

KALLAM HARANADHAREDDY INSTITUTE OF TECHNOLOGY



CAD/CAM
(Units- 4,5,6)

B.Tech –IV Year – I Semester

DEPARTMENT OF MECHANICAL ENGINEERING

PREPARED BY
Mr. Y RAVI KISHORE
Asst Professor

KALLAM HARANADHAREDDY INSTITUTE OF TECHNOLOGY

COURSE OBJECTIVES:

- The student able to know about the CAD/CAM software.
- Computer graphics, drafting, numerical control, group technology.
- CIM and computer aided quality controls

UNIT – I

Introduction: Computers in Industrial Manufacturing, Product cycle, CAD / CAM Hardware, Basic structure, CPU, Memory types, input devices, display devices, hard copy devices, storage devices. **Computer Graphics:** Raster scan graphics coordinate system, database structure for graphics modeling, transformation of geometry, 3D transformations, mathematics of projections, clipping, hidden surface removal.

UNIT-II

Geometric modeling: Requirements, geometric models, geometric construction models, curve representation methods, surface representation methods, modeling facilities desired.

UNIT-III

Drafting and Modeling systems: Basic geometric commands, layers, display control commands, editing, dimensioning, solid modeling.

Numerical control: NC, NC modes, NC elements, NC machine tools, structure of CNC machine tools, features of Machining center, turning center, CNC Part Programming fundamentals, manual part programming methods, Computer Aided Part Programming.

UNIT-IV

Group Technology: Part family, coding and classification, production flow analysis, advantages and limitations, Computer Aided Processes Planning, Retrieval type and Generative type.

UNIT-V

Computer Aided Quality Control: Terminology in quality control, the computer in QC, contact inspection methods, noncontact inspection methods-optical, noncontact inspection methods-nonoptical, computer aided testing, integration of CAQC with CAD/CAM.

UNIT-VI

Computer integrated manufacturing systems: Types of Manufacturing systems, Machine tools and related equipment, material handling systems, computer control systems, human labor in the manufacturing systems, CIMS benefits.

TEXT BOOKS:

1. CAD / CAM Theory and Practice / Ibrahim Zeid / TMH Publishers
2. CAD / CAM /A Zimmers & P.Groover/PE/PHI Publishers
3. Automation, Production systems & Computer integrated Manufacturing/ Groover/ Pearson Education

REFERENCE BOOKS:

1. CAD / CAM / CIM / Radhakrishnan and Subramanian / New Age Publishers
2. Principles of Computer Aided Design and Manufacturing / Farid Amirouche / Pearson Edu
3. CAD/CAM: Concepts and Applications/Alavala/ PHI Publishers Computer Numerical Control Concepts and programming / Warren S Seames / Thomson Publishers

OUTCOMES:

- The learning outcomes are assessed through the assignment and various practical performed modeling, drafting.
- Computer aided quality control and computer integrated manufacturing systems.
- Know about different CIM Techniques.

CONTENTS

UNIT NO	NAME OF THE UNIT
IV	Group Technology
V,VI	Computer Aided Quality Control and Computer Integrated Manufacturing Systems

UNIT – 4

Group Technology

INTRODUCTION:

Group technology (abbreviated GT) is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in manufacturing and design. Similar parts are arranged into part families. For example, a plant producing 10,000 different part numbers may be able to group the vast majority of these parts into 50 or 60 distinct families. Each family would possess similar design and manufacturing characteristics. Hence, the processing of each member of a given family would be similar, and this results in manufacturing efficiencies. These efficiencies are achieved in the form of reduced setup times, lower in-process inventories, better scheduling, improved tool control, and the use of standardized process plans. In some plants where GT has been implemented, the production equipment is arranged into machine groups, or cells, in order to facilitate work flow and parts handling.

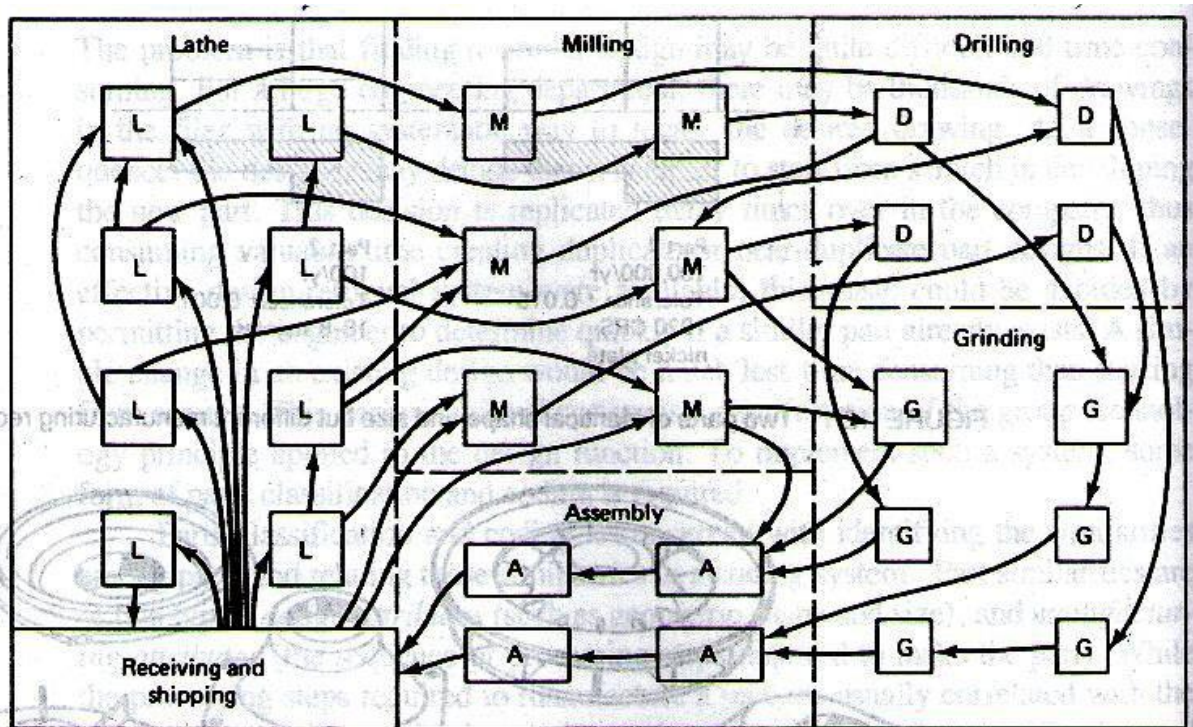
Parts classification and coding is concerned with identifying the similarities among parts and relating these similarities to a coding system. Part similarities are of two types: design attributes (such as geometric shape and size), and manufacturing attributes (the sequence of processing steps required to make the part).

Whereas a parts classification and coding system is required in a design retrieval system, it can also be used in computer-aided process planning (CAPP). Computer-aided process planning involves the automatic generation of a process plan (or route sheet) to manufacture the part. The process routing is developed by recognizing the specific attributes of the part in question and relating these attributes, to the corresponding manufacturing operations.

Group technology and parts classification and coding are based on the concept of a part family.

PART FAMILIES

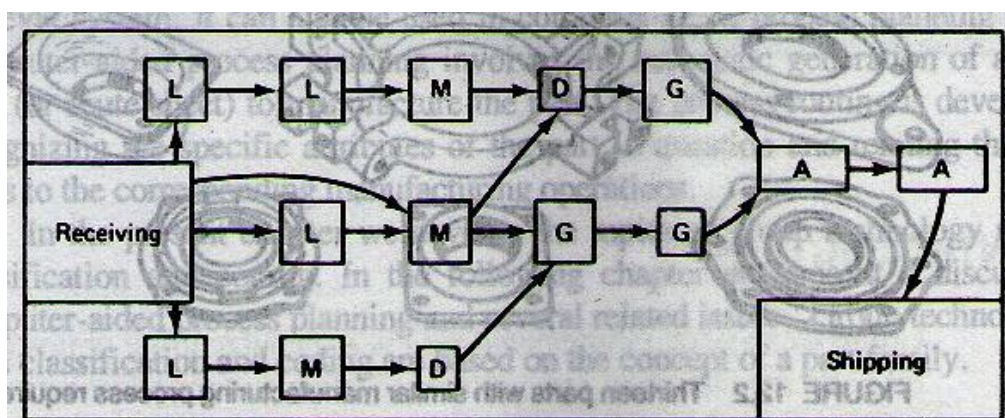
A part family is a collection of parts which are similar either because of geometric shape and size or because similar processing steps are required in their manufacture. The parts within a family are different, but their similarities are close enough to merit their identification as members of the part family.



Process-type layout.

The part family concept is central to design-retrieval systems and most current computer-aided process planning schemes. Another important manufacturing advantage derived from grouping work part into families. The machines arranged into cells. Each cell is organized to specialized in the manufacturing of a particular part family. Advantages are gained in the form of reduced workpiece handling, lower setup times, less in-process inventory, less floor space, and shorter lead times. Some of the manufacturing cells can be designed to form production flow lines, with conveyors used to transport work parts between machines in the cell.

The biggest single obstacle in changing over to group technology from a traditional production shop is the problem of grouping parts into families.



Group technology layout.

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

1. **Visual inspection** - The visual inspection method is the least sophisticated and least expensive method. It involves the classification of parts into families by looking at either the physical parts or photographs and arranging them into similar groupings. This method is generally considered to be the least accurate of the three.
2. **Production flow analysis (PFA)** - PFA is a method of identifying part families and associated machine tool groupings by analyzing the route sheets for parts produced in a given shop. It groups together the parts that have similar operation sequences and machine routings. The disadvantage of PFA is that it accepts the validity of existing route sheets, with no consideration given to whether these process plans are logical or consistent.
3. **Parts classification and coding system** - It is the most time consuming and complicated of the three methods. However, it is the most frequently applied method and is generally recognized to be the most powerful of the three.

PARTS CLASSIFICATION AND CODING

This method of grouping parts into families involves an examination of the individual design and/or manufacturing attributes of each part. For example, parts produced in the shop during a certain given time period could be examined to identify part family categories. The trouble with any sampling procedure is the risk that the sample may be unrepresentative of the entire population. However, this risk may be worth taking, when compared to the relatively enormous task of coding all the company's parts.

Design systems versus manufacturing systems

Parts classification and coding systems divide themselves into one of three general categories:

1. Systems based on part design attributes- This category are useful for design retrieval and to promote design standardization.
2. Systems based on part manufacturing attributes –This category are used for computer-aided process planning, tool design, and other production-related functions.
3. Systems based on both design and manufacturing attributes – This category represents an attempt to combine the functions and advantages of the other two systems into a single classification scheme.

Coding system structure

A parts coding scheme consists of a sequence of symbols that identify the part's design and/or manufacturing attributes. The symbols in the code can be all numeric, all alphabetic, or a combination of both types. However, most of the common classification and coding systems use number digits only. There are three basic code structure used in group technology applications:

1. **Hierarchical structure** - The interpretation of each succeeding symbol depends on the value of the preceding symbols. Other names commonly used for this structure are **monocode** and **tree structure**. The hierarchical code provides a relatively compact structure which conveys much information about the part in a limited number of digits.
2. **Chain-type structure** - In the chain-type structure, the interpretation of each symbol in the sequence is fixed and does not depend on the value of preceding digits. Another name commonly given to this structure is **polycode**. The problem associated with polycodes is that they tend to be relatively long.
3. **Hybrid structure**, a combination of hierarchical and chain-type structures - The hybrid structure is an attempt to achieve the best features of monocodes and polycodes. Hybrid codes are typically constructed as a series of short polycodes. Within each of these shorter chains, the digits are independent, but one or more symbols in the complete code number are used to classify the part population into groups, as in the hierarchical structure. This hybrid coding seems to best serve the needs of both design and production.

To illustrate the difference between the hierarchical structure and the chain-type structure, consider a two-digit code, such as 15 or 25. Suppose that the first digit stands for the general part shape. The symbol 1 means round workpart and 2 means flat rectangular geometry. In a hierarchical code structure, the interpretation of the second digit would depend on the value of the first digit. If preceded by 1, the 5 might indicate some length/diameter ratio, and if preceded by 2, the 5 might be interpreted to specify some overall length. In the chain-type code structure, the symbol 5 would be interpreted the same way regardless of the value of the first digit. For example, it might indicate overall part length, or whether the part is rotational or rectangular.

THREE PARTS CLASSIFICATION AND CODING SYSTEMS

Inyong Ham [8] recommends that the following factors be considered in selecting a parts coding and classification system:

Objective.

The prospective user should first define the objective for the system.

Will it be used for design retrieval or part-family manufacturing or both?

Scope and application.

What departments in the company will use the system? What specific requirements do these departments have?

What kinds of information must be coded? How wide a range of products must be coded?

How complex are the parts, shapes, processes, tooling, and so forth?

Costs and time.

The company must consider the costs of installation, training, and maintenance for their parts classification and coding system. Will there be consulting fees, and how much?

How much time will be required to install the system and train the staff to operate and maintain it?

How long will it be before the benefits of the system are realized?

Adapability to other systems.

Can the classification and coding system be readily adapted to the existing company computer systems and data bases?

Can it be readily integrated with other existing company procedures, such as process planning, NC programming, and production scheduling?

Management problems.

It is important that all involved management personnel be informed and supportive of the system. Also, will there be any problems with the union?

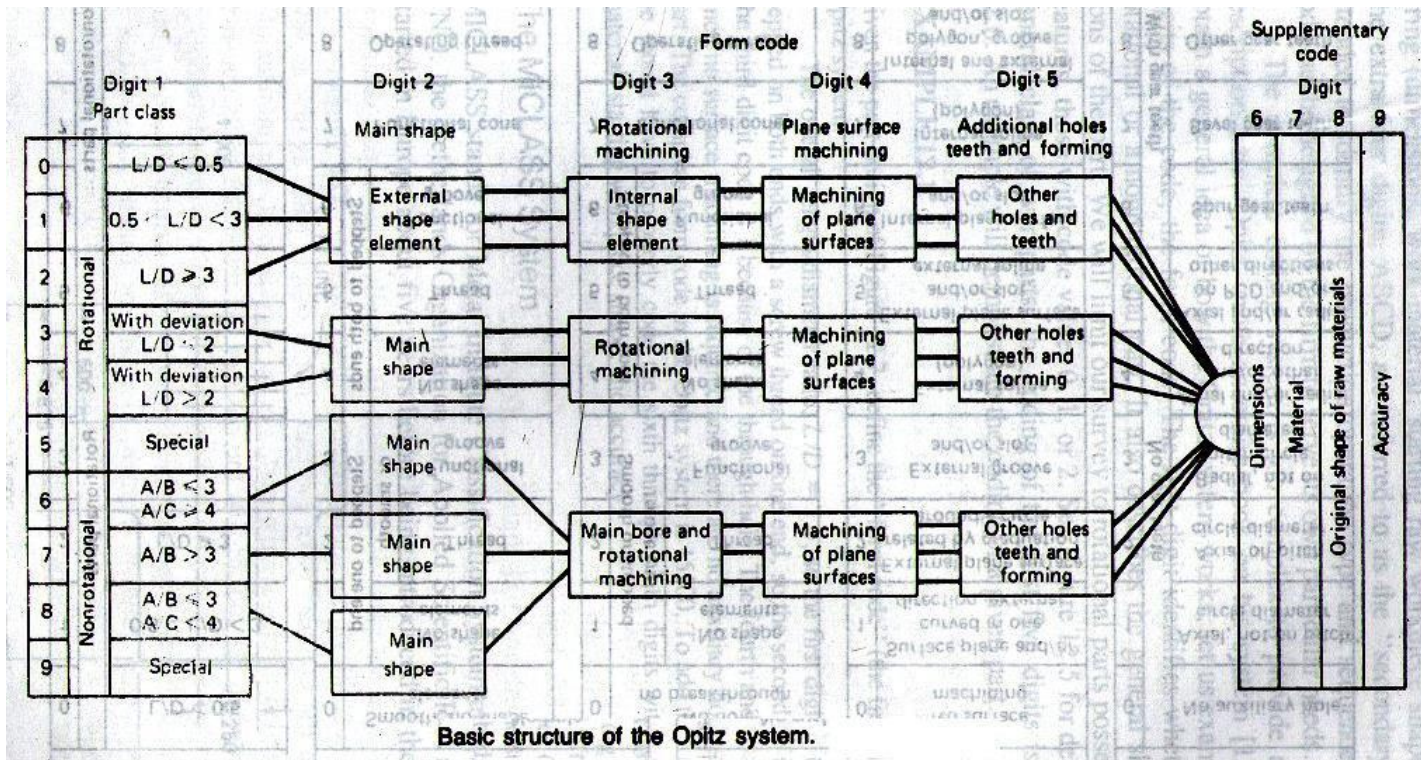
Will cooperation and support for the system be obtained from the various departments involved?

- Three parts classification and coding systems which are widely recognized among people familiar with GT:

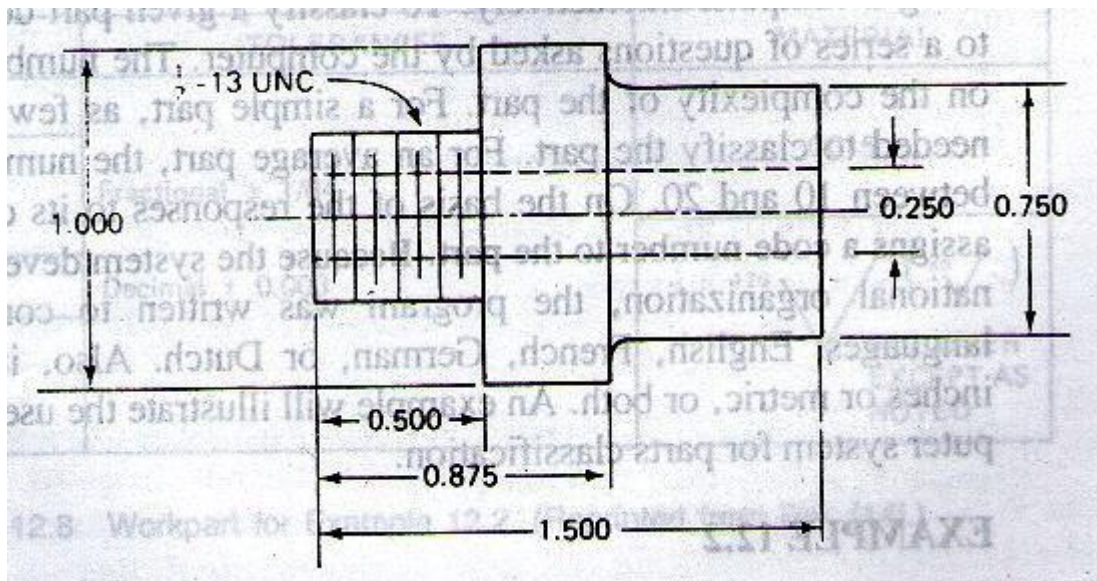
1. **Opitz system** - This parts classification and coding system was developed by H. Opitz of the University of Aachen in West Germany. The Opitz coding system uses the following digit sequence:

12345 6789 ABCD

The basic code consists of nine digits, which can be extended by adding four more digits. The first nine digits are intended to convey both design and manufacturing data. The general interpretation of the nine digits is indicated. The first five digits, 12345, are called the "form code" and describe the primary design attributes of the part. The next four digits, 6789, constitute the supplementary code. It indicates some of the attributes that would be of use to manufacturing (dimensions, work material, starting raw workpiece shape and accuracy). The extra four digits, ABCD, are referred to as the "secondary code" and are intended to identify the production operation type and sequence. The secondary code can be designed by the firm to serve its own particular needs.



2. **The MICLASS system** - MICLASS stands for Metal Institute Classification System was developed by TNO, the Netherlands Organization for Applied Scientific Research.



The MICLASS system was developed to help automate and standardize a number of design, production, and management functions. These include:

- Standardization of engineering drawings
- Retrieval of drawings according to classification number
- Standardization of process routing
- Automated process planning
- Selection of parts for processing on particular groups of machine tools

- Machine tool investment analysis

The MICLASS classification number can range from 12 to 30 digits. The first 12 digits are a universal code that can be applied to any part. Up to 18 additional digits can be used to code data that are specific to the particular company or industry. For example, lot size, piece time, cost data, and operation sequence might be included in the 18 supplementary digits.

The workpart attributes coded in the first 12 digits of the MICLASS number are as follows:

1st digit	Main shape
2nd and 3rd digits	Shape elements
4th digit	Position of shape elements
5th and 6th digits	Main dimensions
7th digit	Dimension ratio
8th digit	Auxiliary dimension
9th and 10th digits	Tolerance codes
11th and 12th digits	Material codes

One of the unique features of the MICLASS system is that parts can be coded using a computer interactively. To classify a given part design, the user responds to a series of questions asked by the computer. The number of questions depends on the complexity of the part. For a simple part, as few as seven questions are needed to classify the part. For an average part, the number of questions ranges between 10 and 20. On the basis of the responses to its questions, the computer assigns a code number to the part

3. **CODE system** - The CODE system is a parts classification and coding system developed and marketed by Manufacturing Data Systems, Inc. (MDSI), of Ann Arbor, Michigan. Its most universal application is in design engineering for retrieval of part design data, but it also has applications in manufacturing process planning, purchasing, tool design, and inventory control.

The CODE number has eight digits. For each digit there are 16 possible values (zero through 9 and A through F) which are used to describe the part's design and manufacturing characteristics. The initial digit position indicates the basic geometry of the part and is called the Major Division of the CODE system. This digit would be used to specify whether the shape was a cylinder, flat piece, block, or other. The interpretation of the remaining seven digits depends on the value of the first digit, but these remaining digits form a chain-type structure.

The second and third digits provide additional information concerning the basic geometry and

principal manufacturing process for the part. Digits 4, 5, and 6 specify secondary manufacturing processes such as threads, grooves, slots, and so forth. Digits 7 and 8 are used to indicate the overall size of the part (e.g., diameter and length for a turned part) by classifying it into one of 16 size ranges for each of two dimensions.

PRODUCTION FLOW ANALYSIS (PFA)

It is another methodology in GT. In this analysis, grouping of parts is done in terms of the manufacturing sequence. For this, the route sheets of components are examined and the grouping is made on the basis of the facilities used and not on the sequence of operations. The defects of this analysis are that it is based on the existing method of manufacture which may change after sometime, secondly it assumes that the route sheets have been correctly prepared which is often questionable; and lastly, since this analysis is based on the existing practice within a company, it cannot be universally applied.

PFA is carried out in three stages, namely, Factory Flow Analysis, Group Analysis and Line Analysis. These analyses help in arranging facilities and groups of components so as to minimize movement and improve the utilization of facilities. For example, group analysis is carried out as follows:

1. Examine the route sheet of all the components to be manufactured in the shop.
2. Prepare a matrix showing the operation numbers and the components number and fill it to show which component requires which operations.
3. While grouping parts, any particular part should be included only in one group. For facility grouping, one machine type should be only in one group. Such operations as are incompatible should be in different groups. For example, if a machined part needs heat treatment or painting, then while grouping parts, for machining, painting or heat-treatment facilities should be considered as separate groups.
4. If an operation is required by only one or very few components, or if some operation is required by all (or nearly all) the components, then these operations should not be taken note of while deciding the groups, e.g. operations 2, 8 and 9.

Operation	Components							
	1	2	3	4	5	6	7	8
1	X	X		X	X		X	
2	X	X	X	X	X	X	X	X
3			X	X	X		X	
4								
5								
6								
7								
8				X				
9	X	X	X	X	X	X	X	X

Fig a - Matrix : operations - components

This matrix is rearranged (Fig b) by excluding operation numbers 2,8 and 9; and putting together components which need the same operations.

Components 1,2,4 and 5 are formed into a single group by excluding operation 1 on component 8.

Components 8,3,6 and 7 are formed into another group. Thus, the final grouping would be (Fig c):

Operation	Components							
	1	2	4	5	8	3	6	7
1	X	X	X	X	(X)			
3			X	X		X		X
4					X	X	X	X
5	X		X	X				
6					X		X	X
7						X	X	

Fig b – Rearranged Matrix

Operation	Components							
	1	2	4	5	8	3	6	7
1	X	X	X	X				
2	X	X	X	X				
5	X		X	X				
9								
3						X		X
4					X	X	X	X
6					X		X	X
7						X	X	

Fig c – Grouping based on production flow analysis

BENEFITS OF GROUP TECHNOLOGY

Although group technology is expected to be an important principle in future production plants, it has not yet achieved the widespread application which might be expected. There are several reasons for this.

- There is the problem of rearranging the machines in the plant into GT cells. Many companies have been inhibited from adopting group technology because of the expense and disruption associated with this transition to GT machine cells.
- There is the problem of identifying part families among the many components produced in the plant. Usually associated with this problem is the expense of parts classification and coding. Not only is this procedure expensive, but it also requires a considerable investment in time and personnel resources. Managers often feel that these limited resources can better be allocated to other projects than group technology with its uncertain future benefits.
- It is common for companies to encounter a general resistance among its operating personnel when changeover to a new system is contemplated.

When these problems are solved and group technology is applied, the company will typically realize benefits in the following areas:

1. **Product design benefits** - In the area of product design, improvements and benefits are derived from the use of a parts classification and coding system, together with a computerized design retrieval system. When a new part design is required, the engineer or draftsman can devote a few minutes to figure the code of the required part. Then the existing part designs that match the code can be retrieved to see if one of them will serve the function desired. The few minutes spent searching the design file with the aid of the coding system may save several hours of the designer's time. If the exact part design cannot be found, perhaps a small alteration of the existing design will satisfy the function. Use of the automated design-retrieval system helps to eliminate design duplication and proliferation of new part designs.

Other benefits of GT in design are that it improves cost estimating procedures and helps to promote design standardization. Design features such as inside corner radii, chamfers, and tolerances are more likely to become standardized with group technology.

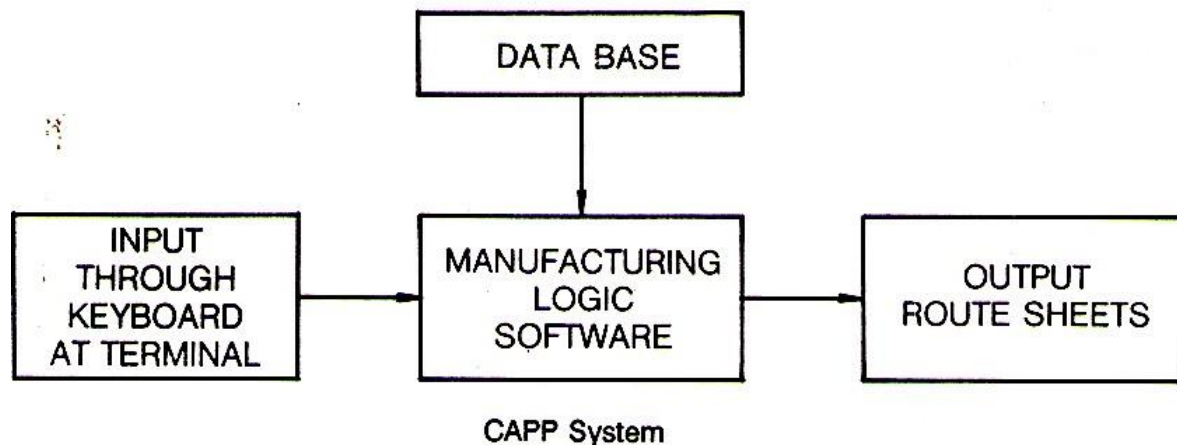
2. **Tooling and setups** - In tooling, an effort is made to design group jigs and fixtures that will accommodate every member of a parts family. Workholding devices are designed to use special adapters which convert the general fixture into one that can accept each part family member. The machine tools in a GT cell do not require drastic changeovers in setup because of the similarity in the workparts processed on them. Hence, setup time is saved.

3. **Materials handling** - Another advantage in manufacturing is a reduction in the workpart move and waiting time. The group technology machine layouts lend themselves to efficient flow of materials through the shop. The contrast is sharpest when the flow line cell design is compared to the conventional process-type layout
4. **Production and inventory control** - Production scheduling is simplified with group technology. In effect, grouping of machines into cells reduces the number of production centers that must be scheduled. Grouping of part's into families reduces the complexity and size of the parts scheduling problem. And for those workparts that cannot be processed through any of the machine cells, more attention can be devoted to the control of these parts. Because of the reduced setups and more efficient materials handling with machine cells, production lead times, work-in-process, and late deliveries can all be reduced. Estimates on what can be expected are provided by DeVries et al. :
 - 70% reduction in production times
 - 62% reduction in work-in-process inventories
 - 82% reduction in overdue orders
5. **Employee satisfaction** - The machine cell often allows parts to be processed from raw material to finished state by a small group of workers. The workers are able to visualize their contributions to the firm more clearly. This tends to cultivate an improved worker attitude and a higher level of job satisfaction. Another employee-related benefit of GT is that more attention tends to be given to product quality. Workpart quality is more easily traced to a particular machine cell in group technology. Consequently, workers are more responsible for the quality of work they accomplish. Traceability of part defects is sometimes very difficult in a conventional process-type layout, and quality control suffers as a result.
6. **Process planning Procedures** - The time and cost of the process planning function can be reduced through standardization associated with group technology. A new part design is identified by its code number as belonging to a certain parts family, for which the general process routing is known. The logic of this procedure can be written into computer software to form a computer-automated process planning system.

COMPUTER AIDED PROCESS PLANNING

INTRODUCTION

Before the role of computer aided process planning (CAPP) is discussed, it is worthwhile understanding the role of process planning in the product cycle. Once the design of the product has been evolved from customers' views, its manufacture necessitates careful planning and scheduling of the various processes of manufacture so that the product is made to right specifications and delivered at the right time at a minimal cost. This cycle (Fig. A) from concept to design, planning, production, quality control and feedback to design goes on in which one can easily understand the crucial role of planning. In job/ batch manufacture, as an enormous amount of data is needed for planning as well as other activities, data bases are required and the flow of information should be fast for a high performance of the total manufacturing system.



WHAT IS PROCESS PLANNING ?

This activity deals with determining the machine tools and the sequence of manufacturing operations involved in the manufacture of the components/products. Route sheets are used for documentation of such activity. A process planner is expected to plan the process, determine the machining conditions and set the time standards for the component in question. He is to be familiar with the shop practice and equipment capabilities.

Every process planner would try to follow the best procedure based on his experience. Thus, it is possible that the routings would not be the same if different engineers are involved and it would also not be surprising if the same engineer may put up different routings for the same component if done at different occasions over a period of time. Such situations generally happen in large variety manufacture when documentation is difficult to retrieve. These problems occur because no process standardization exists. This proves that conventional process planning can never be optimal.

For process planning to be done in a rational and consistent manner leading to optimal routing, the

manual routine work needs to be eliminated. Instead, use should be made of modern computer software facilities, which on inputting specifications of the component will not only output the routings fast and correctly but be amenable to efficient storage and communication. This is Computer Aided Process Planning.

COMPUTER AIDED PROCESS PLANNING

Process planning can be considered under the two broad classes, retrieval and generative.

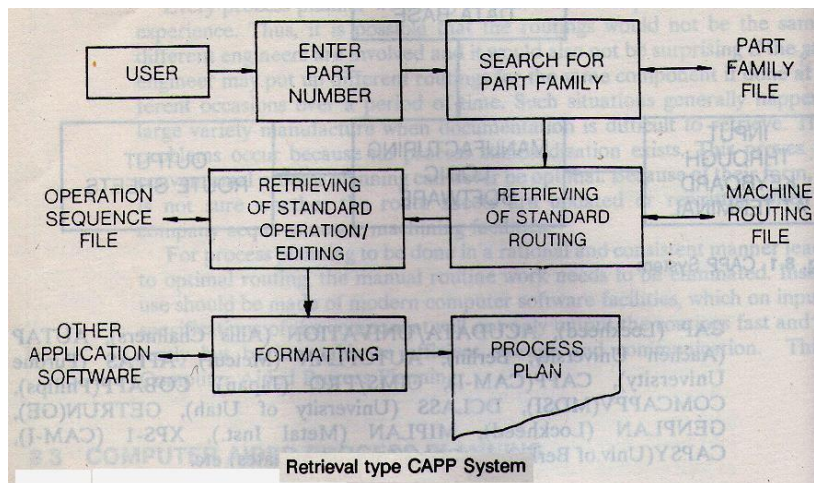
- Retrieval, or variant, process planning is based on Group Technology approach. Standard process plans for part families are made and stored using the code system. When a process plan of a component is required, it can be speedily retrieved and edited, if necessary. In this system, a proper file organization is to be maintained and the coding used enables efficient retrieval.
- The other type is the generative, in which individual process plans are made for each component. In this, retrieval is not involved. As the component features are input in the required way, the system itself prepares the process plan. The logic used enables rationality and consistency in the process plans obtained.

It is difficult to name all the packages available so far for process planning. A few have been listed along with their sources.

- CAP (Lockheed)
- ACUDATA/UNIVATION (Allis Chalmers),
- AUTAP (Aachen University, Berlin),
- AUTOPLAN (Metcut),
- APPAS (Purdue University),
- CAPP(CAM-I),
- CIMS/PRO (Japan),
- COBAPP(Philips),
- COMCAPPV(MDSI),
- DCLASS (University of Utah),
- GETRUN(GE),
- GENPLAN (Lockheed),
- MIPLAN (Metal Inst.),
- XPS-1 (CAM-I),
- CAPSY(Univ.of Berlin),
- LOCAM (Logan Associates)

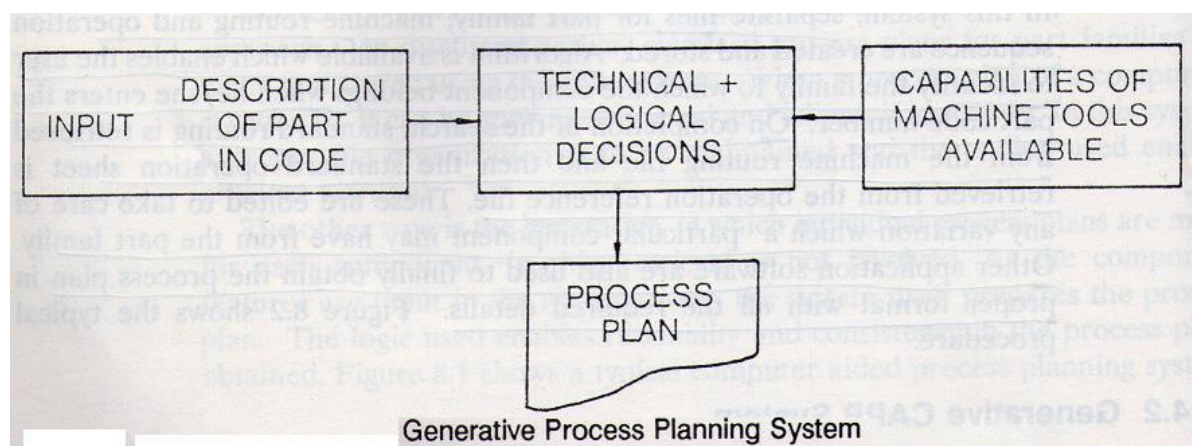
Retrieval Type CAPP System

In this system, separate files for part family, machine routing and operation sequence are created and stored. Algorithm is available which enables the user to identify the family to which the component belongs when he/she enters the part code number. On completion of the search, Standard routing is retrieved from the machine routing file and then the standard operation sheet is retrieved from the operation reference file. These are edited to take care of any variation which a particular component may have from the part family. Other application software are also used to finally obtain the process plan in proper format with all the required details



Generative CAPP System

As mentioned earlier, this differs from the variant type in that in this case the process plan is made from scratch. No standard plans exist and as such no retrieval is involved in this case. The software in the system is capable of taking technical and logical decisions (based on stored information pertaining to capabilities of machine tool available) when the user inputs description of the part in proper coded form and thus outputs the process plan. It builds up optimal process sequence based on part description provided on the machine capabilities.



UNIT – 5

Computer-Aided Quality Control

INTRODUCTION

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

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

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

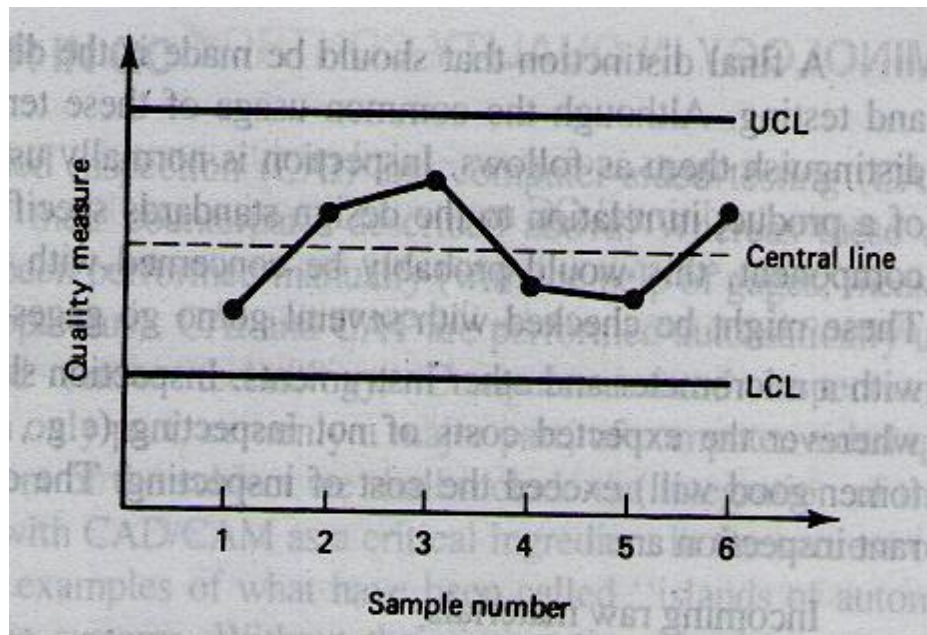
The objectives of computer-aided quality control are ambitious, yet straight forward. They are:

1. To improve product quality
2. To increase productivity in the inspection process
3. To increase productivity and reduce lead times in manufacturing

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

TERMINOLOGY IN QUALITY CONTROL

- ✓ **Quality** in a manufacturing context can be defined as the degree to which a product or its components conform to certain standards that have been specified by the designer. The design standards generally relate to the materials, dimensions and tolerances, appearance, performance, reliability, and any other measurable characteristic of the product.
- ✓ **Quality assurance (QA)** is concerned with those activities which will maximize the probability that the product and its components will be manufactured within the design specifications. These activities should start in the product design area, where the designer can make decisions among alternatives that might have quality consequences. QA activities continue in manufacturing planning, where decisions relative to production equipment, tooling, methods, and motivation of employees will all have an influence on quality.
- ✓ **Quality control** is concerned with those activities related to inspection of product and component quality, detection of poor quality, and corrective action necessary to eliminate poor quality. These activities also involve the planning of inspection procedures and the specification of the gages and measuring instruments needed to perform the inspections.
- ✓ **Statistical QC** is generally divided into two categories: **acceptance sampling** and **control charts**.
 - Acceptance sampling is a procedure in which a sample is drawn from a batch of parts in order to assess the quality level of the batch and to determine whether the batch should be accepted or rejected. Acceptance sampling is based on the statistical notion that the quality of a random sample drawn from a larger population will be representative of the quality of that population.
 - Control charts are used to keep a record over time of certain measured data collected from a process. A company would use control charts to monitor its own production processes. The central line indicates the expected quality level of the process. The upper and lower control limits (UCL and LCL) are statistical measures of the variation in the process which would be tolerated without concluding that the process has erred. when these limits are exceeded, it usually means that something has changed the process, and an investigation should be initiated to determine the cause



- ✓ Both acceptance sampling and control charts can be applied to two situations in quality control: fraction defects and measured variables.
 - In the **fraction-defect** case, the objective is to determine what proportion of the sample (and the population from which it came) are defective. This is often accomplished by a go/no go gage, which can quickly determine whether a part is within specification or not.
 - In the **measured-variable** case, the object is to determine the value of the quality characteristic of interest (e.g., dimension, resistance, hardness, etc.). This requires the use of a measuring instrument of some kind (e.g., micrometer, ohmeter, hardness tester, etc.) and is normally a more time-consuming manual process than the go/no go case.
- ✓ **Inspection** is normally used to examine a component of a product in relation to the design standards specified for it. For a mechanical component, this would probably be concerned with the dimensions of the part. These might be checked with several go/no go gages or they might be measured with a micro meter and other instruments. The corfion situations that warrant inspection are:
 - Incoming raw materials
 - At various stages during manufacturing (e.g., when the parts are moved from one production department to another)
 - At the completion of processing on the parts
 - Before shipping the final assembled product to the customer

- ✓ **Testing**, on the other hand, is normally associated with the functional aspects of the item, and it is often directed at the final product rather than its components. In this usage, testing consists of the observation of the final product during operation under actual or simulated conditions. If the product passes the test, it is deemed suitable for sale. Several categories of tests used for final product evaluation:
- Simple functional tests under normal or simulated normal operating conditions
 - Functional tests in which the product is tested under extreme (usually adverse conditions)
 - Fatigue or wear tests to determine how long the product will function until Failure.
 - Overload tests to determine the level of safety factor built into the product
 - Environmental testing to determine how well the product will perform under different environments (e.g., humidity, temperature)

THE COMPUTER IN QC

CAI and CAT are performed automatically using the latest computer and sensor technology. Computer-assisted inspection and testing methods form only part, certainly a major part, of computer-aided quality control. In our treatment of the subject we shall include the integration of the quality control function with CAD/CAM as a critical ingredient in the success of CAQC.

The implications of the use of computer-aided quality control are important. The automated methods of CAQC will result in significant changes from the traditional concepts and methods. The following list will summarize the important effects likely to result from CAQC.

1. With CAI and CAT, inspection and testing will typically be accomplished on a 100% basis rather than by the sampling procedures normally used in traditional QC.
2. Inspection during production will be integrated into the manufacturing process rather than requiring that the parts be taken to some inspection area. This will help to reduce the elapsed time to complete the parts. On line will have to be accomplished in much less time than with current manual techniques.
3. The use of noncontact sensors will become much more widely used with computer-aided inspection. With contact inspection devices, the part must usually be stopped and often repositioned to allow the inspection device to be applied properly. With noncontact sensor devices, the part can often be inspected "on the fly." These devices,

driven by the high-speed data processing capability of the computer, can complete the inspection in a small fraction of a second.

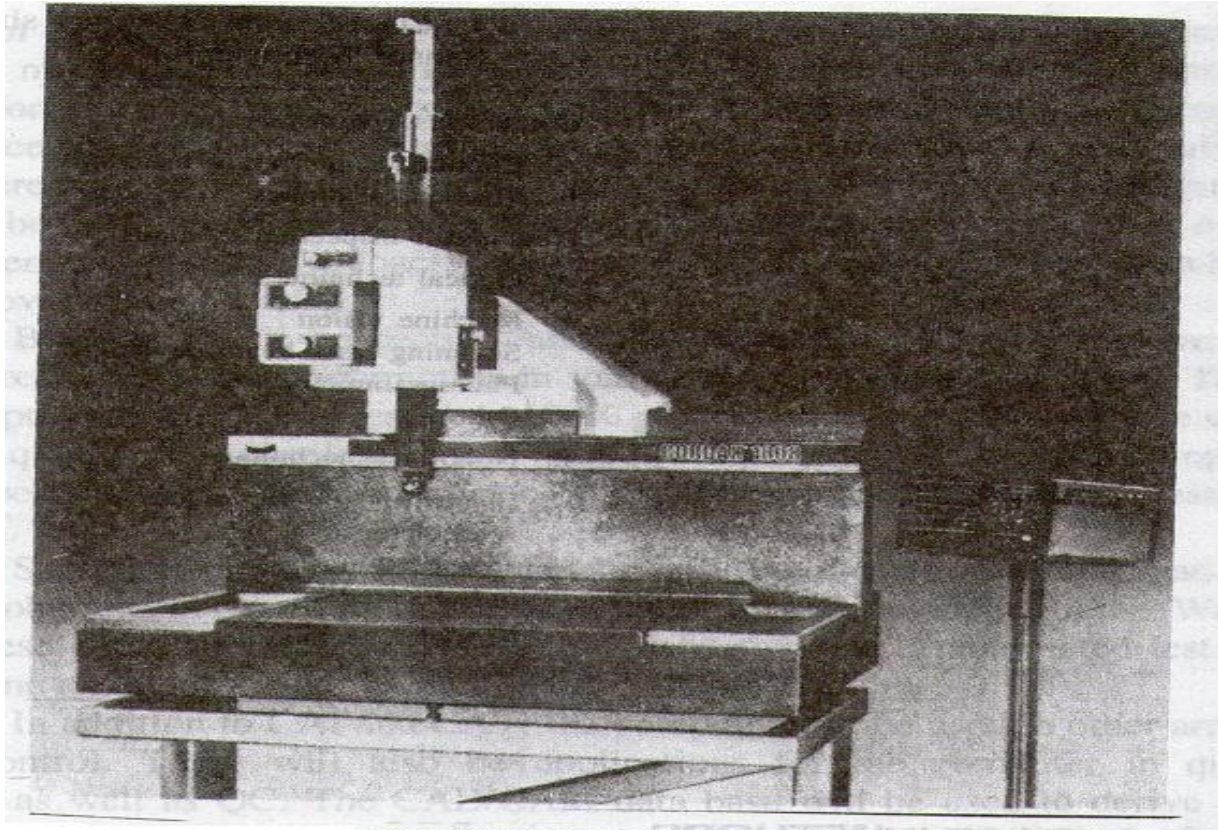
4. The on-line noncontact sensors will be utilized as the measurement component of computerized feedback control systems. These systems will be capable of making adjustments to the process variables based on analysis of the data collected by the sensors. Data would be plotted. This would not only allow out of tolerance conditions to be identified, but gradual shifts in the process could also be uncovered and corrective action taken. By regulating the process in this manner, parts will be made much closer to the desired nominal dimension rather than merely within tolerance. Quality feedback control systems will help to reduce scrap losses and improve product quality.
5. With computer-aided inspection technology, it may no longer be necessary to settle for less than perfection.
6. Robots will be used increasingly in future inspection applications
7. There will also be applications for the computer in quality assurance as well as QC. The CAD/CAM data base will be used to derive these various quality applications,
8. There will be CAI and CAT take its place, manual inspection activity will be reduced. Quality control personnel will have to become more computer-wise and technologically sophisticated to operate the more complex inspection and testing equipment and to manage the information that will result from these more automated methods.

CONTACT INSPECTION METHODS

The contact methods usually involve the use of coordinate measuring machines (CMM). Most of these machines today are either controlled by NC or computers. The coordinate measuring machine (CMM) is the most prominent example of the equipment used for contact inspection of workparts. It consists of a table which holds the part in a fixed, registered position and a movable head which holds a sensing probe. The probe can be moved in three directions, corresponding to the x, y, and z coordinates. During operation, the probe is brought into contact with the part surface to be measured and the three coordinate positions are indicated to a high level of accuracy.

Today's coordinate measuring machines are computer controlled. The operation of the machine is similar to an NC machine tool in which the movement of the measuring probe is either tape controlled or computer controlled. Programs and coordinate data can be

downloaded from a central computer, much in the manner of direct numerical control. Also similar to DNC is the capability to transmit data from the CMM back up to the host computer.



Coordinate measuring machine.

Savings in inspection time by using coordinate measuring machines are significant. Typically, between 5 and 10% of the time is required on a CMM compared to traditional manual inspection methods. Other advantages include consistency in the inspection process from one part to the next which cannot be matched by manual inspection, and reductions in production delays to get approval of the first workpiece in a batch.

The coordinate measuring machine is physically located away from the production machine, usually in a separate area of the shop. Accordingly, the parts must be transported from the production area to the CMM. In fact, if inspection is required at several different stages of production, several moves will be involved. One possible approach to overcome this problem is to use inspection probes mounted in the spindle of the machine tool. These inspection probes are contact sensing devices that operate with the machine tool much like the coordinate measuring machine.

NONCONTACT INSPECTION METHODS

The noncontact methods are divided into two categories for our purposes:

1. Optical
 - a. Machine vision
 - b. Scanning laser beam devices
 - c. Photogrammetry
2. Non Optical
 - a. Electric Fiel techniques
 - b. Radiation techniques
 - c. Ultrasonic

NONCONTACT INSPECTION METHODS- OPTICAL

The advantages of noncontact inspection are:

1. It usually eliminates the need to reposition the work part.
2. Noncontact inspection is usually much faster than contact inspection.
3. It eliminates mechanical wear encountered with the contacting inspection probe because it eliminates the probe.
4. It reduces potential danger to people, who must touch a hazardous material if contact inspection is used.
5. It removes the possibility of damage to the surface of a part which might result during contact inspection.

Machine vision

Other names given to these systems include microprocessor-based television and computer vision. The typical machine vision system consists of a TV camera, a digital computer, and an interface between them that functions as a preprocessor. The combination of system hardware and software digitizes the picture and analyzes the image by comparing it with data stored in memory. The data are often in the form of a limited number of models of the objects which are to be inspected. There are several limitations of machine vision;

- The first limitation is concerned with the problem of dividing the picture into picture elements. This is very similar to the problem encountered in the development of graphics terminals for computer-aided design.

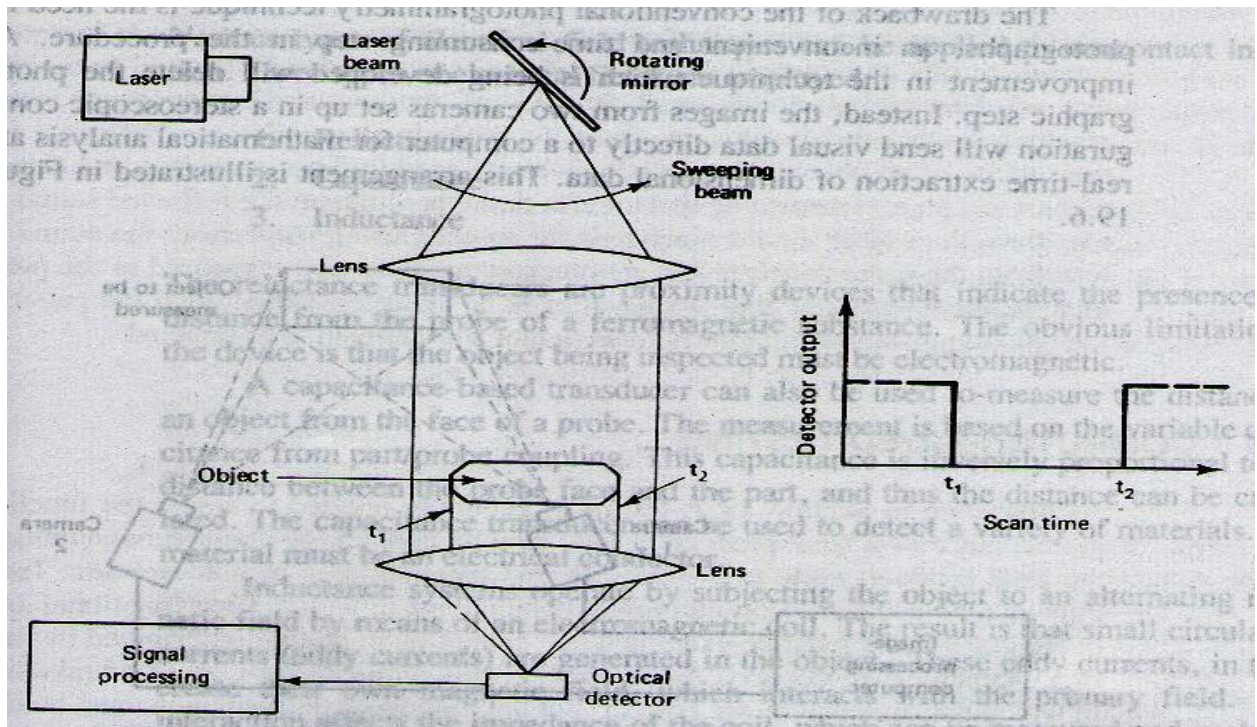
- A second limitation is that the object in front of the camera must be capable of being divided into areas of contrasting lightness and darkness.
- Third limitations is on the capability of machine vision systems recognize the object in the viewing area.

Machine vision inspection problems can be divided into two categories:

1. Noncontact gaging of dimensions - Noncontact gaging in machine vision involves the inspection of part size and other features where it is not necessary to process the image of the entire part out line, only those portions that must be examined for dimensional accuracy. During setup for an inspection, a parts-training program is used to view the workpart of interest on a TV monitor. With the image in fixed position on the screen, the operator manipulates a cursor to define the edges of interest and to apply an appropriate scale factor to establish the correct units of measure.
2. Inspection based on pattern recognition of object features - It is based on pattern recognition techniques. In this category, the attributes of the object to be inspected are typically more subjective and in some respects more complicated than part dimensions. The machine vision pattern recognition process can be conceptualized as involving a comparison of features (for example, area, perimeter, and so on) between the object being inspected and the model of the object stored in computer memory.

Scanning laser beam devices

The scanning laser beam device relies on the measurement of time rather than light, although a light sensor is required in its operation. The schematic diagram of its operation is pictured in Figure. A laser is used to project a continuous thin beam of light. A rotating mirror deflects the beam so that it sweeps across the object to be measured. The light sensor is located at the focal point of the lens system to detect the interruption of the light beam as it is blocked by the object. The time lapse corresponding to the interruption of the light beam is measured to determine the desired dimension of the part. Typically, a microprocessor is programmed to make the conversion of the time lapse into a dimensional value and to perform other functions, such as signaling an automatic parts-rejection mechanism to eject a defective part from the line.

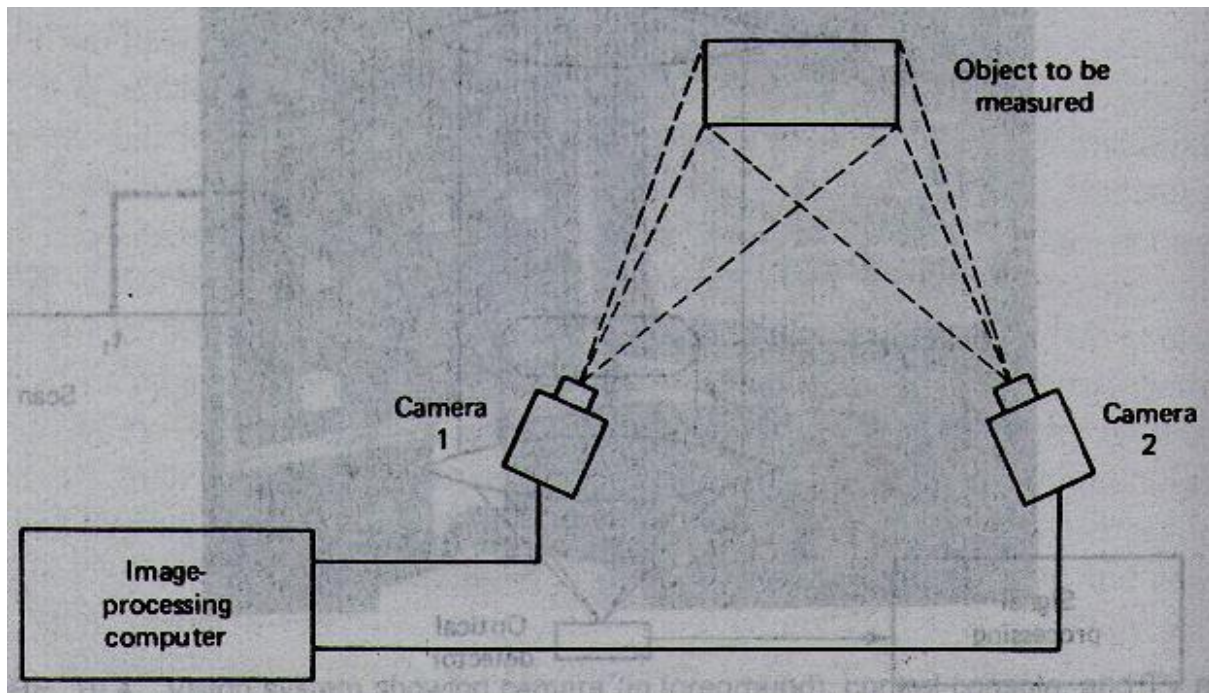


Photogrammetry

Photogrammetry involves the extraction of three-dimensional data from a pair of photographs taken at different angles. The two photographs can be combined much in the way that a stereoscope uses a pair of photographs to form a three-dimensional image for the viewer.

In the measurement process used for inspection, the two photographs are read by a device called a mono comparator to establish coordinates and positions of objects. These data are then computer-analyzed to extricate the desired information.

The drawback of the conventional photogrammetry technique is the need for photographs, an inconvenient and time-consuming step in the procedure. An improvement in the technique which is being developed will delete the photo graphic step. Instead, the images from two cameras set up in a stereoscopic configuration will send visual data directly to a computer for mathematical analysis and real-time extraction of dimensional data. This arrangement is illustrated in Figure.



NONCONTACT INSPECTION METHODS

NONOPTICAL

In addition to noncontact inspection methods based on optical systems, nonoptical approaches can also be used. We will describe three general types which are quite representative of the current technology in this area. The three general types are:

1. Electrical field techniques
2. Radiation techniques
3. Ultrasonics

Electrical field techniques

Various types of electrical field techniques can be applied to noncontact inspection. Three types of electrical fields are employed:

1. Reluctance - The reluctance transducers are proximity devices that indicate the presence and distance from the probe of a ferromagnetic substance. The obvious limitation of the device is that the object being inspected must be electromagnetic.
2. Capacitance - A capacitance-based transducer can also be used to measure the distance of an object from the face of a probe. The measurement is based on the variable capacitance from part/probe coupling. This capacitance is inversely proportional to the distance between the probe face and the part, and thus the

distance can be calculated. The capacitance transducer can be used to detect a variety of materials. The material must be an electrical conductor

3. Inductance - Inductance systems operate by subjecting the object to an alternating magnetic field by means of an electromagnetic coil. The result is that small circulating currents (eddy currents) are generated in the object. These eddy currents, in turn, create their own magnetic field, which interacts with the primary field. This interaction affects the impedance of the coil, which can be measured and analyzed to determine certain characteristics about the object

Radiation Techniques

X-ray radiation techniques are employed for purposes of noncontact inspection in the metals and metalworking industry. The amount of radiation absorbed by a material can be used to measure its thickness and other quality characteristics. In a typical application in a rolling mill, an X-ray scanning unit measures the thickness of the plates or strips going through the rolls so that the proper adjustments can be made in the rollers. X-ray techniques are also used to inspect weld quality in fabricated steel and aluminum pressure vessels and pipes. In this case the radiation can be used to detect flaws and voids in the weld.

Ultrasonics

Ultrasonics in inspection work involves the use of very high frequency (above 20,000 Hz) sound waves to indicate quality. A principal application is in nondestructive testing of materials. Ultrasonic techniques can also be applied to the problem of determining dimensional features of workparts. One approach, called acoustical phase monitoring, involves the analysis of sound waves reflected from the surface of an object. The sound waves are produced by an emitter and directed against the object. Assuming that all else remains constant, the reflected sound pattern from the object should always be the same. During inspection, the sound pattern from the part is analyzed by a computer program and compared to the pattern of a standard part, one that is known to be of acceptable quality. If the pattern of the test part differs significantly from that of the standard, it is rejected.

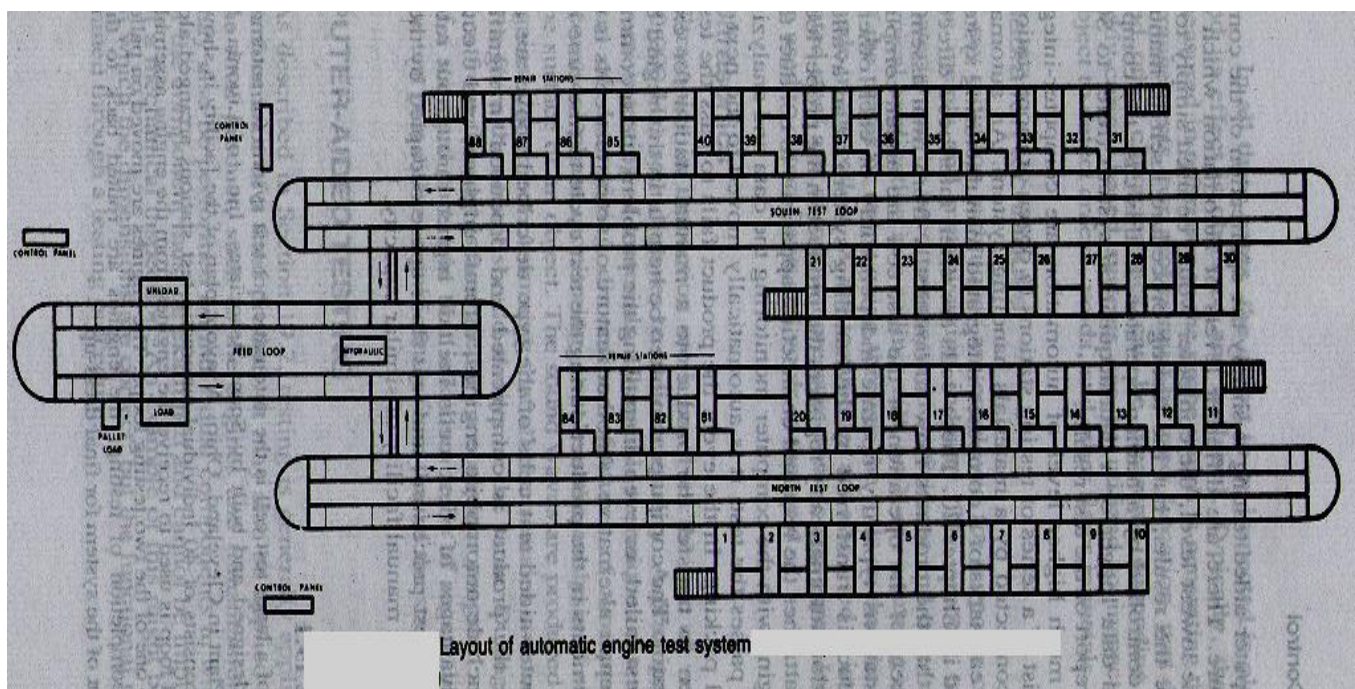
COMPUTER-AIDED TESTING

Testing is generally applied to assess the functional performance of a final product. It may also be applied for major subassemblies of the final product, such as the engines and transmissions of automobiles. Testing may also be performed on individual components in

which some functional aspect of the component must be examined and cannot be implicitly determined by means of a mechanical inspection. An example of this might be the case of a brake lining in which the dimensions are correct, but the functional performance must be determined through a testing procedure.

Computer-aided testing is simply the application of the computer in the testing procedure. There are different levels of automation which can be found CAT. At the lowest level, the computer would be used simply to monitor the test and analyze the results, but the testing procedure itself is manually set up, initiated, and controlled by a human operator. In this case the computer receives the data from a data logger or a data acquisition system and prepares a report of the test results

Computer-aided test cells are applied in situations where the product is complicated and produced in significant quantities, Examples include automobile engines, aircraft engines, and electronic integrated circuits. Advantages of these cells include higher throughput rates, greater consistency in the test procedure, and less floor space occupied by the automated cell As compared to a manual facility of similar capacity.



INTEGRATION OF CAQC WITH CAD/CAM

Although many important benefits result from the use of computer-aided quality control, additional benefits can be obtained by integrating CAQC with CAD/CAM.

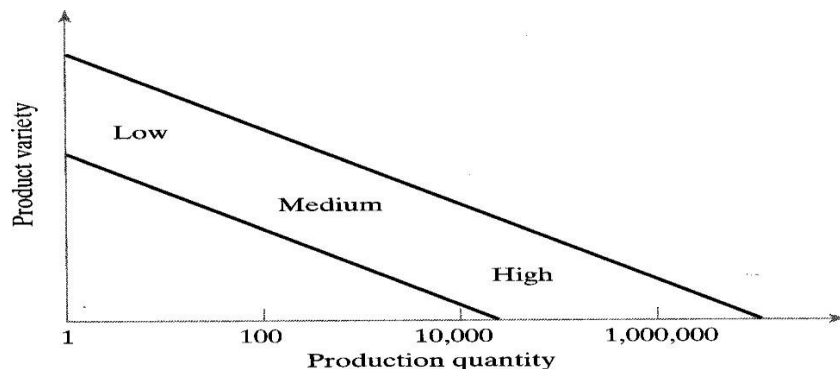
- The design department creates the product definition and the manufacturing department makes use of and supplements this definition to develop the

manufacturing plan. It is important to add the QC connection to the CAD/CAM framework.

- The quality control department must use the same CAD/CAM data base to perform its function. These quality standards are all contained in the CAD/CAM data base, available for QC to use.
- One way in which the data base can be used is to develop the NC programs to operate the tape-controlled or computer-controlled coordinate measuring machines. These programs can be generated automatically.
- These programs would then be down loaded to the CMM through a DNC link from the central computer to the controller unit for the CMM. The same sort of downloading process is possible for some of the noncontact inspection methods.
- Another way in which a common data base is helpful to QC is when engineering changes are made to the product. It is helpful for any changes to be recorded in a common data file for all departments, including QC, to use.
- Another area where CAD/CAM benefits the QC function is in computer production monitoring. The types of production records that are generated during computer monitoring are sometimes useful to the quality control department in tracing the cause of poor quality in a particular production lot.

FLEXIBLE MANUFACTURING SYSTEM (FMS)

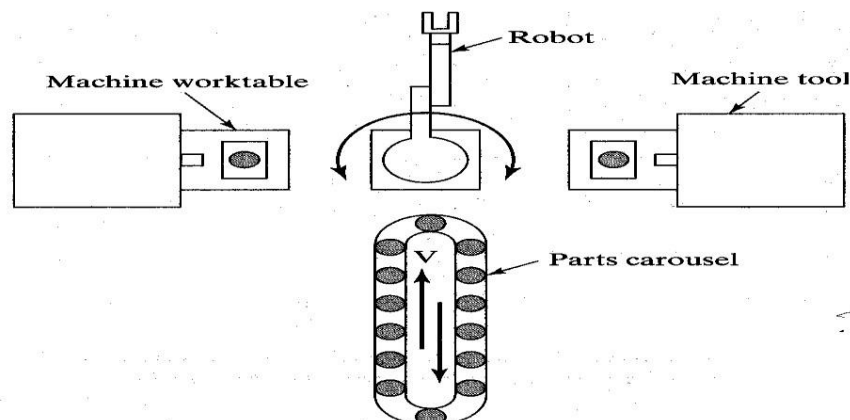
- A *flexible manufacturing system (FMS)* is a highly automated GT machine cell, consisting of a group or processing workstations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by a distributed computer system.
- The reason the FMS is called *flexible* is that it is capable of processing a variety of different part styles simultaneously at the various workstations, and the mix of part styles and quantities of production can be adjusted in response to changing demand patterns.
- The FMS is most suited for the mid-variety, mid-volume production range



What Make It Flexible?

Three capabilities that a manufacturing system must possess to be a flexible.

1. The ability to identify and distinguish among the different part styles processed by the system.
1. Quick changeover of operating instructions, and
2. Quick changeover of physical setup.



Tests of Flexibility

To qualify as being flexible, a manufacturing system should satisfy several criteria. The following are four reasonable tests of flexibility in an automated manufacturing system:

- *Part variety test.* Can the system process different part styles in a nonbatch mode?
- *Schedule change test.* Can the system readily accept changes in production schedule, and changes in either part mix or production quantity.
- *Error recovery test.* Can the system recover quickly from equipment breakdowns, so that the production is not completely disrupted?
- *New part test.* Can new part designs be introduced into the existing product mix with relative ease.

If the answer to all of these questions is “YES” for a given manufacturing system, then the system can be considered flexible.

Types of Flexibility in Manufacturing

<i>Flexibility Type</i>	<i>Definition</i>	<i>Depends on Factors Such As:</i>
Machine flexibility	Capability to adapt a given machine (workstation) in the system to a wide range of production operations and part styles. The greater the range of operations and part styles, the greater the machine flexibility.	Setup or changeover time. Ease of machine reprogramming (ease with which part programs can be downloaded to machines). Tool storage capacity of machines. Skill and versatility of workers in the system.
Production flexibility	The range or universe of part styles that can be produced on the system.	Machine flexibility of individual stations. Range of machine flexibilities of all stations in the system.
Mix flexibility	Ability to change the product mix while maintaining the same total production quantity; that is, producing the same parts only in different proportions.	Similarity of parts in the mix. Relative work content times of parts produced. Machine flexibility.
Product flexibility	Ease with which design changes can be accommodated. Ease with which new products can be introduced.	How closely the new part design matches the existing part family. Off-line part program preparation. Machine flexibility.
Routing flexibility	Capacity to produce parts through alternative workstation sequences in response to equipment breakdowns, tool failures, and other interruptions at individual stations.	Similarity of parts in the mix. Similarity of workstations. Duplication of workstations. Cross-training of manual workers. Common tooling.
Volume flexibility	Ability to economically produce parts in high and low total quantities of production, given the fixed investment in the system.	Level of manual labor performing production. Amount invested in capital equipment.
Expansion flexibility	Ease with which the system can be expanded to increase total production quantities.	Expense of adding workstations. Ease with which layout can be expanded. Type of part handling system used. Ease with which properly trained workers can be added.

Comparison of Four Criteria of Flexibility in a Manufacturing System and the Seven Types of Flexibility

<i>Flexibility Tests or Criteria</i>	<i>Type of Flexibility (Table 16.1)</i>
1. Part variety test. Can the system process different part styles in a non-batch mode?	Machine flexibility Production flexibility
2. Schedule change test. Can the system readily accept changes in production schedule, changes in either part mix or production quantities?	Mix flexibility Volume flexibility Expansion flexibility
3. Error recovery test. Can the system recover gracefully from equipment malfunctions and breakdowns, so that production is not completely disrupted?	Routing flexibility
4. New part test. Can new part designs be introduced into the existing product mix with relative ease?	Product flexibility

COMPONENTS OF FMS

There are several basic components of an FMS:

1. Workstations.
2. Material handling and storage systems.
3. Computer control system.

WORKSTATIONS

• Following are the types of workstations typically found in an FMS:

1. Load/Unload Stations.
2. Machining Stations.
3. Other processing Stations. (punching, shearing, welding, etc.)
4. Assembly Station.
5. Other Stations and Equipment. (Inspection, Vision, etc)

Material Handling and Storage System

Functions of the Handling System

1. Independent movement of work parts between stations.
2. Handle a variety of work part configurations.
3. Temporary storage.
4. Convenient access for loading and unloading work parts.

5. Compatible with computer control.

Material Handling Equipment

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

1. Primary handling system establishes the basic layout of the FMS and is responsible for moving work parts between stations in the system. (Conveyor)
2. Secondary handling system consists of transfer devices, automatic pallet changing, and similar mechanisms located at the workstations in the FMS.

The function of the secondary handling system is to transfer work from the primary system to the machine tool or other processing station and to position the parts with sufficient accuracy and repeatability to perform the process or assembly operation.

Computer Control System

The FMS includes a distributed computer system that is interfaced to

- ❖ Workstations,
- ❖ Material handling system, and
- ❖ Other hardware components.

A typical FMS computer system consists of a central computer and microcomputers.

- ❖ Microcomputers controlling the individual machines and other components.
- ❖ The central computer coordinates the activities of the components to achieve smooth overall operation of the system

Production control—management of the mix and rate at which various parts are launched into the system is important; alongside data input of a number of essential metrics, such as: daily desired production rates, number of raw work parts available, work-in-progress etc.

Traffic control—management of the primary handling system is essential so that parts arrive at the right location at the right time and in the right condition

Shuttle control—management of the secondary handling system is also important, to ensure the correct delivery of the work part to the station's work head

Work piece monitoring—the computer must monitor the status of each cart or pallet in the primary and secondary handling systems, to ensure that we know the location of every element in the system

Tool control—this is concerned with managing tool location (keeping track of the different tools used

at different workstations, which can be a determinant on where a part can be processed), and tool life (keeping track on how much usage the tool has gone through, so as to determine when it should be replaced)

Performance monitoring and reporting—the computer must have collected data on the various operations on-going in the FMS and present performance findings based on this

Diagnostics—the computer must be able to diagnose, to a high degree of accuracy, where a problem may be occurring in the FMS

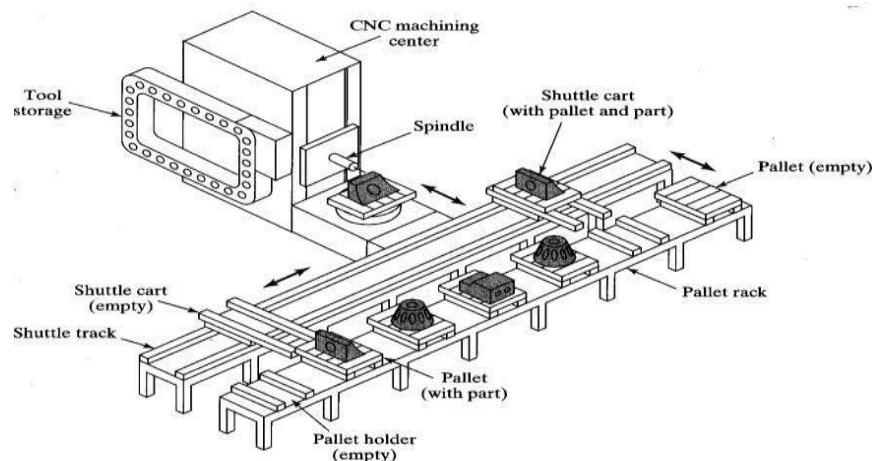
TYPES OF FMS SYSTEMS

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

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

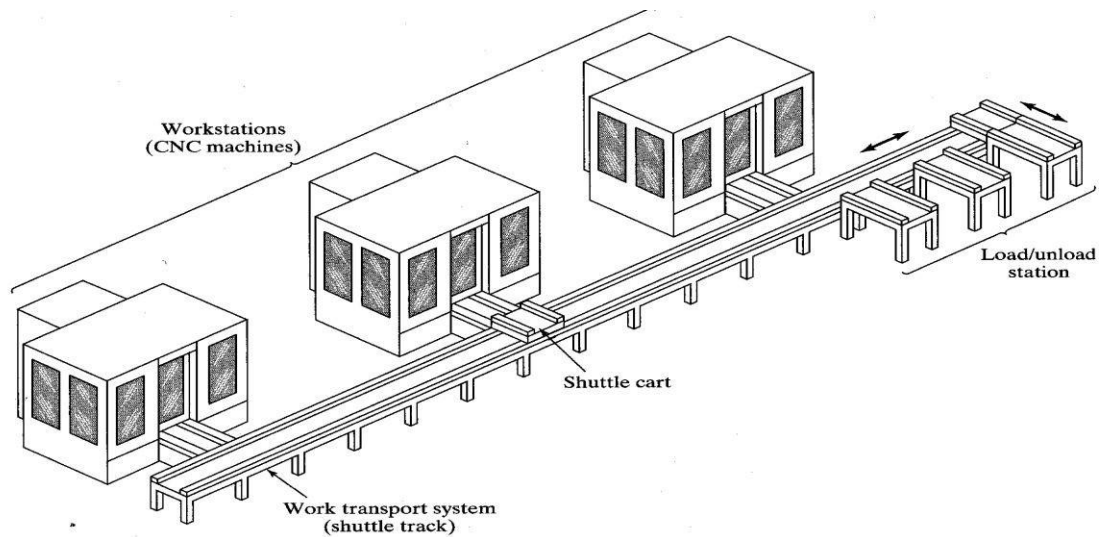
Single Machine Cell (SMC)

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



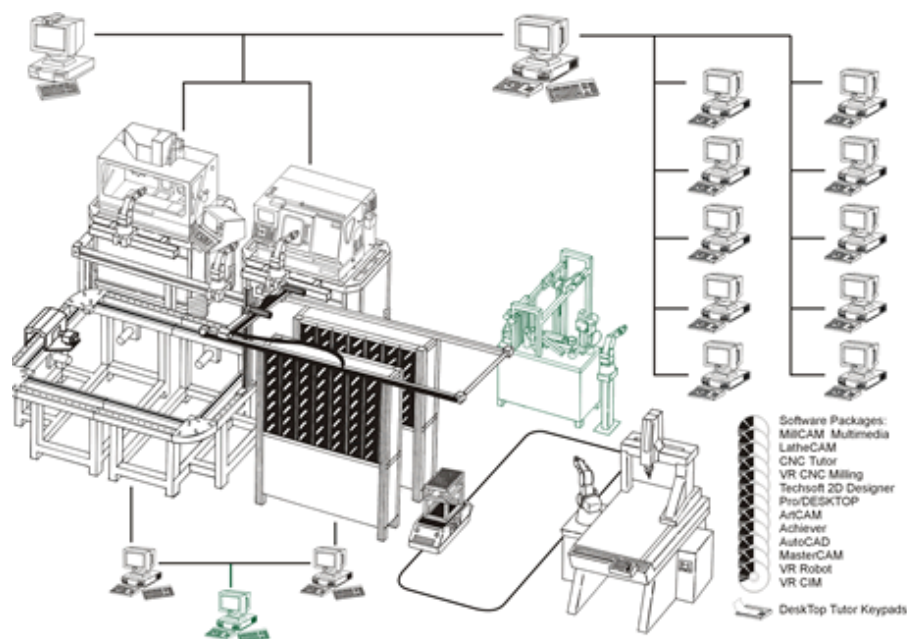
Flexible Manufacturing Cell (FMC)

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



Flexible Manufacturing System (FMS)

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

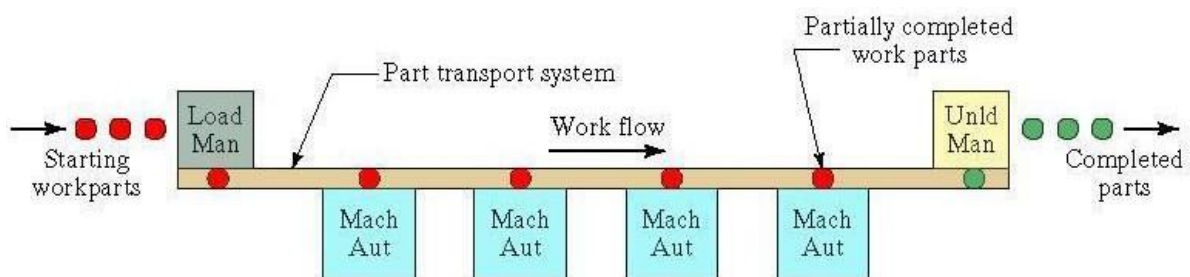


FMS LAYOUTS

The material handling system establishes the FMS layout. Most layout configurations found in today's FMS are:

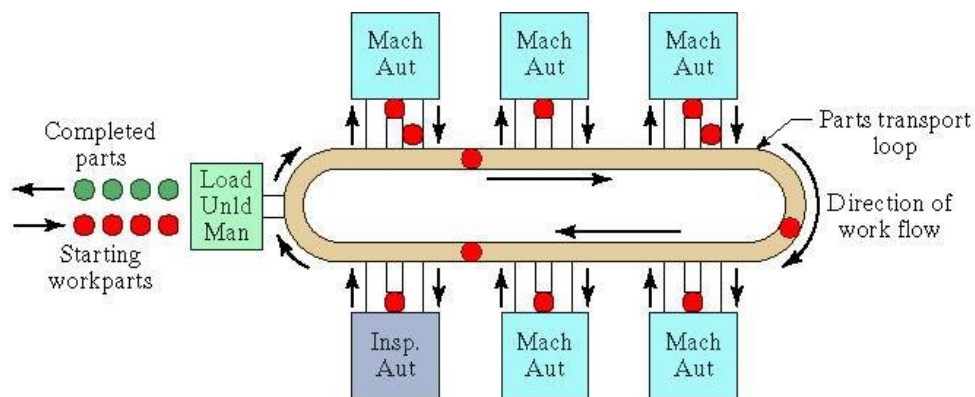
In-line Layout:

All the machine tools are kept along a straight line as shown in Figure. This is the simplest form and is generally used for smaller number of machines in a system. The parts move in well-defined sequences and the workflow is generally in both the directions. The Part handling at the individual workstations is performed by the transport vehicle, which will have the necessary pallet changer. Often The machine tools used in such a system are identical, so that the part routing will not be a problem.



Loop Layout:

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

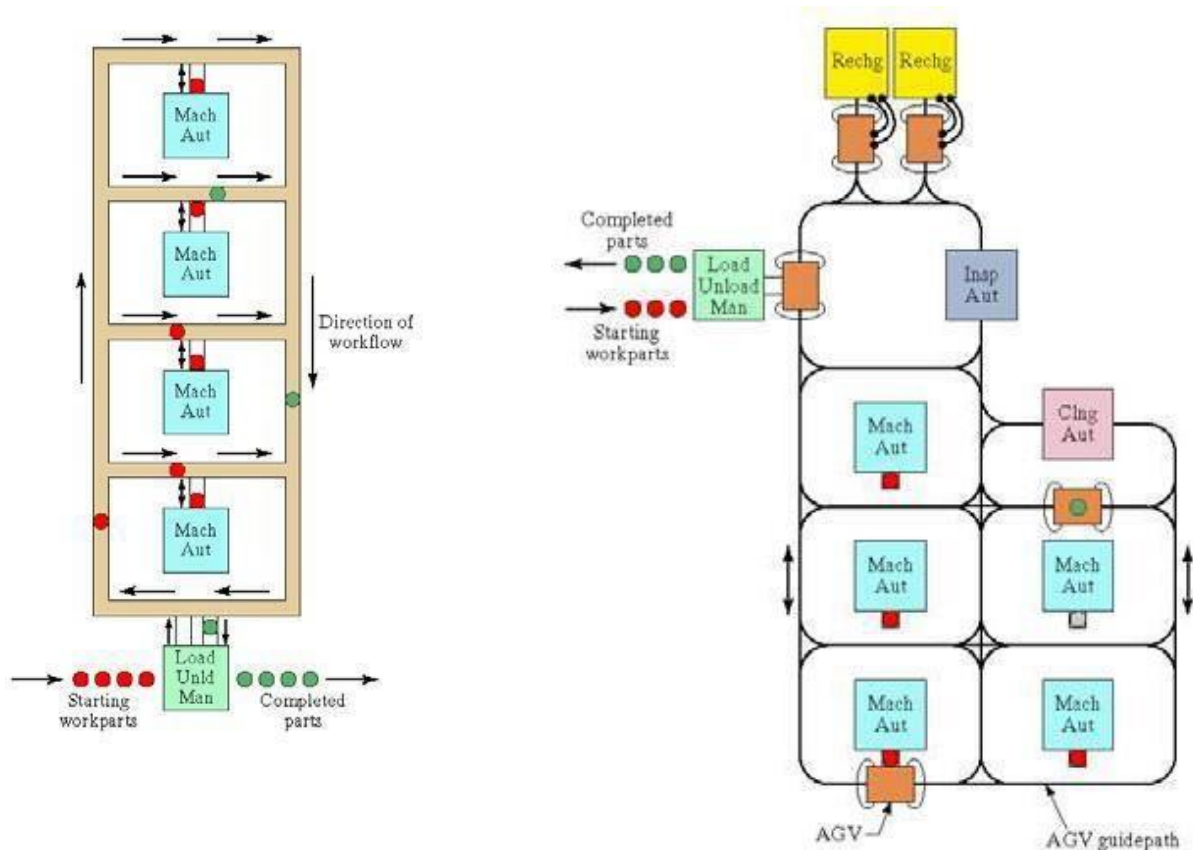


Ladder Layout:

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 obviates 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.

Open Field Layout:

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.



HUMAN RESOURCES

Human are needed to manage the operations of the FMS. Functions typically performed by human includes:

- ❖ Loading raw work parts into the system
- ❖ Unloading finished parts (or assemblies) from the system,
- ❖ Changing and setting tools,
- ❖ Equipment maintenance and repair,
- ❖ NC part programming in a machining system, and
- ❖ Programming and operation the computer system.

ADVANTAGES OF FMS

1. Flexible manufacturing systems are regarded as one of the most efficient methods to employ in reducing or eliminating problems in manufacturing industries.
2. FMS brings flexibility and responsiveness to the manufacturing floor.
3. FMS enables manufacturing to machine a wide variety of work places on few machines with low staffing levels, productively reliably and predictably.
4. FMS shortens the manufacturing process through improved operational control round the clock availability of automated equipment, increases machines utilization and responsiveness, and reduction of human intervention.
5. Better competitive advantage.
6. Lower work in process inventories.
7. Reduced through put time and its variability.
8. Improved manufacturing control.
9. Improved quality and reduced scrap rate.
10. Reduction of floor space used.
11. Better status monitor of machines tools and material handling devices.

DISADVANTAGES OF FMS

1. FMS is a complex system.
2. Requires highly skilled technicians.
3. Needs high level of planning.
4. Demands high initial investment.

UNIT I – INTRODUCTION TO CAD/CAM AND COMPUTER GRAPHICS

1. What is CAD?

Computer-Aided Design (CAD) is the technology concerned with the use of computer systems to assist in the creation, modification, analysis, and optimization of a design.

2. Define Product cycle.

Product cycle is the process of managing the entire lifecycle of a product from starting, through design and manufacture, to repair and removal of manufactured products.

3. List out fundamentals of product life cycle management.

- Customer Relationship Management (CRM)
- Supply Chain Management (SCM)
- Enterprise resource planning (ERP)
- Product Planning and Development (PPD).

4. Mention any four applications of CAD in Mechanical Engineering.

A CAD system helps designer in various ways

- i) Invites and promotes interaction through various input/output devices.
- ii) Allows manipulation of image (such as scaling, translation, rotation) in the computer screen.
- iii) Enable the designer to carry out the engineering analyses for stress, vibration, noise thermal distortions and more using FEA.
- iv) Design optimization through simulation and animation.
- v) Automated drafting.

5. Name any 4 reasons for implementing CAD in design?

- i) CAD can make each design step much easier and less tedious for designer to perform.
- ii) Errors during change of design will be less.
- iv) Models generated can be easily manipulated and modification in the model can be done very easily carried out in the system itself.

6. What is conceptualization in design process?

A Concept Study is the stage of project planning that includes developing ideas and taking into account the all features of executing those ideas. This stage of a project is done to reduce the likelihood of assess risks, error and evaluate the potential success of the planned project.

7. What is meant by concurrent engineering?

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.

8. What are the advantages of Concurrent engineering?

- The design decisions are taken by a team of multi-disciplinary experts.
- Changes and modification on the product design will be faster.
- Higher quality.

9. What are the benefits of CAD?

- i) New products are designed faster. CAD can drastically reduce the number of steps involved in the design process for a particular product and can also make each design step much easier and less tedious for designer to perform.
- ii) Hard copy of the drawing is of better quality. Hence there will be less ambiguity.
- iii) Errors during change of design will be less.

10. Define Computer graphics.

Computer graphics are pictures and movies created using computers - usually referring to image data created by a computer specifically with help from specialized graphic hardware and software.

11. What are the various display control facilities in graphics?

- Vector Generation
- Windowing and viewing transformation.
- Clipping transformation
- Zooming
- Panning
- Transmitting information on a network and

- Graphics libraries.

12. What are the Co-ordinate systems?

World space or Model

13. What are the main types of 2D transformations?

a) Translation b) Scaling c) Reflection d) Rotation e) Shearing

14. What is Scaling?

In scaling transformation, the original coordinates of an object are multiplied by the given scale factor. There are two types of scaling transformations: uniform and nonuniform. In the uniform scaling, the coordinate values change uniformly along the x, y, and z coordinates, whereas, in non-uniform scaling, the change is not necessarily the same in all the coordinate directions.

15. What is Translation?

In translation, every point on an object translates exactly the same distance. The effect of a translation transformation is that the original coordinate values increase or

decrease by the amount of the translation along the x, y, and z-axes.

16. What is meant by Clipping?

Clipping is the process of determining the visible portion of a drawing lying within a window and discarding the rest.

17. What is viewing transformation and windowing transformation?

The process of mapping from the model co-ordinate system to the screen co-ordinate system is known as viewing transformation. The viewing transformation with no rotation is called the windowing transformation.

18. What do you mean by homogeneous coordinates?

Homogeneous coordinates form a basis for the projective geometry used extensively to project a three-dimensional scene onto a two-dimensional image plane. They also unify the treatment of common graphical transformations and operations. The main purpose of homogeneous coordinates is to capture the concept of infinity. Without the use of homogeneous coordinates system, it would be difficult to design certain classes of very useful curves and surfaces in computer graphics and computer-aided design.

UNIT II – GEOMETRIC MODELING

1. Define Geometric modeling.

The geometric modeling concerned with computer compatible mathematical description of geometry of an object. The mathematical description should be such that the image of the object can be displayed and manipulated in computer terminal, modification on the geometry can be done easily and the image can be stored in computer memory retrieve back to display in computer screen for review, analysis or alternation.

2. What is a Spline?

A spline is a parametric curve defined by control points. The term spline dates from engineering drawing, where a spline was a piece of flexible wood used to draw smooth curves. The control points are adjusted by the user to control the shape of the curve.

3. Give any two characteristics of Bezier curves.

- The curve is tangent to the first and last segments of the characteristic's polygon.
- The curve is symmetric with respect to u and $(1-u)$. Therefore, the sequence of control points defining the curve can be reversed without change of curve shape.

4. What are the characteristics of B-spline curves?

- The B-spline curves do not pass through the first and last control points except when a linear blending functions are used
- A non-periodic B-spline curve pass through the first and last control points and is tangent to first and last segments of control polygon.
- A second degree curve ($k=3$) is always tangents to the midpoints of all the internal polygon segments

5. Define rational curve.

Rational curve is defined by the algebraic ratio of two polynomials while a non-rational curve is defined by one polynomial.

6. Name the two basic approaches followed in solid modeling.

- Constructive solid geometry (CSG) or (C-rep)
- Boundary representation (B - rep)

7. List the basic entities available in CSG approach of solid modeling.

(a) Cuboid (b) Cylinder (c) Sphere (d) Cone (e) Wedge (f) Torus

8. What is Bezier curve?

Bezier curve is used for curve and surface design of automobile panels. It is blended at the joints and is completely defined by four consecutive points (x_0, y_0) , (x_1, y_1) , (x_2, y_2) , (x_3, y_3) . The curve passes only through the first and fourth point. The two intermediate points are used to define the slope of the curve at the end points.

9. What is B-spline curve?

B-spline is a single piecewise parametric polynomial curve through any number of control points with the degree of polynomial selected by the designer. B-splines exhibit a local control where in whenever a single vertex is moved, only those vertices around that will be affected while the rest remains the same.

10. What is Hermite Spline?

A Hermite spline is a curve for which the user provides the endpoints of the curve. The parametric derivatives of the curve at the endpoints are dx/dt , dy/dt , dz/dt . That is enough to define a cubic Hermite spline, more derivatives are required for higher order curves.

11. What are the different types of surfaces?

- Plane surface
- Ruled (lofted) surface
- Surface of revolution
- Tabulated surface
- Bi-linear surface.
- Coons patch
- Bezeir surface
- B-spline surface

12. What is Coons patch? Also write down its applications.

Coons patch or surface is generated by the interpolation of 4 edge curves. It is easy to create, and therefore, many 2-D CAD packages utilize it for generating models. However, it has only a limited application since the surface is inflexible and cannot create very smooth surfaces. It would be very difficult to

produce a smooth automobile fender using the Coons surface. Several CAD software, including AutoCAD, use this surface for generating surfaces between 4-bounded edges.

13. What is Bezier surface?

This is a synthetic surface similar to the Bezier curve and is obtained by transformation of a Bezier curve. It permits twists and kinks in the surface. The surface does not pass through all the data points.

14. What is B-spline surface?

This is a synthetic surface and does not pass through all data points. The surface is capable of giving very smooth contours, and can be reshaped with local controls.

15. Differentiate between analytical, interpolated and approximated curves.

Analytical Curves: This type of curve can be represented by a simple mathematical equation, such as, a circle or an ellipse. They have a fixed form and cannot be modified to achieve a shape that violates the mathematical equations.

Interpolated curves: An interpolated curve is drawn by interpolating the given data points and has a fixed form, dictated by the given data points. These curves have some limited flexibility in shape creation, dictated by the data points.

Approximated Curves: These curves provide the most flexibility in drawing curves of very complex shapes. The model of a curved automobile fender can be easily created with the help of approximated curves and surfaces.

UNIT III – Drafting and Modeling systems and Numerical control

1. Write the functions of sideways.

The functions of sideways:

- To control the line of action of the carriage/table on which the tool/work piece is held.
- To absorb static and dynamic forces.

2.

List out the characteristics of sideways used in CNC.

The sideways should have the following characteristics.

- Good rigidity and damping capability.
- Good wear and friction resistance.
- Geometric and kinematic accuracy.
- Ensure higher velocity of slide.
- Protect against damage and sward.
- Provision for adjusting the play
- Position in relation to work area.

3. Define numerical control.

Numerical control is a form of programmable automation in which the mechanical action of machine tool or other processing equipment are controlled by a program containing alphanumeric data numbers, letters and symbols.

4. How tapes are standardized? List some of them.

Tape standardization covers two important categories.

- a. Physical dimensions, and
- b. Character coding.

5. What are the different types of dimensioning system used?

- a. Absolute dimensioning or baseline dimensioning system.
- b. Incremental dimensioning or delta dimensioning system.

6. What is BIT? What is the use of it?

‘Bit’ is an abbreviation of “Binary digit” which can be 1 or 0. Uses in binary coded decimal system.

7. What is block? Write the significance of it?

Block is the basic unit of a part program input to the control. It contains adequate information for the machine to perform a movement and for functions.

8. What Is G code? How G codes are represented?

It is the series of combination of '1's and '0's. It represents a number or an alphabet or any symbol.

9. Write the different types of tape programming format?

The following are the types of tape programming format.

- Word address format,
- Table sequential format,
- Fined block format.

10. Explain the functions of codes G28 and M30.

- G28 = Mirroring
- M30 = End of data.

11. List out some of the important NC languages.

- APT
- ADAPT
- EXAPT
- Compact II
- PROMPT
- CINTURNII

12. What are the four statements used in APT language?

- Geometric statements
- Motion statements
- Post processor statements
- Auxiliary statements.

13. How can you represent an APT geometric statement?

- Symbol = Geometry/Descriptive data
- Example: point, line, circle, plane

UNIT IV – Group Technology

1. What is group technology?

Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to get the advantages of similarities in both design and manufacturing attributes.

2. List out any four benefits of GT?

- Setup time and cost for MHS is reduced
- Standardization of tooling and setups
- Production scheduled are simplified

3. What is meant by part family?

Part family is a collection of parts which are similar either because of geometric shape or because of similar steps that are required in their manufacture.

4. Write the various methods of part family formation

- Visual inspection
- Production flow analysis
- Part classification and coding system

5. What is meant by PFA method?

Production flow analysis is a method for identifying part families and associated machine groupings that uses the information contained on production route sheets rather than on part drawings.

6. What are the steps involved in PFA?

- Preparation of route sheets
- Preparation of PFA charts
- Cluster analysis.

7. What are different types of coding structure used in part coding schemes?

- Hierarchical codes
- Attribute codes
- Hybrid codes

8. List out some of the coding system commonly used in industries?

- Optiz
- MICLASS
- DCLASS
- CODE

9. What is the basis for forming groups in group Technology?

The groups are formed based on the similarities of part design and part manufacturing attributes.

10. Define process planning.

Process planning can be defined as “an act of preparing a described processing documentation for the manufacture of a part or assembly”

11. Write the various approaches in process planning.

- a. Manual process planning
- b. Computer aided process planning

12. What are the components of generative CAPP systems?

- A part description
- A sub system
- Database
- A report generator

13. Why the retrieval CAPP system is called as variant CAPP system?

A retrieval CAPP system has the capacity to alter an existing plan. That's why it is known as variant CAPP system.

14. List any two commercially available retrieval CAPP systems.

- a. Multi CAPP
- b. MIPLAN

15. List any two commercially available generative CAPP systems.

- a. APPAS
- b. CMPP
- c. EXCAP
- d. XPLAN

UNIT V&VI - Computer Aided Quality Control and Computer Integrated Manufacturing Systems

1. Define FMS.

- a. A Flexible Manufacturing System (FMS) is an individual machine or group of machines served
- b. by an automated materials handling system that is computer controlled and has a tool handling
- c. capability.

2. What are the Objectives of FMS?

- a. To provide flexible manufacturing facility for part family components.
- b. To provide the benefits of grouping the operation in single location.
- c. To provide the flexibility in producing small and medium parts.
- d. To maximize the utilization of facilities.
- e. To have a good management control.

3. What are the components of FMS?

Flexible Manufacturing Systems (FMS) consists of the following four components.

- a. Processing stations or workstations
- b. Material handling and storage
- c. Computer control system
- d. human labour

4.

What are the FMS layout configurations?

FMSs can be divided into five categories

- 1) In-line layout
- 2) Loop layout
- 3) Ladder layout
- 4) Open field layout
- 5) Robot-centered cell.

5. What are the functions of computers in FMS?

The functions of computers in FMS

- 1. Workstation control
- 2. Distribution of control instructions to workstations

3. Production control
4. Traffic control
5. Shuttle control
6. Work piece monitoring
7. Tool control
8. Performance monitoring and reporting
9. Diagnosis

6. List the applications of FMSs.

Applications of FMS installations are in the following areas.

- Machining
- Assembly
- Sheet-metal press-working
- Forging
- Plastic injection molding
- Welding
- Textile machinery manufacture
- Semiconductor component manufacture

7. Give the benefits of FMSs.

The benefits that can be expected from an FMS include

- Increased machine utilization
- Fewer machines required
- Reduction in factory floor space required
- Greater responsiveness to change
- Reduced inventory requirements
- Lower manufacturing lead times
- Reduced direct labour requirements and higher labor productivity
- Opportunity for unattended production

8. List any two advantages and disadvantages of FMS implementation.

Advantages

- Faster, lower-cost changes from one part to another which will improve capital utilization.

- lower direct labor cost, due to the reduction in number of workers.

Disadvantages

- Substantial pre-planning activity.
- Expensive, costing millions of dollars.

9. How does FMS classified based on level of flexibility?

FMS classified based on level of flexibility as,

- Production flexibility
- Machine flexibility
- Mix flexibility
- Product flexibility

10. How does FMS classified based on number of machines?

- Single Machine Cell (SMC)
- Flexible Manufacturing Cell (FMC)
- Flexible Manufacturing System (FMS)