UNIT – IV
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 info machine groups, or cells, in order to facilitate workflow and parts handling.

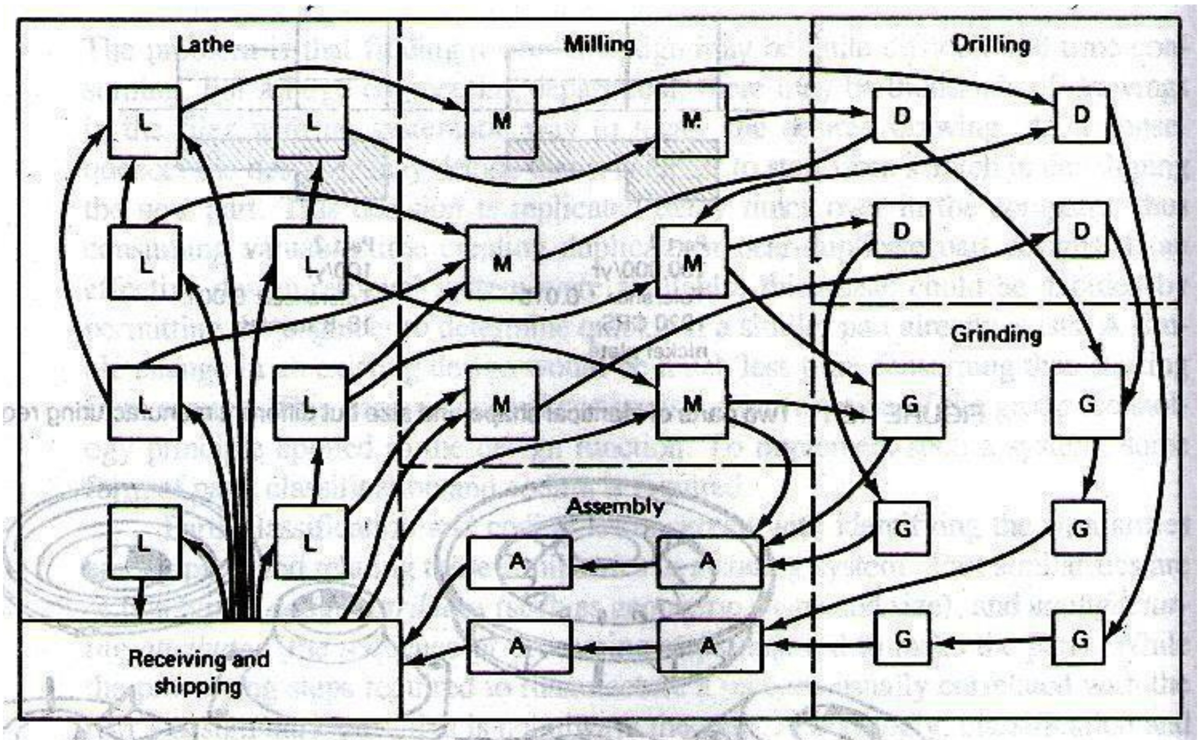
Parts classification and coding is concerned with identifying the similarities among parts and relating these similarities to a coding system. Part similarities are of two types: design attributes (such as geometric shape and size), and manufactuing attributes (the sequence of processing steps required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

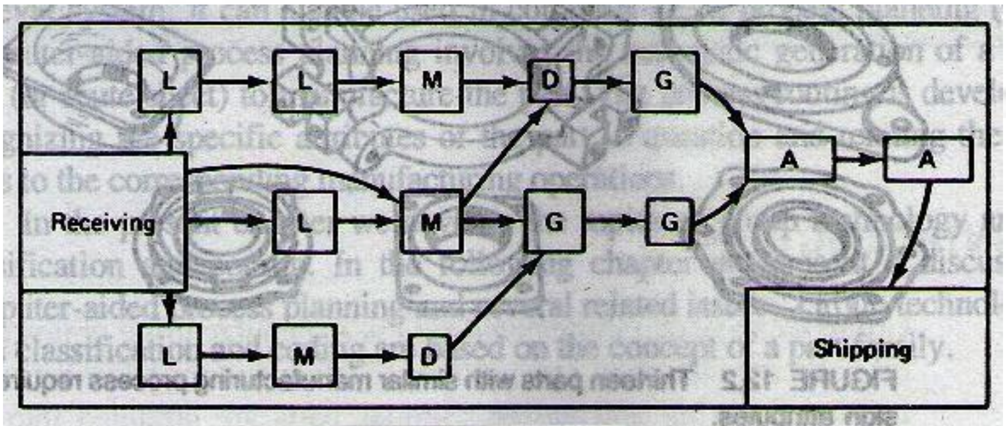
A part family is a collection of parts which are similar either because of geometric shape and size or because similar processing steps are required in their manufacture. The parts within a family are different, but their similarities are close enough to merit their identification as members of the part 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 workpart into families. The machines arranged into cells. Each cell is organized to specialized in themanufacturing of a particular part family. Advantages are gained in tha form of reduced workpiecehandling, lower setup times, less in-process inventory, less floor space, and shorter lead times. Someof the manufacturing cells can be designed to form production flow lines, with conveyors used totransport work parts between machines in the cell.

The biggest single obstacle in changing over to group technology from a traditional production shop isthe 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. <u>Systems based on part design attributes-</u> This category are useful for design retrieval and to promote design standardization.
2. <u>Systems based on part manufacturing attributes</u> –This category are used for computer-aided process planning, tool design, and other production-related functions.
3. <u>Systems based on both design and manufacturing</u> 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 iree 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 com monly 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 processplanning, NC programming, and production scheduling?

Management problems.

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

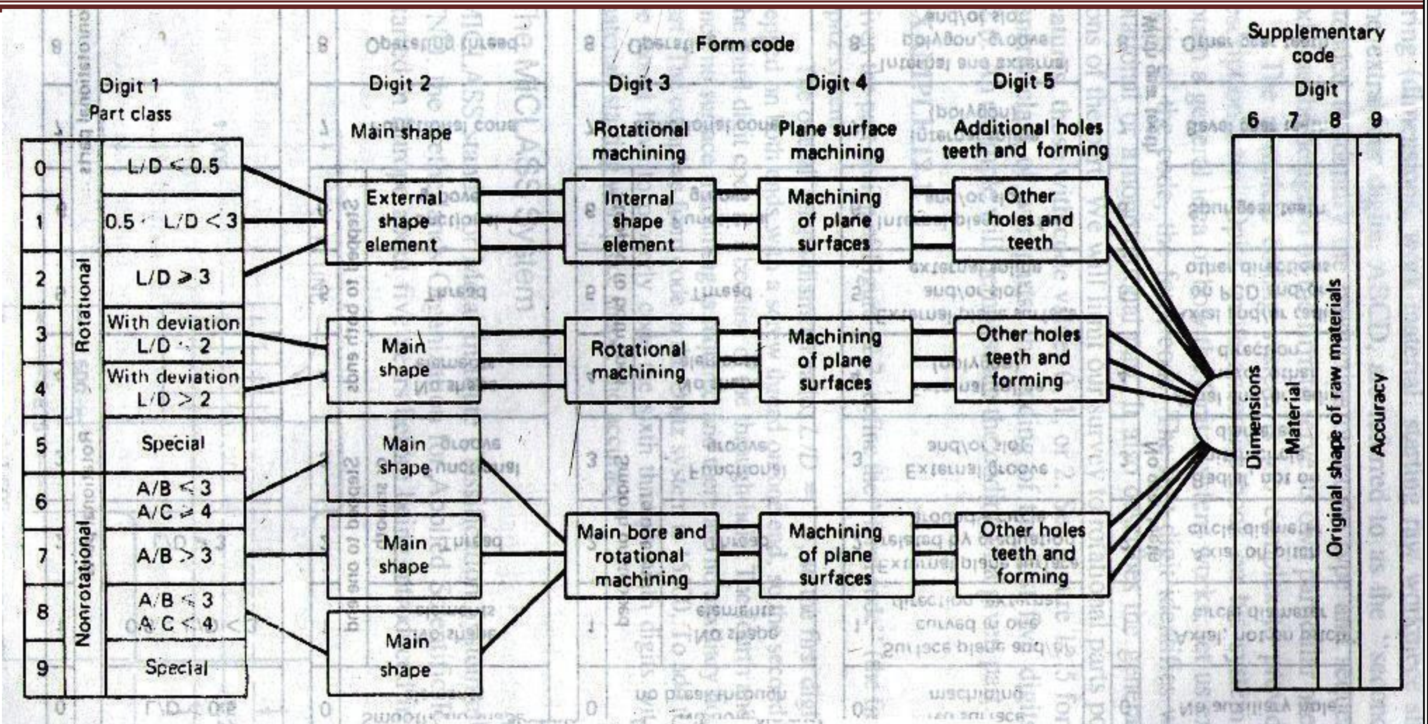
Will cooperation and support for the system be obtained from the various departmentsinvolved?

- Three parts classification and coding systems which are widely recognized among people familiarwith 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:

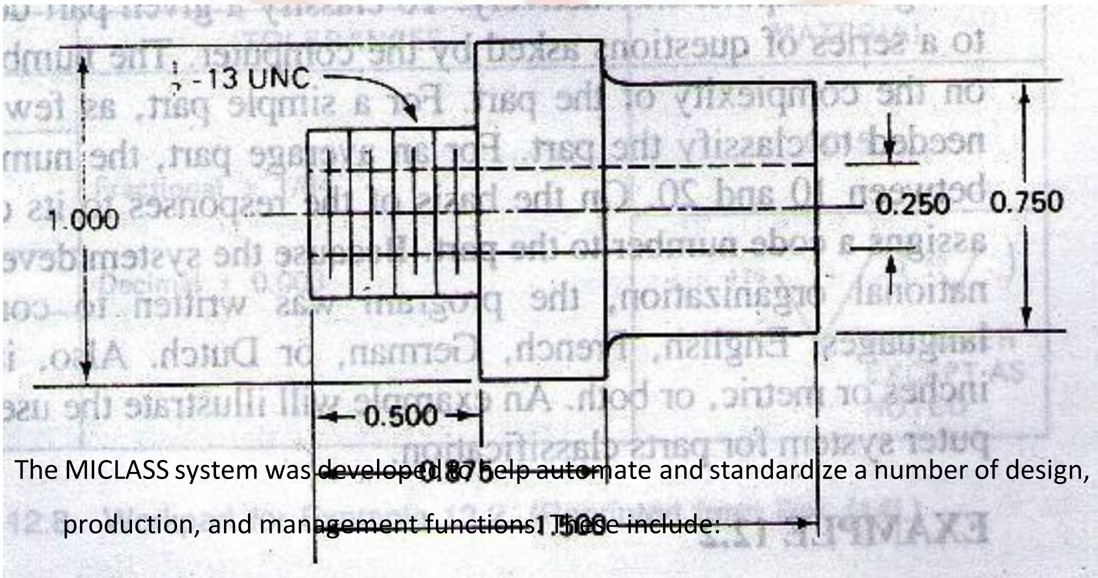
12345 6789 ABCD

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 supple mentary code." It indicates some of the attributes that would be ot use to manuiacturing (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.



Basic structure of the Opitz system.

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 thee exist iHglriethod 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 shouldbe 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	

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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 realizebenefits 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 becauseof 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

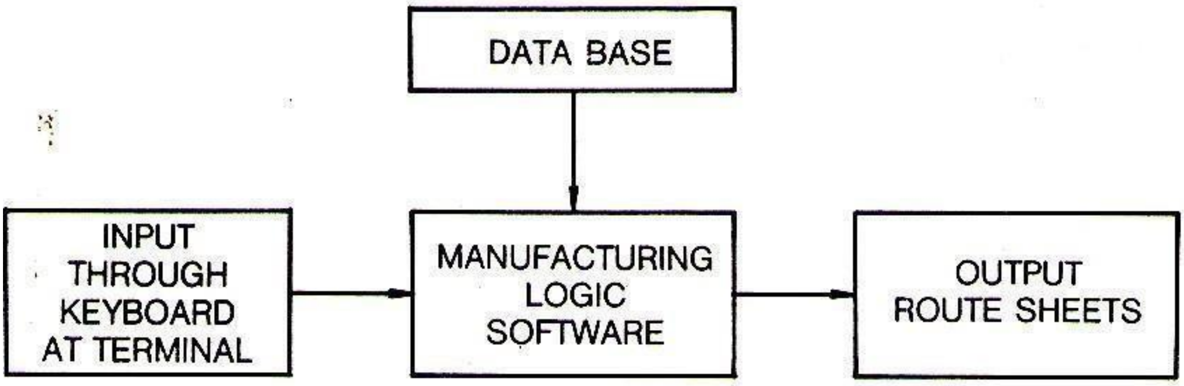
5. **Employee satisfaction** - The machine cell often allows parts to be processed from raw material to finished state by a small group of workers. The workers are able to visualize their contributions to the firm more clearly. This tends to cultivate an improved worker attitude and a higher level of 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 ina 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 softwareto 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.



CAPP 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.

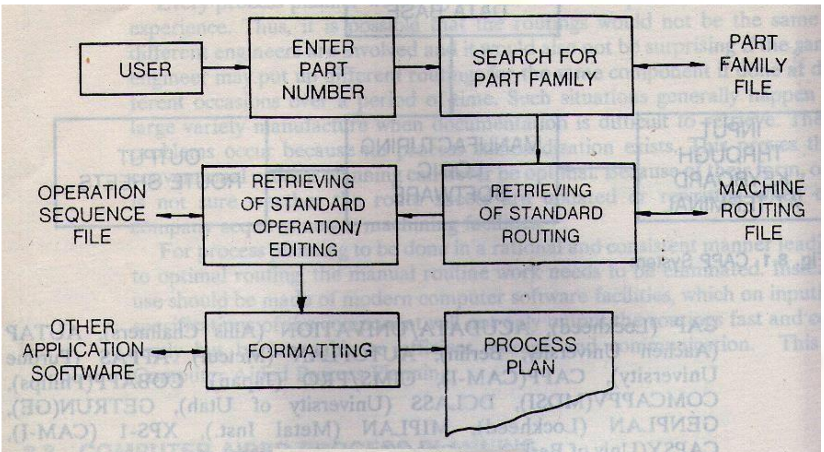
It is difficult to name all the packages available so far for process planning. A few have been listed alone with their sources.

- 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

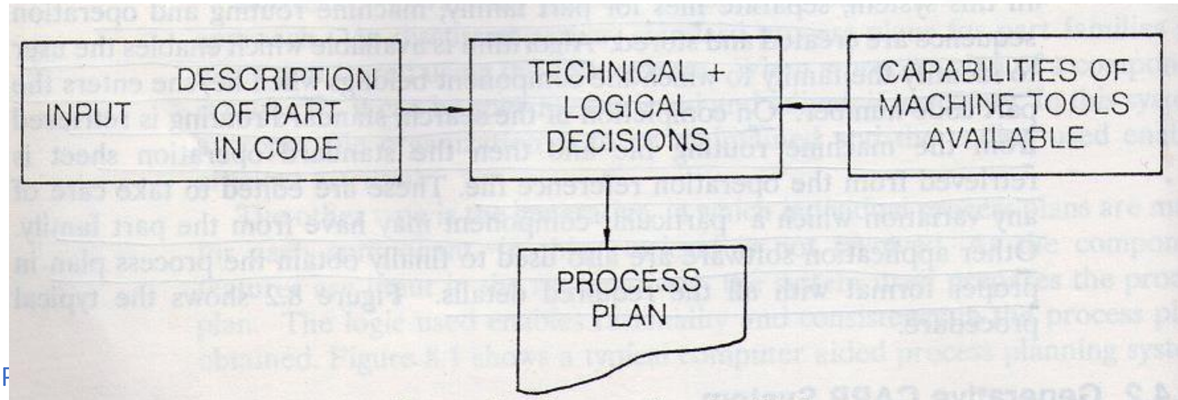
In this system, separate files for part family, machine routing and operation sequence are created and stored. Algorithm is available which enables the user to identlfy the family to which the component belogs whenhe/she enters the part code number. On completion of the search, Standard routing is retrieved 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 art family. Other application software are also used to finajlly obtainthe process plan in proper format with all the required details



Retrieval type CAPP System

Generative CAPP System

As mentioned earlier, this differs from the varient 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 inthe 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 processe sequence based on part description provided on the machine capabilities.



Generative Process Planning System