of parts in the mix
- Machine flexibility
- Relative work content times of parts produced

4. **Product Flexibility**. It refers to ability to change over to a new set of products economically and quickly in response to the changing market requirements. The change over time includes the time for designing, planning, tooling, and fixturing of new products introduced in the manufacturing line-up. It depends upon following factors:

- Relatedness of new part design with the existing part family
- Off-line part program preparation
- Machine flexibility

5. **Routing Flexibility.** It can define as capacity to produce parts on alternative workstation in case of equipment breakdowns, tool failure, and other interruptions at any particular station. It helps in increasing throughput, in the presence of external changes such as product mix, engineering changes, or new product introductions. Following are the factors which decide routing flexibility:

- Similarity of parts in the mix

- Similarity of workstations
- Common tooling

6. Volume Flexibility. It is the ability of the system to vary the production volumes of different products to accommodate changes in demand while remaining profitable. It can also be termed as capacity flexibility. Factors affecting the volume flexibility are:

- Level of manual labor performing production
- Amount invested in capital equipment

7. Expansion Flexibility. It is defined as the ease with which the system can be expanded to foster total production volume. Expansion flexibility depends on following factors:

- Cost incurred in adding new workstations and trained workers
- Easiness in expansion of layout
- Type of part handling system used

As indicated in our definition, there are several basic components of an FMS. In the following segment, a framework for understanding the components of an FMS is presented. A flexible manufacturing system consists of two subsystems:

- Physical subsystem
- Control subsystem

Physical subsystem includes the following elements:

1. Workstations. It consists of NC machines, machine-tools, inspection equipments, loading and unloading operation, and machining area.
2. Storage-retrieval systems. It acts as a buffer during WIP (work-in-processes) and holds devices such as carousels used to store parts temporarily between work stations or operations.
3. Material handling systems. It consists of power vehicles, conveyers, automated guided vehicles (AGVs), and other systems to carry parts between workstations.

Control subsystem comprises of following elements:

1. Control hardware. It consists of mini and micro computers, programmable logic controllers, communication networks, switching devices and others peripheral devices such as printers and mass storage memory equipments to enhance the working capability of the FMS systems.
2. Control software. It is a set of files and programs that are used to control the physical subsystems. The efficiency of FMS totally depends upon the compatibility of control hardware and control software.

Basic features of the physical components of an FMS are discussed below:

1. Numerical control machine tools.

Machine tools are considered to be the major building blocks of an FMS as they determine the degree of flexibility and capabilities of the FMS. Some of the features of machine tools are described below;

- The majority of FMSs use horizontal and vertical spindle machines. However, machining centers with vertical spindle machines have lesser flexibility than horizontal machining centers.
- Machining centers have numerical control on movements made in all directions e.g. spindle movement in x, y, and z directions, rotation of tables, tilting of table etc to ensure the high flexibility.
- The machining centers are able to perform a wide variety of operations

e.g. turning, drilling, contouring etc. They consist of the pallet exchangers

2. Work holding and tooling considerations.

It includes pallets/fixtures, tool changers, tool identification systems, coolant, and chip removal systems. It has the following features:

- Before machining is started on the parts, they are mounted on fixtures. So, fixtures must be designed in a way, to minimize part-handling time. Modular fixturing has come up as an attractive method to fixture a variety of parts quickly.
- The use of automated storage and retrieval system (AS/RS) and material handling systems such as AGVs, lead to high usage of fixtures.
- All the machining centers are well equipped with tool storage systems called tool magazines. Duplication of the most often used tools in the tool magazines is allowed to ensure the least non-operational time. Moreover, employment of quick tool changers, tool regrinders and provision of spares also help for the same.

3. Material-Handling Equipments

The material-handling equipments used in flexible manufacturing systems include robots, conveyers, automated guided vehicle systems, monorails and other rail guided vehicles, and other specially designed vehicles. There important features are:

- They are integrated with the machine centers and the storage and retrieval systems.
- For prismatic part material handling systems are accompanied with modular pallet fixtures. For rotational parts industrial robots are used to load/unload the turning machine and to move parts between stations.

The handling system must be capable of being controlled directly by the computer system to direct it the various work station, load/unload stations and storage area.

4. Inspection equipment

It includes coordinate measuring machines (CMMs) used for offline inspection and programmed to measure dimensions, concentricity, perpendicularity, and flatness of surfaces. The distinguishing feature of this equipment is that it is well integrated with the machining centers.

5. Other components

It includes a central coolant and efficient chip separation system. Their features are:

- The system must be capable of recovering the coolant.
- The combination of parts, fixtures, and pallets must be cleaned properly to remove dirt and chips before operation and inspection.

HARDWARE COMPONENTS OF FLEXIBLE MANUFACTURING SYSTEM

1. Pallets and fixtures
2. Machining centers
3. Robots
4. Inspection equipment
5. Chip removal system
6. In process storage facility
7. Material handling systems

Flexible manufacturing system layouts

Flexible manufacturing system has different layouts according to arrangement of machine and flow of parts. According to part flow and arrangement of machine, layout of flexible manufacturing system are discussed below

In-line FMS layout

The machines and handling system are arranged in a straight line. In Figure 1(a) parts progress from one workstation to the next in a well-defined sequence with work always moves in one direction and with no back-flow. Similar operation to a transfer line except the system holds a greater variety of parts. Routing flexibility can be increased by installing a linear transfer system with bi-directional flow, as shown in Figure 1(b). Here a secondary handling system is provided at each workstation to separate most of the parts from the primary line. Material handling equipment used: in-line transfer system; conveyor system; or rail-guided vehicle system.

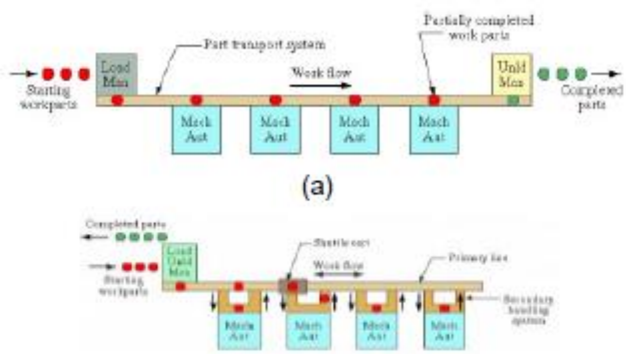


Figure 1 in line FMS layout

Loop FMS layout

Workstations are organized in a loop that is served by a looped parts handling system. In Figure 2, parts usually flow in one direction around the loop with the capability to stop and be transferred to any station.

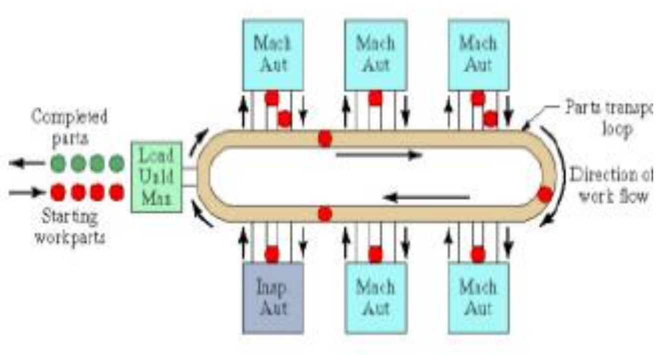


Figure 2: Loop FMS layout

Figure 2: Loop FMS layout Each station has secondary handling equipment so that part can be brought-to and transferred from the station work head to the material handling loop. Load/unload stations are usually located at one end of the loop.

Rectangular FMS layout

This arrangement allows for the return of pallets to the starting position in a straight line arrangement

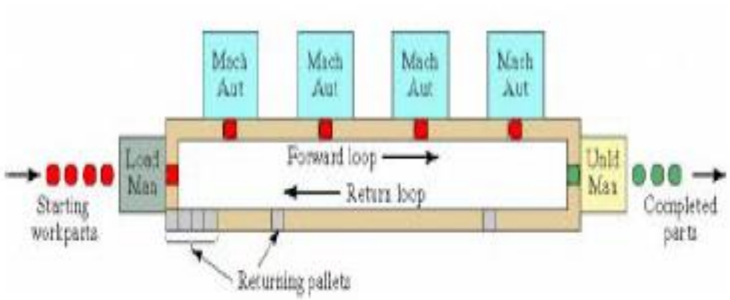


Figure 3: Rectangular FMS layout

Ladder FMS layout

This consists of a loop with rungs upon which workstations are located. The rungs increase the number of possible ways of getting from one machine to the next, and obviate the need for a secondary material handling system. It reduces average travel distance and minimizes congestion in the handling system, thereby reducing transport time between stations. See Figure 4.

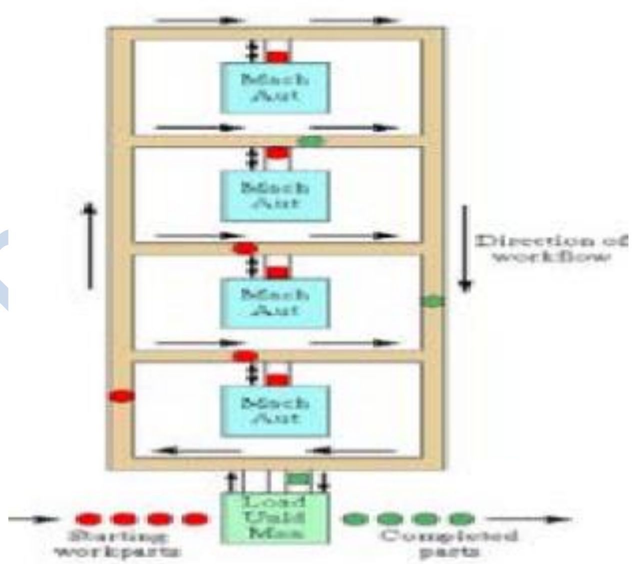


Figure 4: Ladder FMS layout

Open field FMS layout

It consists of multiple loops and ladders, and may include sidings also. This layout is generally used to process a large family of parts, although the number of different machine types may be limited, and parts are usually routed to different workstations depending on which one becomes available first. See Figure 5.

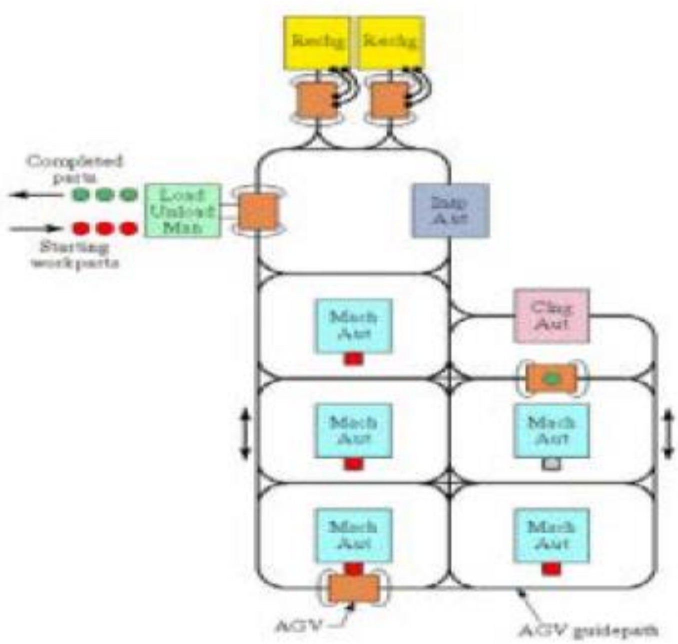


Figure 5: Open Field FMS layout

Robot centered FMS layout

This layout uses one or more robots as the material handling system. See figure 6

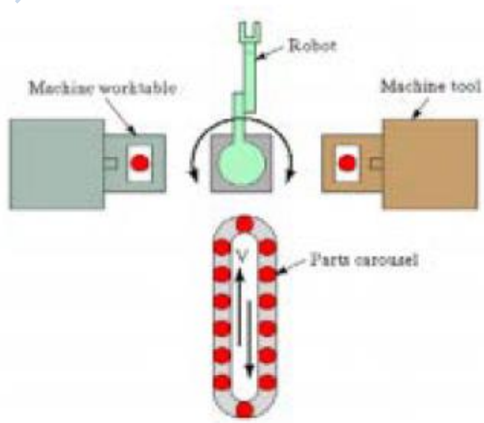


Figure 6: Robot centered FMS layout

FLEXIBLE MANUFACTURING SYSTEM

Factors Influencing the FMS Layouts

The various factors influencing the layouts of FMS are:

1. Availability of raw material
2. Proximity to market
3. Transport facilities
4. Availability of efficient and cheap labor
5. Availability of power, water and fuel
6. Atmospheric and climatic condition
7. Social and recreation facilities
8. Business and economic conditions

Sequencing of jobs

The machines are arranged in a typical layout in a given FMS environment. The set of jobs are processed, those have different operations. According to their processing time, due dates these jobs scheduled to minimize make span. There are following rules selected from many existing priority scheduling rules to obtain optimum sequence.

First-Come, First-Serve (FCFS) - the job which arrives first, enters service first (local rule). It is simple, fast, "fair" to the customer. And disadvantage of this rule is, it is least effective as measured by traditional performance measures as a long job makes others wait resulting in idle downstream resources and it ignores job due date and work remaining (downstream information).

Shortest Processing Time (SPT) - the job which has the smallest operation time enters service first (local rule). Advantages of this sequencing rule is simple, fast, generally a superior rule in terms of minimizing completion time through the system, minimizing the average number of jobs in the system, usually lower in-process inventories (less shop congestion) and downstream idle time (higher resource utilization), and usually lower average job tardiness and disadvantages is, it ignores downstream, due date information, and long jobs wait (high job wait-time variance).

Earliest Due Date (EDD) - the job which has the nearest due date, enters service first (local rule) and it is simple, fast, generally performs well with regards to due date, but if not, it is because the rule does not consider the job process time. It has high priority of past due job and it ignores work content remaining.

Critical Ratio (CR) Rule - sequences jobs by the time remaining until due date divided by the total remaining processing time (global rule). The job with the smallest ratio of due date to processing time enters service first. The ratio is formed as (Due Date-Present Time)/Remaining Shop Time where remaining shop time refers to: queue, set-up, run, wait, and move times at current and downstream work centers. it recognizes job due date and work remaining (incorporates downstream information)but in this sequencing, past due jobs have high priority, does not consider the number of remaining operations

Slack Per Operation - is a global rule, where job priority determined as (Slack of remaining operations) it recognizes job due date and work remaining (incorporates downstream information) Least Changeover Cost (Next Best rule) - sequences jobs by set-up cost or time (local rule).it is simple, fast, generally performs well with regards to set-up costs. it does not consider the job process time, due date and work remaining.

FMS- Components

Components/Elements of FMS

As pointed out in the definition four basic components/elements of a FMS are

i) Workstations

ii)Material handling and storage system

iii) Computer control system

iv) Human resources

1) FMS Workstations

The workstations/processing stations used in FMS depend upon the type of product manufactured by the system. In metal cutting/machining systems, the principle processing stations are usually CNC machine tools. In addition, a FMS requires other several machines for Completing the manufacturing

The types of workstations that are usually found in a FMS are

i) Load/unload stations

ii)Machining stations

iii)Assembly workstations

iv)Inspection stations

v)Other processing stations

- 2) Material Handling and Storage System
- Material handling and storage system is the second main component of an FMS
- Requirements set against the FMS material handling and storage system include part transportation, raw material and final product transportation and storage of work pieces, empty pallets, auxiliary materials, wastes, fixtures and tools

Functions of the material handling system

- Random, independent movement of work parts between stations. This means that the material handling system should be capable of moving work parts from one workstation to any other station. This provides various routing alternatives for the different parts
- Handle a variety of work part configurations. The material handling system should be capable of handling any work part configurations, (prismatic or rotational parts)
- Temporary storage. The material handling should be capable of storing the work parts temporarily, so as to wait in a small queue at workstations. This helps to increase machine utilization.
- Convenient access for loading and unloading work parts. The material handling system should provide a means to load and unload parts from the FMS. This can be achieved by locating one or more loading and/or unloading stations in the system.
- Compatible with computer control. Last but not the least, the material handling system should be capable of being controlled by the computer to direct it to the various workstations, load/unload stations and storage areas.

Types of Material Handling Equipment

The material handling function in a FMS is shared between two systems:

i) Primary handling system

ii) Secondary handling system.

i) Primary Handling System

•It establishes the basic layout of the FMS and is responsible for moving work parts between workstations in the system.

•Table given below summarizes the type of material handling equipment typically used as the primary handling system for the five FMS layouts.

ii)Secondary Handling System

•It consists of transfer devices, automatic pallet changers, and similar mechanisms located at the workstations in the FMS.The functions of the secondary handling systems are

i) To transfer work parts from the primary system to the machine tool or other processing station

ii) To position the work parts with sufficient accuracy and repeatability at the workstation for processing

iii) To provide buffer storage of work parts at each workstation, if required

iv) To reorient the work parts, if necessary, to present the surface that is to be processed.

Economics of FMS

i)5–20% reduction in personnel.

ii)15–30% reduction in engineering design cost

iii)30–60% reduction in overall lead time

iv)30–60% reduction in work-in-process

v)40–70% gain in overall production

vi)200–300% gain in capital equipment operating time

(vii)200–500% gain in product quality

viii)300–500% gain in engineering productivity.

Advantages of FMS

Successfully implemented FMS offer several advantages. Some of them are given below:

1. Increased machine utilization - Several features of FMS (such as automatic tool/pallet changing, dynamic scheduling of production and so on).

2. Reduced inventory -Following the GT concept, FMS processes different parts together. This tends to reduce the work-in-process inventory significantly

3. Reduced manufacturing lead time - Because of reduced setups and more efficient materials handling, manufacturing lead times are reduced

4. Greater flexibility in production scheduling - A FMS has a greater responsiveness to change. It means, FMS has the capability to make adjustments in the production schedule on day-to-day basis to respond to immediate orders and special customer requests.

5.Reduced direct labour cost -Reduced (manual) material handling and automation control of machines make it possible to operate an FMS with less direct labour in many instances. Thus the direct labour cost is reduced considerably.

6.Increased labour productivity - Due to higher production rates and reduced direct labour cost, FMS achieves greater productivity per labour hour.

7.Shorter response time - Setup time is relatively low with FMS as majority of the work is done automatically. The lead time of production is hence very low and the response time will be shorter.

8.Consistent quality - Human error is minimized, as there is maximum automation.
In the absence of human interface, the quality is consistent.

9.Other FMS benefits include

i) Reduced factory floor space

ii) Reduced number of tools and machines required

iii) Improved product quality

iv) Easy expandability for additional processes or added capacity

Disadvantages of FMS

The major limitations of implementing a FMS are given below

(i)Very high capital investment is required to implement a FMS

(ii)Acquiring, training and maintaining the knowledgeable labour pool requires heavy investment

(iii)Fixtures can sometimes cost much more with FMS and software development costs could be as much as 12–20% of the total expense.

(iv)Tool performance and condition monitoring can also be expensive since tool variety could undermine efficiency.

v)Complex design estimating methodology requires optimizing the degree of flexibility and finding a trade-off between flexibility and specialization.

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Department of Mechanical Engineering

Computer Integrated Manufacturing

UNIT-V & VII

Process Planning

•Product design for each product has been developed in the design department.

•To convert the product design into a product, a manufacturing plan is required. Activity of developing such a plan is called process planning.

•Process planning consists of preparing sets of instructions that describe how to manufacture the product and its parts.

•The task of process planning consists of determining the manufacturing operations required to transform a part from a rough (raw material) to the finished state specified on the engineering drawing. Also known as operations planning

•It is the systematic determination of the engineering processes and systems to manufacture a product competitively and economically.

•It is a detailed specification which lists the operations, tools and facilities.

It is usually accomplished in manufacturing department.

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 Product 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.

Importance of Process Planning

- Process planning establishes the link between engineering design and shop floor manufacturing.
- It determines how a part/product will be manufactured, the important determinant of production costs and profitability.
- Production process plans should be based on in-depth knowledge of process and equipment capabilities, tooling availability, material processing characteristics, related costs and shop practices.
- Economic future of the industry demands that process plans that are developed should be feasible low cost and consistent with plans for similar parts.
- Process planning facilitates the feedback from the shop floor to design engineering regarding the manufacturing ability of alternative.
- Detailed process plan usually contains the route, processes, process parameters and machine and tool selections.

To prepare a process plan (also called as route. sheet), we require the following information:

1. Assembly and component drawings and bill of materials (part list):
This detail gives the information regarding the general description of part to be manufactured, raw material specification, dimensions and tolerances required, the surface finish and treatment required.

2. Machine and equipment details:

(i)The various possible operations that can be performed.

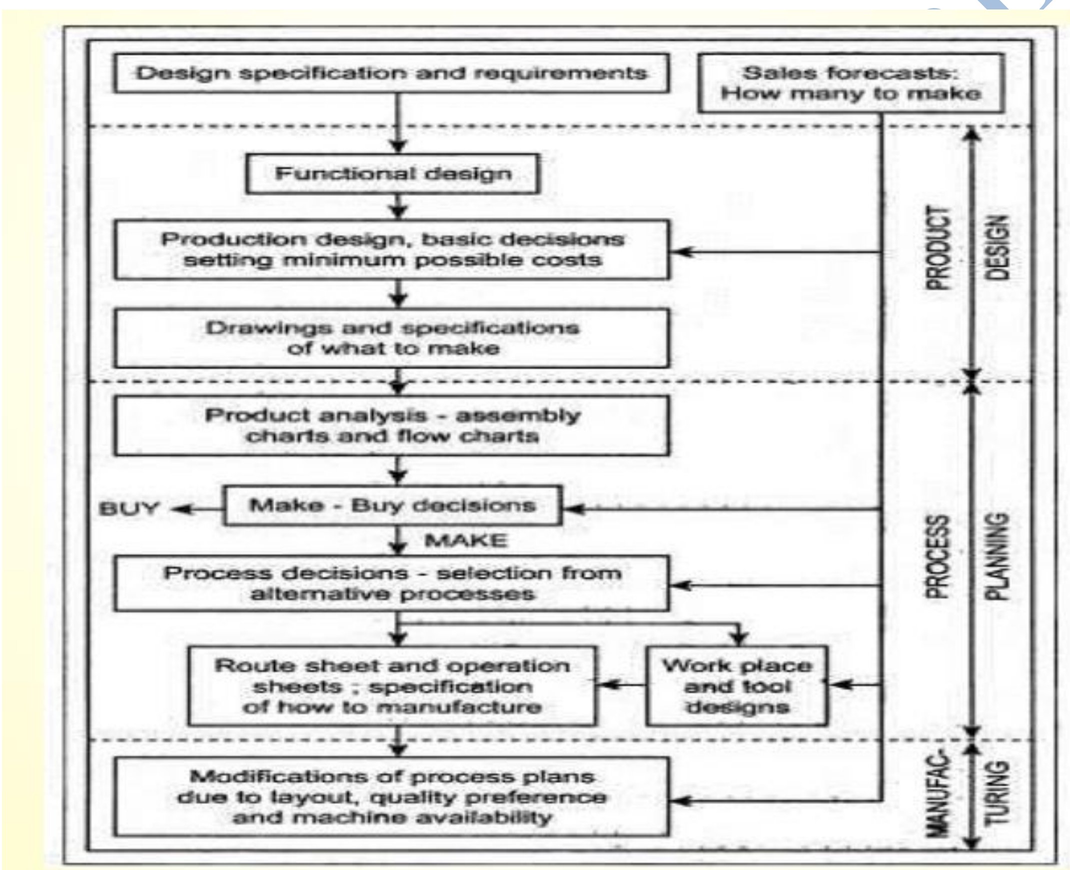
(ii) The maximum and minimum dimensions that can be machined on the machines.

(iii) The accuracy of the dimensions that can be obtained.

(iv)Available feeds and speeds on the machine.

3. Standard time for each operation and details of setup time for each job

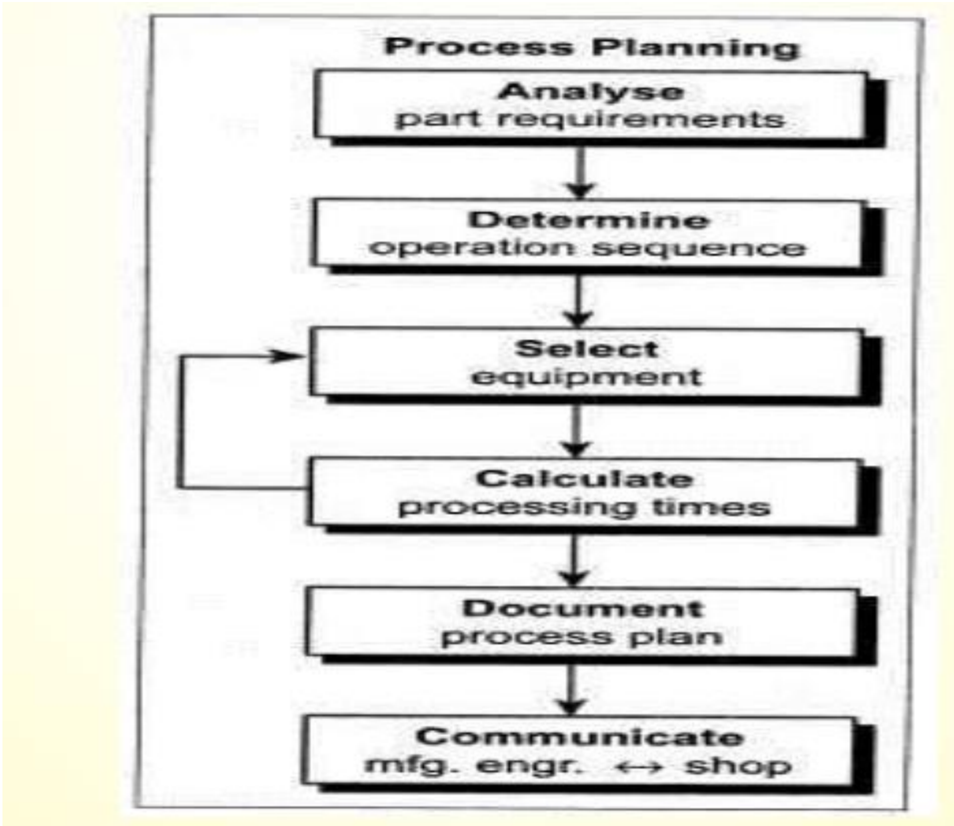
4. Availability of machines, equipment and tools



Process Planning Activities

- The different steps or specific activities involved in process planning are:
- Analysis of the finished part requirements as specified in the engineering design
- Determining the sequence of operations required
- Selecting the proper equipment to accomplish the required operations
- Calculating the specific operation setup times and cycle times on each machine
- Documenting the established process plans
- Communicating the manufacturing knowledge to the shop floor.

- The above process planning activities are diagrammatically presented in figure.



Computer Aided Process Planning (CAPP)

- To overcome the drawbacks of manual process planning, the computer- aided process planning
  (CAPP) is used. With the use of computers in the process planning, one can reduce the routine clerical work of manufacturing engineers.
- It provides the opportunity to generate, rational consistent and optimal plans. In addition CAPP provides the interface between CAD and CAM.

Benefits of CAPP

The benefits of implementing CAPP include the following:

- **Process rationalization and standardization:** CAPP leads to more logical and consistent process plans than manual process planning.
- **Productivity improvement:** As a result of standard process plan, the productivity is improved.
- **Product cost reduction:** Standard plans tend to result in lower manufacturing costs and higher product quality.

- Elimination of human error.
- **Reduction in time:** As a result of computerized work, a job that used to take several days, is now done in a few minutes.
- Reduced clerical effort and paper work
- Improved legibility: Computer-prepared route sheets are neater and easier to read than manually prepared route sheets.
- Faster response to engineering changes: Since the logic is stored in the memory of the Computer, CAPP becomes more responsive to any changes in the production parameters than the manual method of process planning.
- Incorporation of other application programs: The CAPP program can be interfaced with Other application programs such as cost estimating and work standards.

Approaches of CAPP

The two basic approaches or types of CAPP system are:

1. Retrieval (or variant) CAPP system.

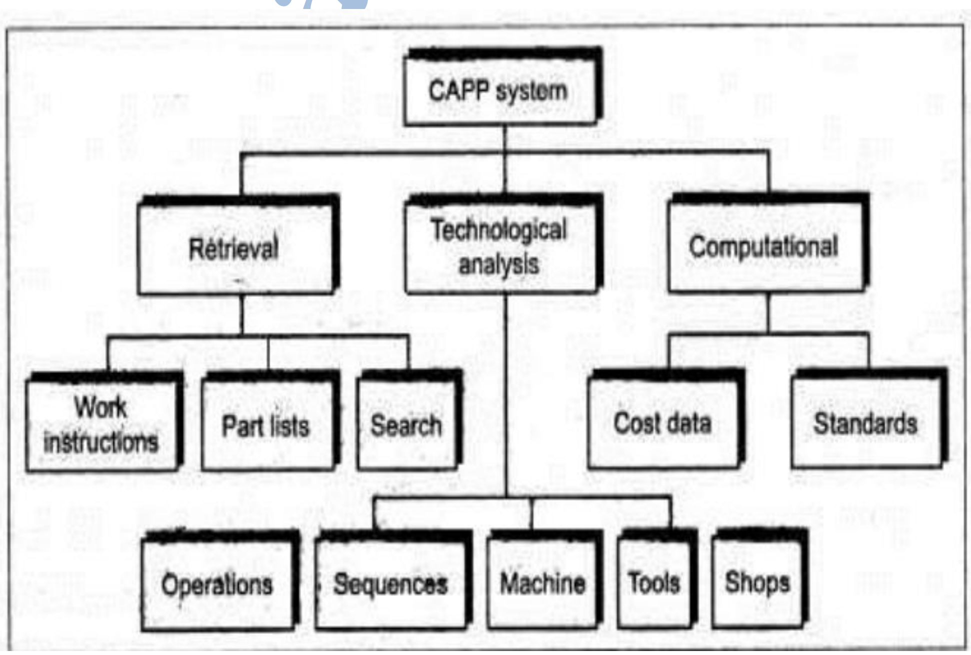
2. Generative CAPP system.

A CAPP tool can be represented as having three separate functions:

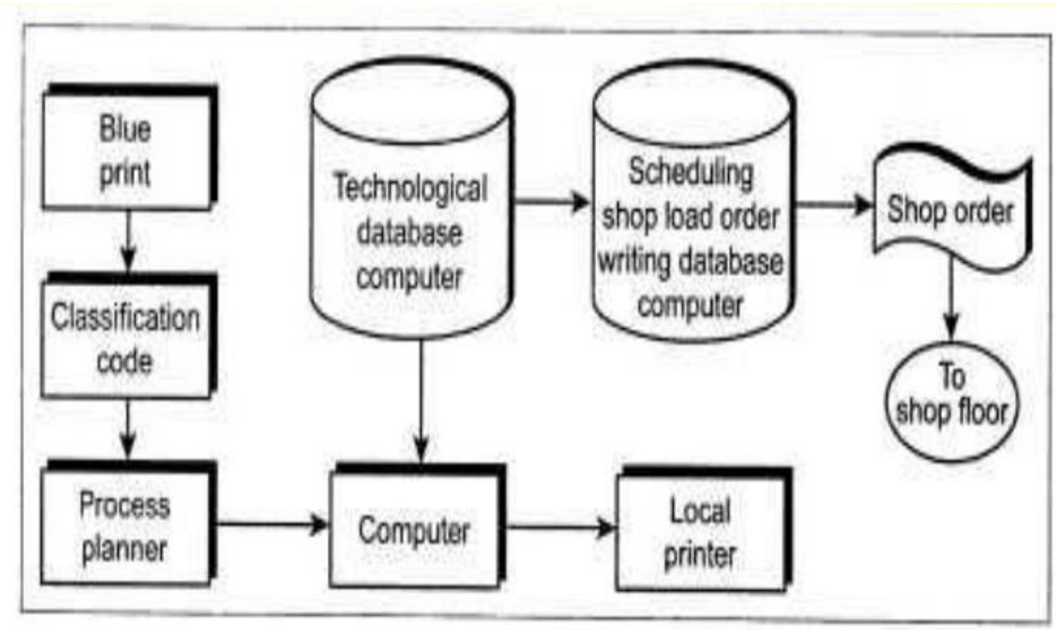
(i) Retrieval

(ii) Technological analysis

(iii) Computational



CAPP System for Engineering Data



Retrieval (or Variant) CAPP System

- It is also called a variant CAPP system and has been widely used in machining applications.
- Basic idea behind the retrieval CAPP is that similar parts will have similar process plans.
- A process plan for a new part is created by recalling, identifying and retrieving an existing plan for a similar part and making the necessary modifications for the new part
- Variant CAPP is a computer-assisted extension of the manual approach.

Advantages of Retrieval CAPP System

- Once a standard plan has been written, a variety of parts can be planned.
- Comparatively simple programming and installation (compared with generative CAPP systems) is required to implement a planning system
- Efficient processing and evaluation of complicated activities and decisions, thus reducing the time and labour requirements.
- Standardized procedures by structuring manufacturing knowledge of the process planners to company's needs.
- Lower development and hardware costs.
- Shorter development times.
- The system is understandable and the planner has control of the final plan.
- It is easy to learn and easy to use.

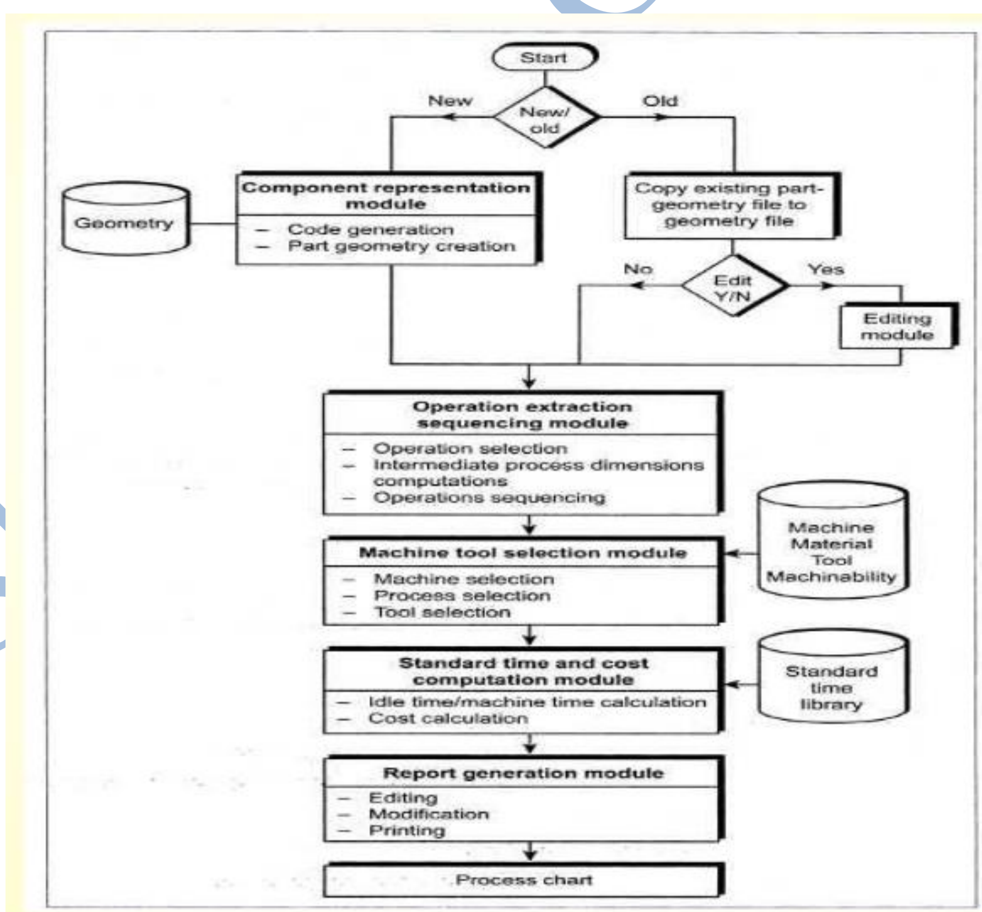
Disadvantages of Retrieval CAPP System

- The components to be planned are limited to similar components previously planned.
- Maintaining consistency in editing is difficult.
- Experienced process planners are still required to modify the standard plan for the specific component.

Components of a Generative CAPP System

- The various components of a generative system are:
- A part description, which identifies a series of component characteristics, including geometric features, dimensions, tolerances and surface condition.
- A subsystem to define the machining parameters, for example using look-up tables and analytical results for cutting parameters.
- A database of available machines and tooling.
- A report generator which prepares the process plan report.

Structure of a Generative CAPP System



Advantages of Generative CAPP System

The generative CAPP has the following advantages:

- It can generate consistent process plans rapidly.
- New components can be planned as easily as existing components.
- It has potential for integrating with an automated manufacturing facility to provide detailed control information

Drawbacks of Generative CAPP System

- The generative approach is complex.
- It is very difficult to develop.

CMPP Process Planning Functions

The CMPP system can perform the following four processes planning functions:

- CMPP generates a sequence of operations in a summary format.
- The summary format contains for each operation an operation, number and description, type of machine orientation of the work piece on the machine, surfaces cut and heat treatment.
- CMPP determines the dimensioning reference surfaces for each cut in each operation. CMPP selects the clamping and locating surfaces.
- CMPP determines machining dimensions, tolerances and stock removals for each surface cut in each operation

CMPP Process Planning Functions

CMPP produces three process plan documents:

(i) A printed summary of operations.

(ii) A printed tolerance analysis

(iii) Dimensional work piece sketches for each machining operation.

CMPP Process Planning Functions

Even though the CMPP system has received limited use in the industrial environment, the CMPP system is considered very significant because of the following three reasons:

(i) CMPP represents one of the most successful attempts at developing a generative system.

(ii) CMPP achieves a higher degree of automated process planning.

(iii) CMPP is being used as a basis for further search into automated process planning.

Selection of a CAPP System

- Evaluation and selection of the best process planning system for a particular firm involves numerous engineering management decisions.

- Process involves identifying, weighing and comparing various interrelated factors.

Logical Steps in Computer Aided Process Planning

Step 1: Define the coding scheme

Adopt existing coding or classification schemes to label parts for the purpose of classification. In some extreme cases, a new coding scheme may be developed.

Step 2: Group the parts into part families

- Group the part families using the coding scheme defined in Step 1 based on some common
- part features.A standard process plan is attached to each part family (see: Step 3).

- Often, a number of part types are associated with a family, thereby reducing the total number of standard process plans

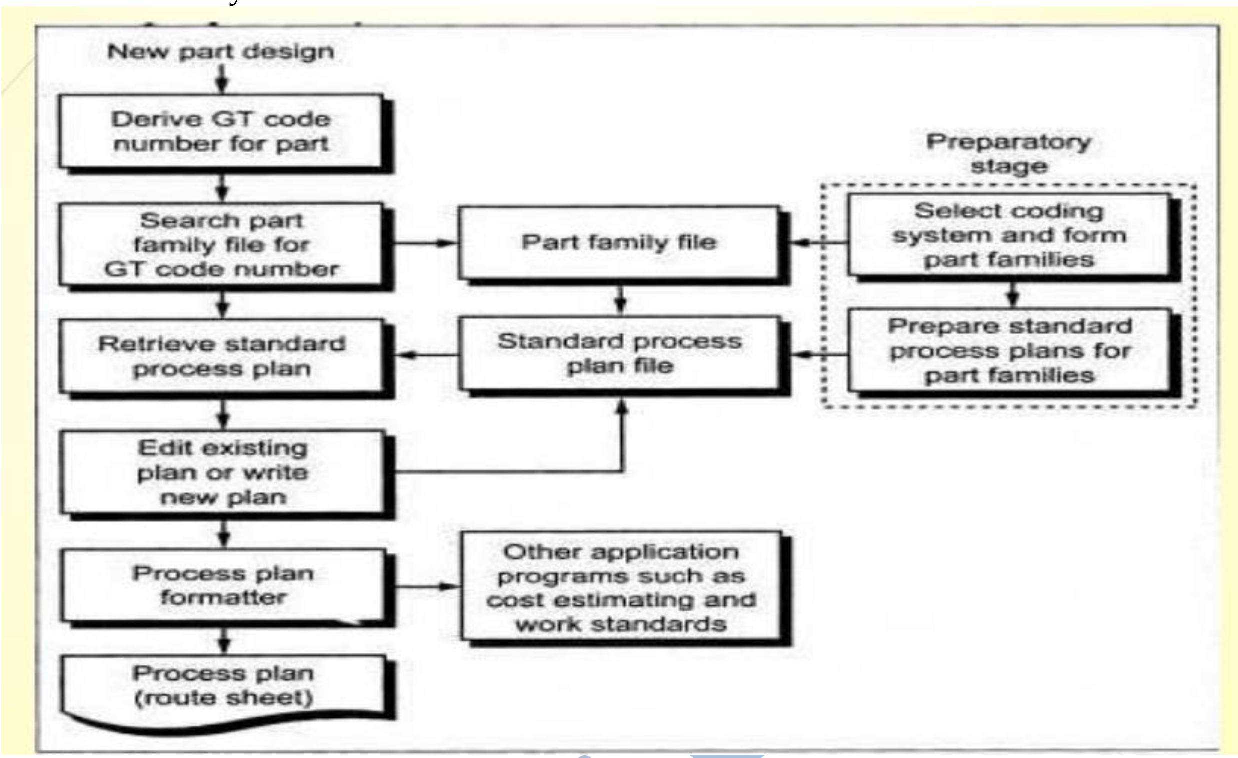
Step 3: Develop a standard process plan

- Develop a standard process plan for each part family based on the common features of the part types.
- This process plan can be used for every part type within the family with suitable modifications.

Step 4: Retrieve and modify the standard plan

- When a new part enters the system, it is assigned to a part family based on the coding and classification scheme.
- Then the corresponding standard process plan is retrieved and modified to accommodate the unique features of the new part

Retrieval CAPP System Procedure



Aggregate Production Planning

- Aggregate planning is concerned with determining the quantity and timing of for the intermediate future (often 3 to 8 months) ahead, setting employment, inventory and subcontracting.
- Aggregate plans should be coordinated among various functions in the firm, including product design, production, marketing and sales. The aggregate production planning strategy provides the data to plan the variable resources, which include full and temporary employment levels, total labour hours per period and number of subcontractors.
- In addition, the aggregate production plan, along with forecasted customer demand, provides the aggregate information from which the disaggregate master production schedule (MPS) is produced.

	Month				
	Jan.	Feb.	Mar.	Apr.	May
Planned output (Number of units of product)	1400	1750	1700	2250	2750
Product line models	Month				
	Jan.	Feb.	Mar.	Apr.	May
Model M1	475	500	500	600	625
Model M2	150	400	425	450	650
Model M3	450	500	475	600	675
Model M4	175	150	125	275	425
Model M5	150	200	175	250	300

Master Production Schedule

The aggregate production plan must be converted into master production schedule (MPS).

- Master production schedule is a listing of the products to be manufactured, when they are to be delivered and in what quantities.
- Aggregate plan production quantities of the major product lines, whereas MPS provides a very specific schedule of individual products.
- Usually MPS is developed from customer orders and forecasts of future demand

Basic Characteristics of MRP

Two basic characteristics of MRP are:

1. Drives demand for components, sub assemblies, materials, etc. from demand for and production schedules of parent items.

2. Offsets replenishment orders (purchase orders or production schedules) relative to the date when replenishment is needed.

Information Needed for MRP

The following information are needed for MRP:

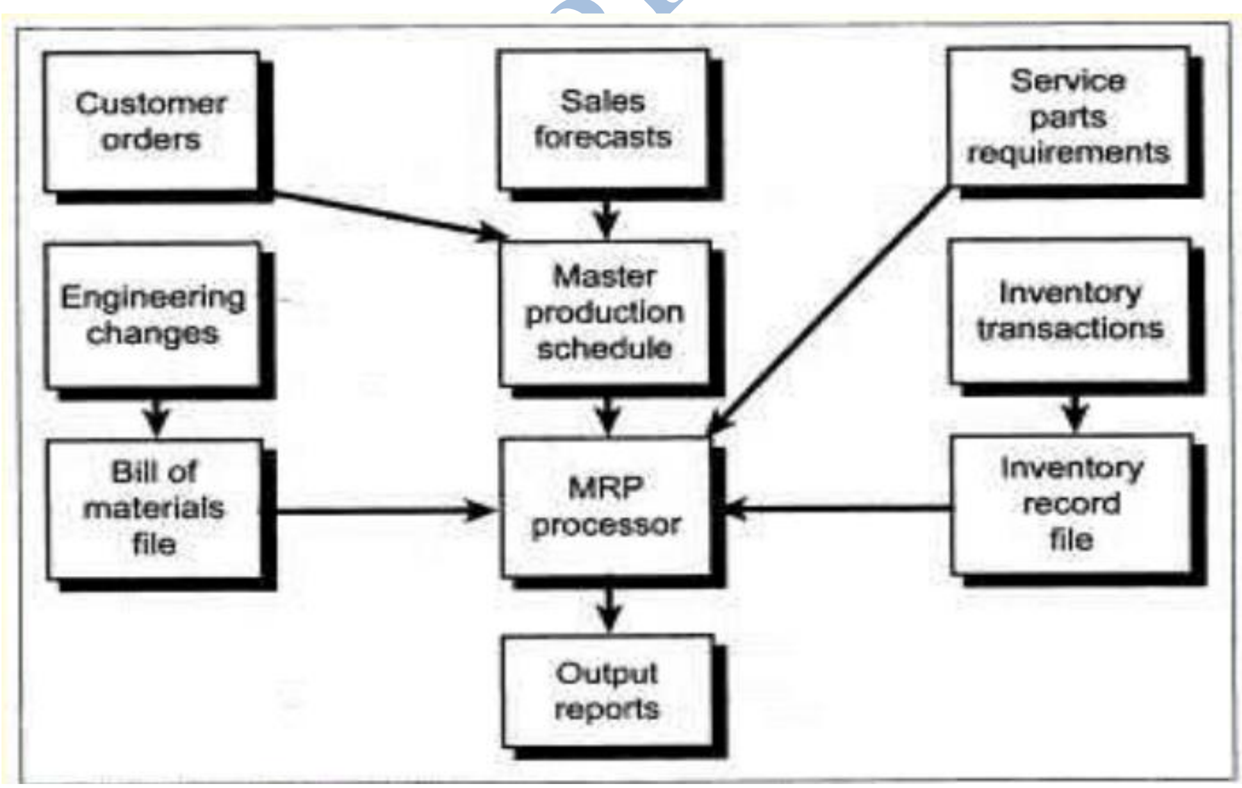
- Demand for all products.
- Lead times for all finished goods, components, parts and raw materials.
- Lot sizing policies for all parts.
- Opening inventory levels.
- Safety stock requirements.
- Any orders previously placed but which haven't arrived yet.

Inputs to MRP

The three important inputs to MRP are:

1. Master production schedule,
2. Bill of materials file and
3. Inventory record file.

Inputs to MRP



Master Production Schedule (MPS)

It is a detailed plan that states how many end items (i.e. the final product to be sold to the customer) will be available for sale or distribution during specific periods
.

Purpose of the master production schedule:

(i)To set due dates for the availability of end items.
(ii)To provide information regarding resources and materials required to support the aggregate plan.
(iii)Input to MRP will set specific production schedules for parts and components used in end items

Inputs to MPS:

The MPS inputs are:

1. Market requirements.
2. Production plan from aggregate planning
3. Resources available.

The MRP Output:

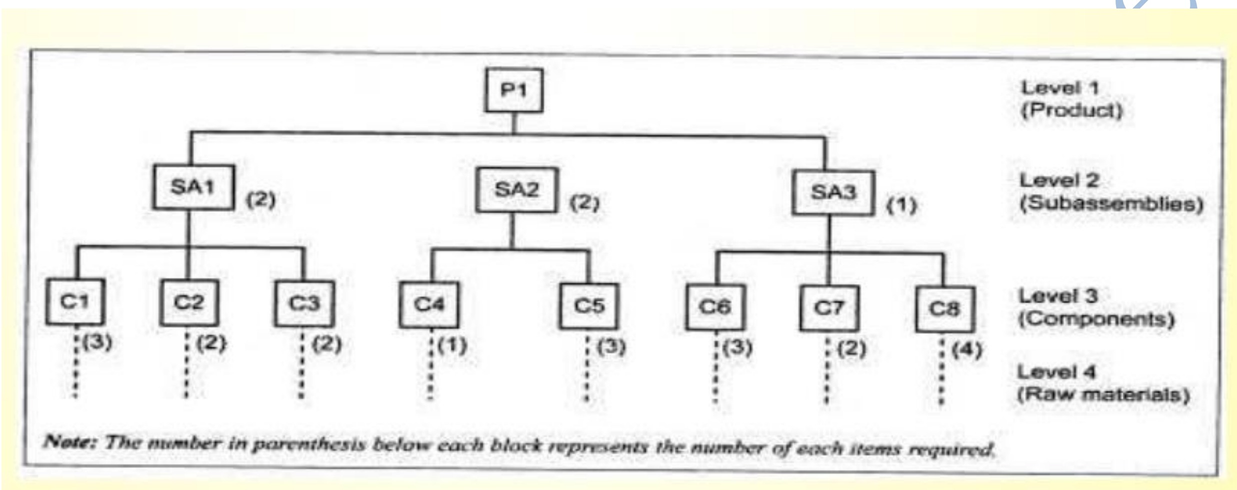
It is the list of end items available every period that is feasible with respect to demand and capacity

Bill of Materials File

- Designates what items and how many of each are used to make up a specified final product
- Used to compute the raw material and component requirements for end products listed in the master schedule.
- It Provides information on the product structure by listing the component parts and subassemblies that make up each product.

Product structure

- Structure of an assembled product, in the form of a pyramid, can be depicted as shown in Fig. It can be seen from Figure. that the product P1 is the parent of sub assemblies SA1, SA2, and
- SA3. similarly SA1 is the parent of components C1, C2 and C3, and so on



Inventory Record File

- All the data related to the inventory are recorded in the inventory record file.
- The inventory record file contains the following three segment

(i)Item Master Data Segment
(ii)Inventory Status Segment
(iii)Subsidiary Data Segment

Working of MRP

- MPS provides a period-by-period list of final products required.
- BOM defines what materials and components are needed for each product.
- Inventory record file contains information on the current and future inventory status of each component. using these three inputs, the MRP processor computes the number of each component and raw material required for the given final product

Types of reports	Purpose
II. Secondary Output Reports	
1. Performance reports of various types	To indicate costs, item usage, etc
2. Exception reports	To show deviations from schedule, orders that are overdue, scrap and so on
3. Inventory forecasts	To indicate the projected level in future periods
4. Cancellation notices	To indicate the cancellation of open orders because of changes in the master schedule
5. Reports on inventory status	To indicate the current status of the inventory

Benefits of MRP

The various benefits of implementing MRP system are:

- Reduced inventory levels.
- Better production scheduling.
- Reduced production lead time.
- Reduced setup cost.
- Reduced product changeover cost.
- Better machine utilization.
- Improved product quality.
- Quicker response to changes in demand

.

Capacity Planning

- It is a major business problem Dependent on the type of company and the state of business;
- Much easier if the work load is declining.
- Simplified if the factory has been laid out, after careful simulation, for a planned production level.

- It takes place in three phases, which need to be reviewed within CIM systems.
- Finite capacity calculations are often optimistic, because they do not show the effect of future work, i.e. work not yet released to the factory.

Logic Required In Capacity Planning Under CIM

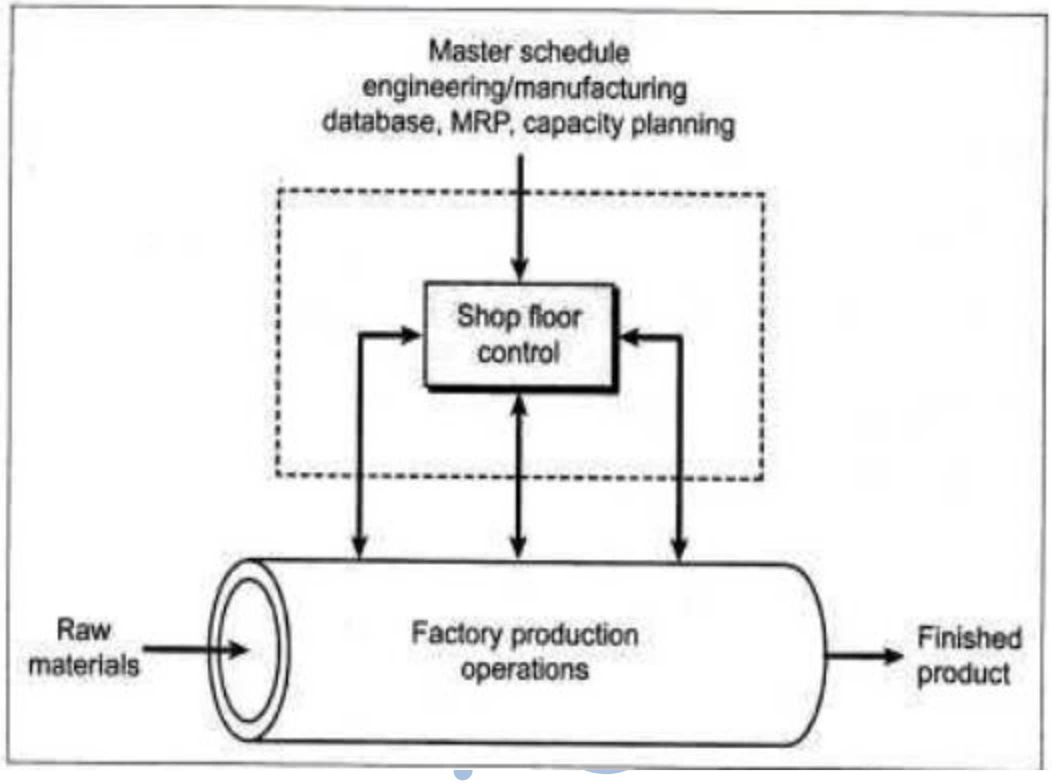
The logic for detailed finite capacity planning (i.e. calculations based on actual capacity) must include the ability to summarize the various priority factors such as lateness on due date, important customer, accumulated cost, into a single numeric value so that queues can be sequenced.

In addition, a number of other process routines that are as follows:

- Reduction of standard inter-operation (or move) time for urgent jobs.
- Overlapping of jobs across different work centers, e.g. the first items in a batch being heat treated while the last items are still being machined.
- Splitting of batches across identical machines,
- Use of alternative routing data, i.e. there may be different ways of making a product that could be chosen, depending on the load at the time on different work centers

Shop Floor Control

- This control manages the detailed flow of materials inside the production facility.
- It Encompasses the principles, approaches and techniques needed to schedule, control, measure and evaluate the effectiveness of production operations.
- Is an activity of production control one of the activity of process planning and control (PPC).
- To understand the significance of the shop floor control, it is essential to have the basic knowledge of various activities of PPC and their relations to shop floor control.
- It is defined as a system for utilizing data from the shop floor as well as data processing files to maintain and communicate status information on shop orders and work centre.



Shopfloor control (SFC) is concerned with:

(i) The release of production orders to the factory.

(ii) Monitoring and controlling the progress of the orders through the various work centres.

(iii) Acquiring information on the status of the orders.

(iv)Shop floor control deals with managing the work-in-process.

Functions of Shop Floor Control

The major functions of shop floor control are:

1. Assigning priority of each shop order (Scheduling).
2. Maintaining work-in-process quantity information (Dispatching).
3. Conveying shop-order status information to the office (Follow up).
4. Providing actual output data for capacity control purposes.

5.Providing quantity by location by shop order for work-in-process inventory
and accounting purposes.

6.Providing measurement of efficiency, utilisation and productivity of manpower and machines.

The

functions of SFC are:

1. Scheduling

2. Dispatching and

3.Follow-up or Expediting.

Phases of SFC

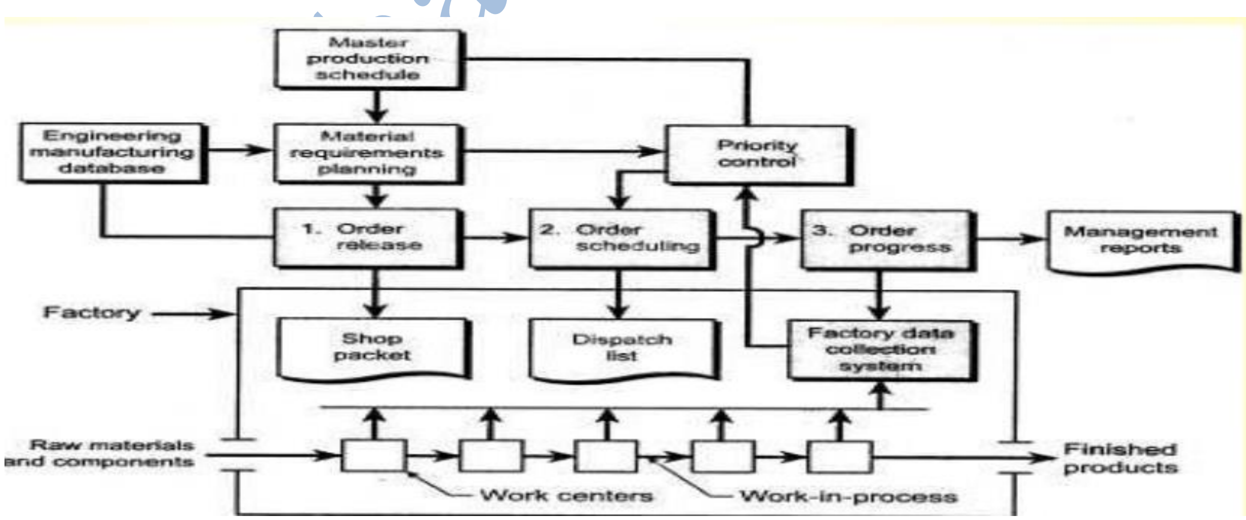
The three important phases of SFC are:

1. Order release

2. Order scheduling and

3. Order progress.

- It depicts the three phases and their relationship to other functions in the Production management system.
- In a computer integrated manufacturing system these phases are managed by computer software.
- In a typical factory which works on manual processing of data, the above documents move with the production order and are used to track the progress through the shop.
- In a CIM factory, more automated methods are used to track the progress of the production orders



i) The first input is the authorization to produce (that derives from master schedule). This authorisation proceeds through MRP which generates work orders with scheduling information.

(ii) The second input is the engineering and manufacturing database.

This database contains engineering data (such as the product design, component material specifications, bills of materials, process plans, etc.) required to make the components and assemble the products.

Database input provides the product structure and process planning information needed to Prepare the various documents that accompany the order through the shop.

2) Order Scheduling

The two inputs required to the order scheduling are:

(i) The order release and

(ii) The priority control information

It Priority control is used in production planning and control to denote the function that maintains the appropriate levels for the various production orders in the shop.

The order scheduling module is used to solve the following two problems in production controls:

- Machine loading: Allocating orders to work centres is known as machine loading.
- The term shop loading is used when loading of all machines in the plant are done.
- Job sequencing: Determining the priority in which the jobs should be processed is termed as job sequencing.
- Each work centre will have a queue of orders waiting to be processed. Queue problem can be solved by job sequencing.
- Priority sequencing rules, also known as dispatching rules, have been developed to establish priorities for production orders in the plant.

Some of the commonly used priority sequencing rules are presented below.

- SOT (shortest operating time): Run the job with the shortest completion time first, next shortest second and so on.
- Earliest due date: Run the job with the earliest due date first.
- STR (slack time remaining): This is calculated as the difference between the time remaining before the due date minus the processing time remaining. Orders with the STR are run first.
- STR/OP (slack time per operation) Orders with shortest STR/OP are run first.

STR/OP is calculated as follows:

CR (critical ratio): This is calculated as the difference between the due date and the current date divided by the number of work days remaining. Orders with the smallest CR are run first

QR (queue ratio): This is calculated as the slack time remaining in the schedule divided by the planned remaining queue time. Orders with the smallest QR are run first

FCFS (first-come, first-served): Orders are run in the order they arrive in the department

LCFS (last-come, first-served): As orders arrive, they are placed on the top of the stock and are run first.

3**) Order Progress**

The third and final phase of SFC is order progress phase.

- The order progress phase monitors the status of the various orders in the plant, work-in-progress (WIP)
- Order progress collects data from shop floor and generates reports to assist production management.
- Function of order progress module is to provide information that is useful in managing the factory based on data collected from the factory.

Inventory Control

Inventory Management:

It is defined as the scientific method of determining what to order, when to order and how much to order and how much to stock so that costs associated with buying and storing are optimal without interrupting production and sales.

Objective of Inventory Control

The main objectives of inventory control are:
(i) To ensure continuous supply of materials so that production should not suffer at any time.
(ii) To maintain the overall investment in inventory at the lowest level, consistent with operating requirements.
(iii) To minimize holding, replacement and shortage cost of inventories and maximize the efficiency in production and distribution.
(iv) To keep inactive, waste, surplus, scrap and obsolete items at the minimum level.
(v) To supply the product, raw material, WIP, etc., to its users as per their requirements at right time and at right price.
(vi) To ensure timely action for replenishment.
(vii) To maintain timely record of inventories of all the items and to maintain the stock within the desired limits.
(viii) To avoid both over-stocking and under-stocking of inventory costs Associated with Inventory (What are Inventory Costs?)

The major costs associated with procuring and holding inventories are:
1. Ordering costs
2. Carrying (or holding) costs
3. Shortage (or stock out) costs and
4. Purchase costs

- It is Refer to the managerial and clerical costs to prepare the purchase or production order.
- It is also known by the names procurement costs, replenishment costs and acquisition costs

.

These costs include:

1. Ordering costs

(i) Costs of staff of purchase department,
(ii) Costs of stationery consumed for ordering, postage, telephone bills, etc.
(iii) Depreciation costs and expenses for maintaining equipment required for ordering, receiving and inspecting incoming items.
(iv) Inspection costs of incoming materials.

2) Holding (or inventory carrying) costs

- Inventory carrying costs are the costs associated with holding a given level of inventory on hand.
- It varies in direct proportion to the amount of holding and period of holding the stock in stores. This cost will not occur if inventory is not carried out

.
The holding costs include:

(i) Costs for storage facilities.
(ii) Handling costs.
(iii) Depreciation, taxes and insurance.
(iv) Costs on record keeping.
(v) Losses due to pilferage, spoilage, deterioration and obsolescence.
(vi)Opportunity cost of capital

3) Shortage (or stock-out) costs

When the stock of an item is depleted and there is a demand for it, then the shortage cost will occur.
Shortage cost is the cost associated with stock-out.

The shortage costs include:
(i) Back order costs.
(ii) Loss of future sales.
(iii) Loss of customer goodwill.
(iv) Loss of profit contribution by lost sales revenue.
(iv) Extra cost associated with urgent, small quantity ordering costs.

4) Purchase (or production) costs
These are the costs incurred to purchase/or produce the item. This Costs include the price paid or the labour, material and overhead charges necessary to produce the item.

Manufacturing Resource Planning (MRP-I)

- It Represents the natural evolution of closed-loop MRP (materials requirements planning).
- It is an integrated information system that synchronizes all aspects of the business.
- It is Coordinates sales, purchasing, manufacturing, finance and engineering by adopting a focal production plan and by using one unified database to plan and update the activities in all the systems.
- MRP II consists of virtually all the functions in the PPC system (presented in Figure) plus additional business functions that are related to production.

Manufacturing Resource Planning (MRP-II)

Important MRP II system functions include:
1. Management planning— business strategy, aggregate production planning, master production scheduling, rough-cut capacity planning and budget planning.
2. Customer services — sales forecasting, order entry, sales analysis and finished goods inventory.
3. Operations planning — purchase order and work order release.
4. Operations execution — purchasing, product scheduling and control, work-in- process inventory control, shop floor control and labour hour tracking.
5. Financial functions — cost accounting, accounts receivable, accounts payable, general ledger and payroll.

Now-a-days many commercial software are available incorporating MRP II functions with more features.

Some of them include:

- Enterprise Resource Planning (ERP)
- Customer-Oriented Manufacturing Management Systems (COMMS)
- Manufacturing Execution Systems (MES)
- Customer-Oriented Management Systems (COMS).

Enterprise Resource Planning (ERP)

It latest step in this evolution is Enterprise Resource Planning (ERP).

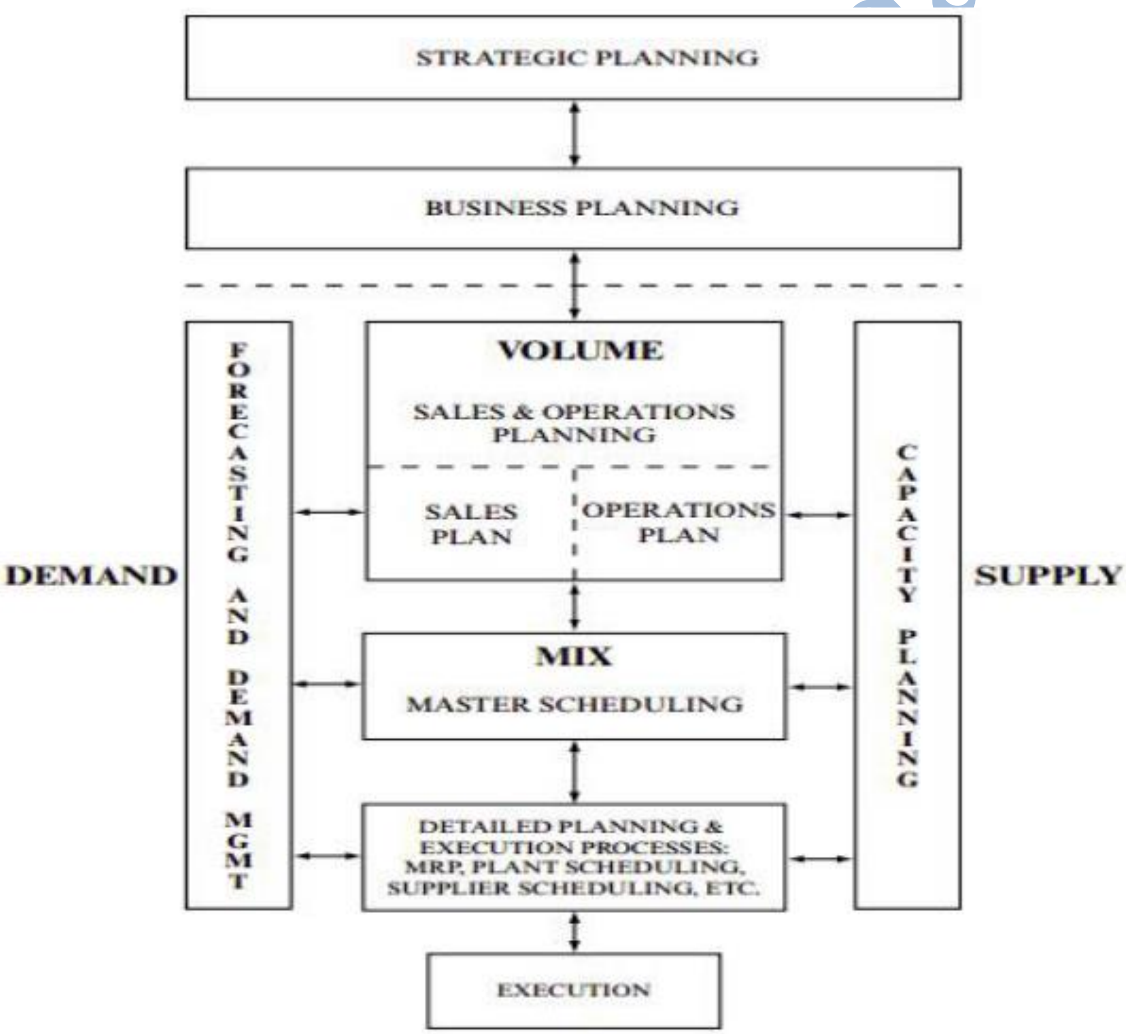
Fundamentals of ERP are the same as with MRP II.

Predicts and balances demand and supply.

It is an enterprise-wide set of forecasting, planning and scheduling tools.

Links customers and suppliers into a complete supply chain, Employs proven processes for decision-making and Coordinates sales, marketing, operations, logistics, purchasing, finance, product development and human resources.

Goals include high levels of customer service, productivity, cost reduction and inventory turnover and it provides the foundation for effective supply chain management and e-commerce.



Enterprise Resource Planning is a direct outgrowth and extension of Manufacturing Resource Planning and as such includes all of MRP II's capabilities.

a) Applies a single set of resource planning tools across the entire enterprise

b) Provides real-time integration of sales, operating and financial data and

c) Connects resource planning approaches to the extended supply chain of customers and suppliers.

Primary purpose of implementing Enterprise Resource Planning is to run the business, in a rapidly changing and highly competitive environment, far better than before.

The Applicability of ERP

ERP and its predecessor, MRP II, have been successfully implemented in companies with the following characteristics:

• Make-to-stock

• Make-to-order

• Design-to-order

• Complex

• Simple product

• Multiple plants

• Single plant

• Contract manufacturers

• Manufacturers with distribution networks

• Sell direct to end users

ERP problems fall into these four types:

- The system itself is bad.
- The system is good, but it's set up incorrectly.
- The system is good, but it's not being used.
- The system is good, but it's being used ineffectively.