Group Technology & CAPP

Contents

4.1 Introduction

Group technology is a manufacturing philosophy in which similar parts are identified and grouped 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 this part 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 to facilitate workflow and parts handling.

In product design, there are also advantages obtained by grouping parts into families. For example, a design engineer faced with the task of developing a new part design must either start from scratch or pull an existing drawing from the files and make the necessary changes to conform to the requirements of the new part.

The problem is that finding a similar design may be quite difficult and time-consuming. For a large engineering department, there may be thousands of drawings in the files with no systematic way to locate the desired drawing.

As a consequence, the designer may decide that it is easier to start from scratch in developing the new part. This decision is replicated many times over in the company, thus consuming valuable time creating duplicate or near-duplicate part designs. If an effective design retrieval system were available, this waste could be avoided by permitting the engineer to determine quickly if a similar part already exists.

A simple change in an existing design would be much less time-consuming than starting from scratch. This design-retrieval system is a manifestation of the group technology principle applied to the design function. To implement such a system, some form of parts classification and coding is required.

4.2 Part Families

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

The two parts shown in *Fig.4.1* are similar from a design viewpoint but quite different in terms of manufacturing. The parts shown in *Fig.4.2* might constitute apart family in manufacturing, but their geometry characteristics do not permit them to be grouped as a design part family.

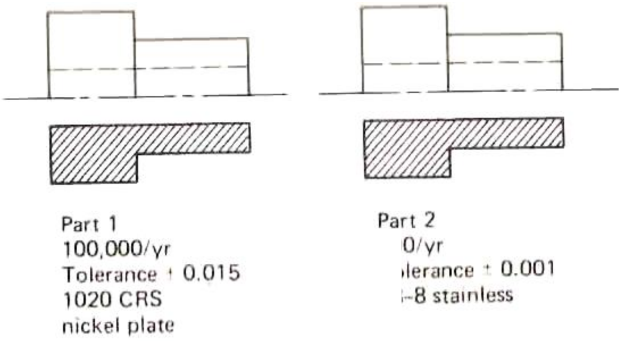

Fig.4.1 - Two parts of identical shape and size but different manufacturing requirements

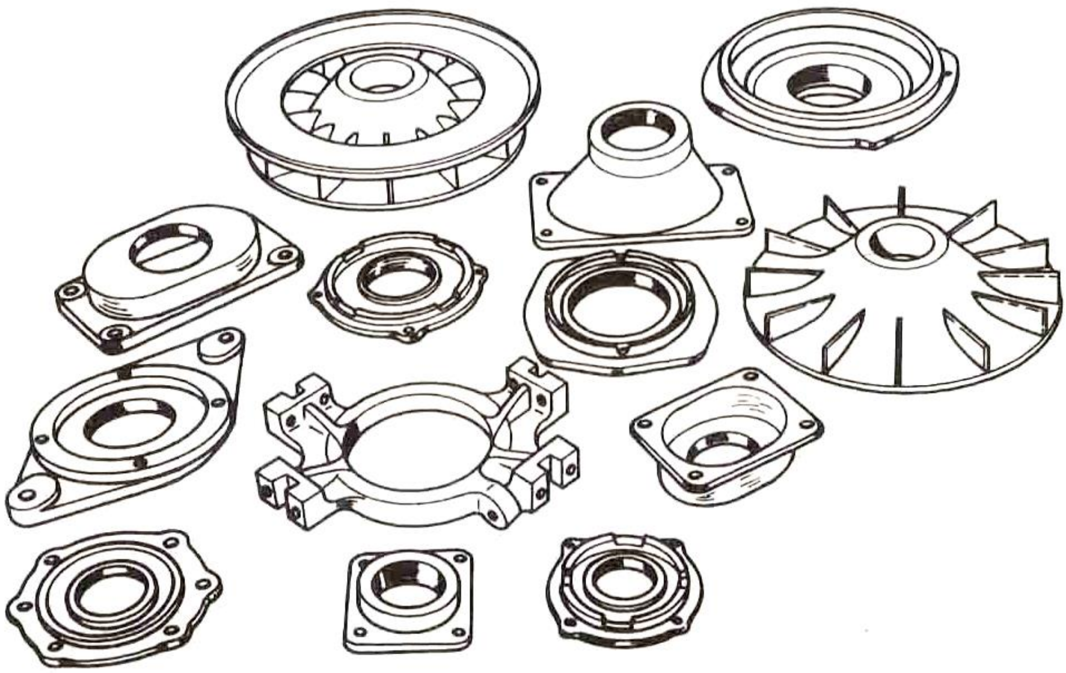

Fig.4.2 - Thirteen parts with similar manufacturing process requirements but different design attributes

4.2.1 Group Technology Layout

The various machine tools are arranged by function in *Fig.4.3*. There is a lathe section, milling machine section, drill press section, and so on.

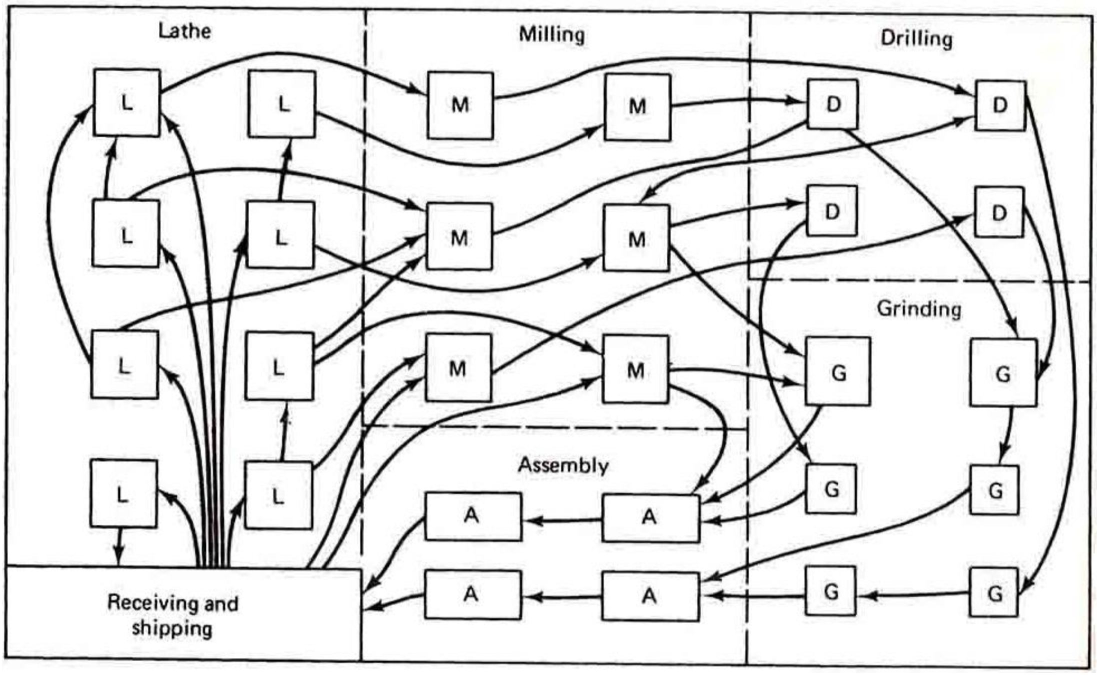

Fig.4.3 - Process-type layout

During the machining of a given part, the workpiece must be moved between sections, with perhaps the same section being visited several times. This results in a significant amount of material handling, a large in-process inventory usually more setups than necessary, long manufacturing lead times, and high cost.

Fig.4.4 shows a production shop supposedly equivalent capacity, but with the machines arranged into cells. Each cell is organized to specialize in the manufacture of a particular part family.

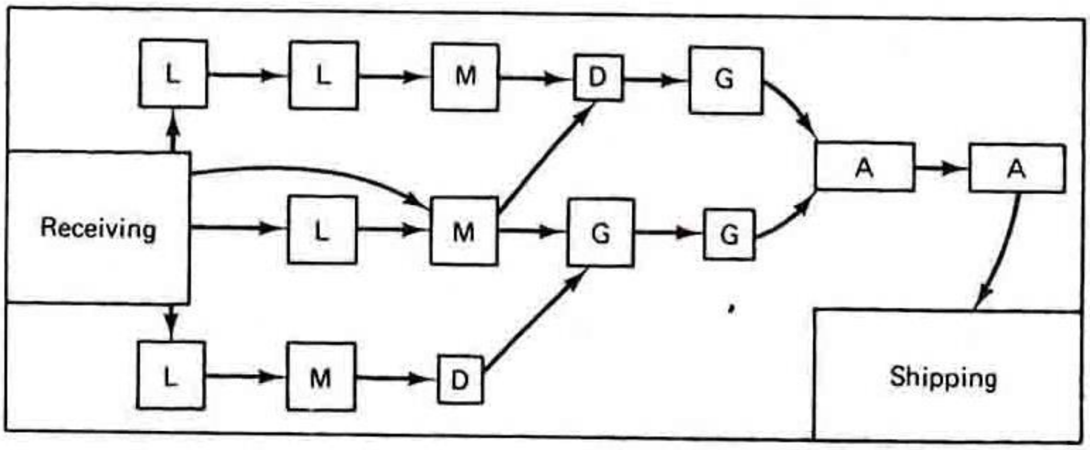

Fig.4.4 - Group technology layout

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.

4.2.2 Methods of Grouping Parts into Part Families

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

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
2. Production flow analysis (PFA)
3. Parts classification and coding system

The **visual inspection method** is the least sophisticated and least expensive. 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.

The second method, **production flow analysis**, was developed by J. L. Burbidge. 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 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. The production flow analysis approach does not seem to be used much at all in the United States.

The third method, **parts classification, and coding** 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.

4.3 Part Classification

This method of grouping parts into families involves an examination of the individual design and/or manufacturing attributes of each part. The attributes of the part are uniquely identified using code number.

This classification and coding may be carried out on the entire list of active parts of the firm or a sampling process may be used to establish the part families.

For example, parts produced in the shop during a certain given 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.

Many parts classification and coding systems have been developed throughout the world, and there are several commercially available packages being sold to industrial concerns. It should be noted that none of them has been universally adopted.

One of the reasons for this is that a classification and coding system should be custom-engineered for a given company or industry. One system may be best for one company while a different system is more suited to another company.

4.3.1 Design system versus manufacturing systems

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

1. Systems based on part design attributes
2. Systems based on part manufacturing attributes
3. Systems based on both design and manufacturing attributes

*Table **4.1** - Design and manufacturing part attributes typically included in GT classification system*

Part design attributes	Part manufacturing attributes
Basic external shape	Major processes
Basic internal shape	Minor operations
Rotational or rectangular shape	Operation sequence
Length to diameter ratio (rotational parts)	Major dimension
Aspect ratio (rectangular parts)	Surface finish
Material types	Machine tool
Part function	Production cycle time
Major dimensions	Batch size
Minor dimensions	Annual production
Tolerances	Fixture required
Surface finish	Cutting tools used in manufacturing

Systems in the first category are useful for design retrieval and to promote design standardization.

Systems in the second category are used for computer-aided process planning, tool design, and other production-related functions.

The third category represents an attempt to combine the functions and advantages of the other two systems into a single classification scheme.

The type of design and manufacturing parts attributes typically included in classification schemes are listed in Table 4.1. There is a certain amount of overlap between the design and manufacturing attributes of a part.

4.3.2 Coding system structure

A part coding scheme consists of a sequence of symbols that identify the part's design and/or manufacturing attributes. The symbol 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 digit only.

There are three basic code structures used in group technology applications:

1. Hierarchical structure
2. Chain-type structure
3. Hybrid structure, a combination of hierarchical and chain type structures

With the **hierarchical structure**, the interpretation of each succeeding symbol depends on the value of the preceding symbols. Other names commonly used for this structure are **mono code** and tree structure. The hierarchical code provides a relatively compact structure that conveys much information about the part in a limited number of digits.

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 the polycodes is that they tend to be relatively long. On the other hand, the use of polycode allows for convenient identification of specific part attributes. This can help recognize parts with similar processing requirements.

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 work part 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, 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.

Most of the commercial parts coding systems used in industry are a combination of the two pure 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 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, as in the hierarchical structure. This hybrid coding seems to best serve the needs of both design and production.

4.4 Parts Classification and Coding Systems

Following factors be considered in selecting a parts coding and classification systems:

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 systems? 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?

Adaptability to other systems: Can be classification and coding system be readily adapted to the existing company computer systems and databases? 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?

There are three parts classification and coding systems that are widely recognized among people familiar with GT:

1. Opitz system
2. MICLASS system
3. CODE system

4.4.1 The Opitz Classification System

This part classification and coding system was developed by H. Opitz of the University of Aachen in West Germany. It represents one of the pioneering efforts in the group technology and is perhaps the best known of the classification and coding schemes

The Opitz coding system uses the following digit sequence

12345 6789 ABCD

The basic consists of nine digits, which can be extended by adding four more digits. The first none digits intended to convey both design and manufacturing data. The general interpretation of the nine digits is indicated below figure.

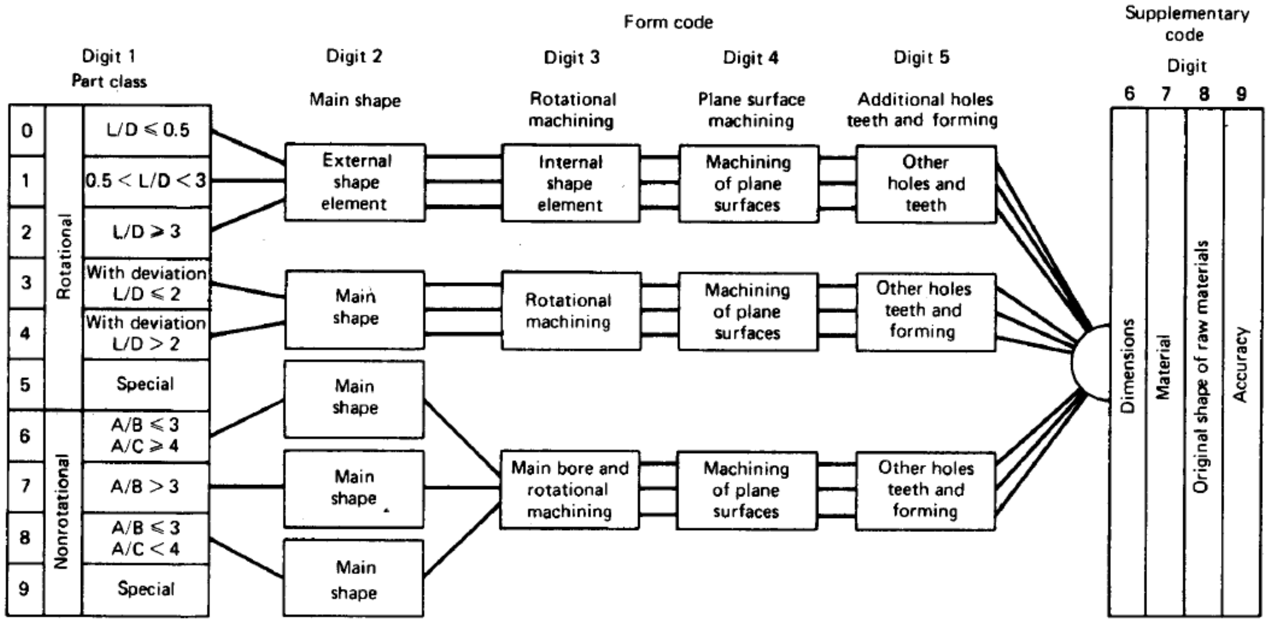

Fig.4.5 - Basic structure of the Opitz system

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.

Code	Digit 1	Digit 1	Digit 2	Digit 2	Digit 3	Digit 3	Digit 4	Digit 5	Digit 5
		Part class		External shape, external shape elements		Internal shape, internal shape elements	Plane surface machining		Auxiliary holes and gear teeth
0	Rotational parts	L/D ≤ 0.5		Smooth, no shape elements		No hole, no breakthrough	No surface machining	No gear teeth	No auxiliary hole
1	Rotational parts	0.5 < L/D < 3	Stepped to one end or smooth	No shape elements	Smooth or stepped to one end	No shape elements	Surface plane and/or curved in one direction, external	No gear teeth	Axial, not on pitch circle diameter
2	Rotational parts	L/D ≥ 3	Stepped to one end or smooth	Thread	Smooth or stepped to one end	Thread	External plane surface related by graduation around a circle	No gear teeth	Axial on pitch circle diameter
3	Rotational parts		Stepped to one end or smooth	Functional groove	Smooth or stepped to one end	Functional groove	External groove and/or slot	No gear teeth	Radial, not on pitch circle diameter
4	Rotational parts		Stepped to both ends	No shape elements	Stepped to both ends	No shape elements	External spline (polygon)	No gear teeth	Axial and/or radial and/or other direction
5	Rotational parts		Stepped to both ends	Thread	Stepped to both ends	Thread	External plane surface and/or slot, external spline	No gear teeth	Axial and/or radial on PCD and/or other directions
6	Nonrotational parts		Stepped to both ends	Functional groove	Stepped to both ends	Functional groove	Internal plane surface and/or slot	With gear teeth	Spur gear teeth
7	Nonrotational parts			Functional cone		Functional cone	Internal spline (polygon)	With gear teeth	Bevel gear teeth
8	Nonrotational parts			Operating thread		Operating thread	Internal and external polygon, groove and/or slot	With gear teeth	Other gear teeth
9	Nonrotational parts			All others		All others	All others	With gear teeth	All others

Fig.4.6 - Form code (digit 1 through 5) for rotational parts in the Opitz system

4.4.2 The MICLASS System

MICLASS stands for Metal Institute Classification System and was developed by TNO, the Netherlands Organization of Applied Scientific Research. It was started in Europe about five years before being introduced in the US in 1974.

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

- Standardization of engineering drawings
- Retrieval of drawing according to the 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 12-30 digits. The first 12 digits are a universal cod 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 work part 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	Positions 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. Based on responses to its questions, the computer assigns a code number to the part.

4.4.3 The 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.

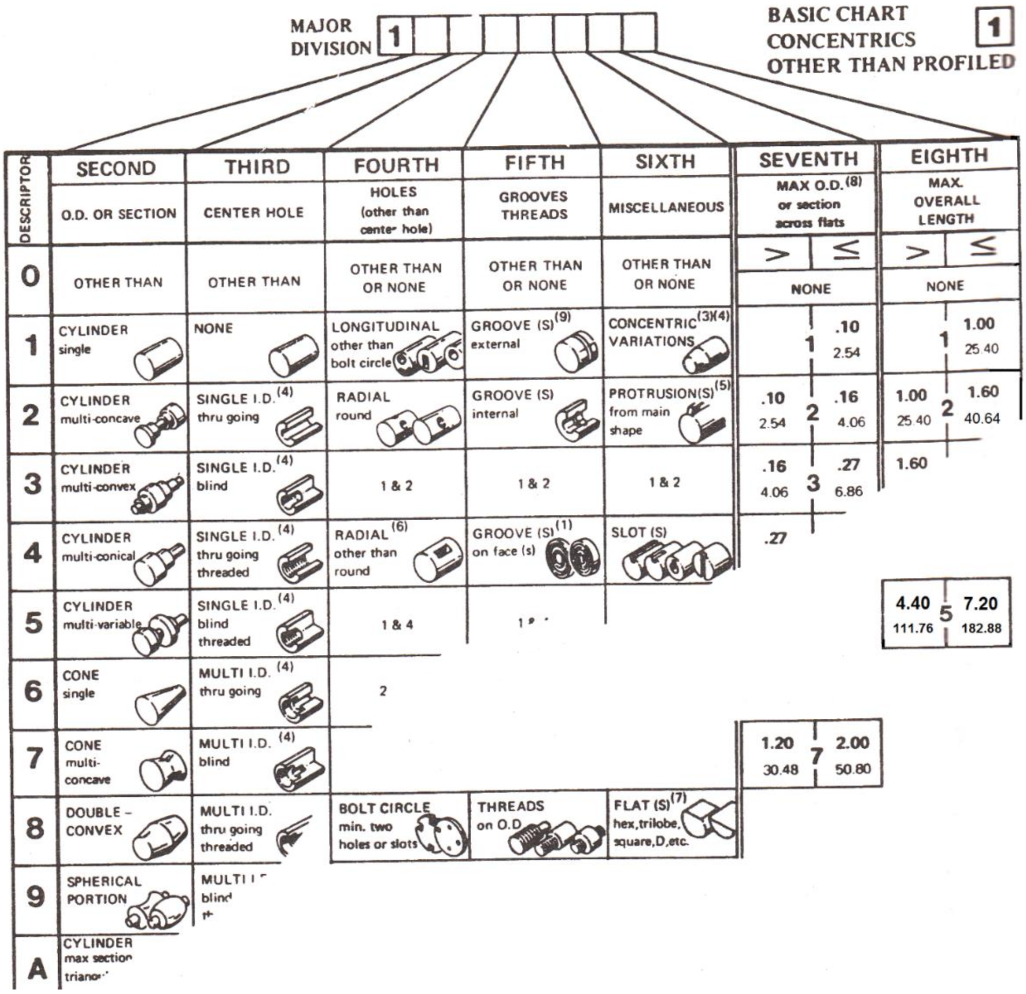

Fig.4.7 - A portion of the CODE system of MDSI

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) that 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. Hence the CODE system possesses a hybrid 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 the 16 sizes range for each of two dimensions.

Fig.4.7 shows a portion of the definitions for digits 2 through 8, given that the part has initially been classified as a cylindrical geometry (Major Division 1 for concentric parts other than profiled).

4.5 The Composite Part Concept

Part families are defined by the fact that their members have similar design and manufacturing attributes. The composite part concept takes this part family definition to its logical conclusion. It conceives of a hypothetical part that represents all of the design and corresponding manufacturing attributes possessed by the various individuals in the family.

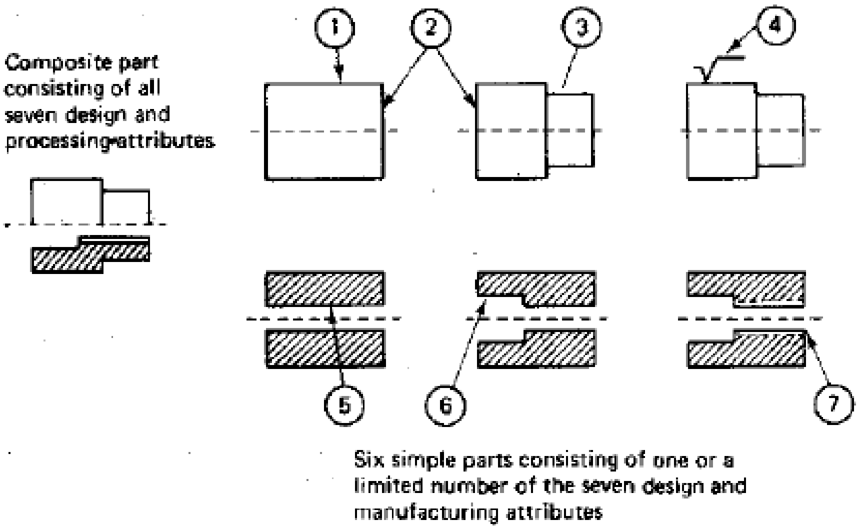

Fig.4.8 - Composite part concept

Such a hypothetical part is illustrated in *Fig.4.8*. To produce one of the members of the part family, operations are added and deleted corresponding to the attributes of the particular part design.

For example, the composite part in *Fig.4.8* is a rotational part made up of seven separate design and manufacturing features. These features are listed in *Table **4.2***.

A machining cell would be designed to provide all seven machining capabilities. The machine, fixtures, and tools would be set up for the efficient flow of work-parts through the cell.

*Table **4.2** - Design and manufacturing attributes of the composite part*

Number	Design and manufacturing attribute
1	Turning operation for the external cylindrical shape
2	Facing operation for ends
3	Turning operation to produce step
4	External cylindrical grinding to achieve the specified surface finish
5	Drilling operation to create through-hole
6	Counterbore
7	Tapping operation to produce internal threads

The part with all seven attributes, such as the composite part of *Fig.4.8*, would go through all seven processing steps. For part designs without all seven features, unneeded operations would simply be canceled.

4.6 Benefits of Group Technology

Product design benefits

In the area of production design, improvement 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. The use of the automated design-retrieval system helps to eliminate design duplication and proliferation of new parts 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, chamfer, and tolerances are more likely to become standardized with GT.

Tooling and Setups

GT also tends to promote standardization of several areas of manufacturing. Two of these areas are tooling and setups.

In tooling, an effort is made to design group jigs and fixtures that will accommodate every member of a parts family. Work holding devices are designed to use special adapters which convert the general 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 work parts processed on them. Hence, setup time is saved, and it becomes more feasible to try to process parts to achieve a bare minimum of setup changeovers. It has been estimated that the use of GT can result in a 69% reduction in setup time.

Material Handling

Another advantage in manufacturing is the reduction in the work part move and waiting time. The group technology machine layouts lend themselves to the efficient flow of material through the shop. The contrast is sharpest when the flow line cell design is compared to the conventional process type layout.

Production and Inventory Control

Several benefits accrue to a company's production and inventory control function as a consequence of GT. Production scheduling is simplified with GT. In effect, the grouping of machines into cells reduces the number of production centers that must be scheduled.

Grouping parts into families reduces the complexity and size of the parts scheduling problem. And for those work parts 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 be reduced.

Employee Satisfaction

The machine cell often allows parts to be processed from raw material to finished sate by small group workers. The workers can 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. Work part quality is more easily traced to a particular machine cell in GT. 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.

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 into computer software to form a computer-automated process planning system.

4.7 The Planning Function

Process planning is concerned with determining the sequence of individual manufacturing operations needed to produce a given part or product.

The resulting operation sequence is documented on a form typically referred to as a route sheet. The route sheet is a listing of the production operation and associated machine tools for a work part or assembly.

Closely related to process planning are the functions of determining appropriate cutting conditions for the machining operations and setting the time standards for the operations.

All three functions—planning the process, determining the cutting conditions, and setting the time standards—have traditionally been carried out as tasks with a very high manual and clerical content.

They are also typically routine tasks in which similar or even identical decisions are repeated over and over. Today, these kinds of decisions are being made with the aid of computers.

4.7.1 Traditional Process Planning

There are variations in the level of detail found in route sheets among different companies and industries. In the one extreme, process planning is accomplished by releasing the part print to the production shop with the instructions "make to drawing".

Most firms provide a more detailed list of steps describing each operation and identifying each work center. In any case, it is traditionally the task of the manufacturing engineers or industrial engineers in an organization to write these process plans for new part designs to be produced by the shop.

The process planning procedure is very much dependent on the experience and judgment of the planner. It is the manufacturing engineer's responsibility to determine an optimal routing for each new part design. However, individual engineers each have their own opinions about what constitutes the best routing.

Accordingly, there are differences among the operation sequences developed by various planners. We can illustrate rather dramatically these differences through an example.

In one case, a total of 42 different routes were developed for various sizes of a relatively simple part called an "expander sleeve." There were a total of 64 different sizes and styles, each wit h its part number. The 42 routings included 20 different machine tools in the shop.

The reason for this absence of process standardization was that many different individuals had worked on the parts: 8 or 9 manufacturing engineers, 2 planners, and 25 NC pa rt programmers.

Upon analysis, it was determined that only two different routings through four machines were needed to process the 64 part numbers. There are potentially great differences in the perceptions among process planners as to what constitutes the "optimal" method of production.

Besides with problem of variability among planners, there are often difficulties in the conventional process planning procedure. New machine tools in the factory render old routings less than optimal.

Machine breakdowns force shop personnel to use temporary routings and these become the documented routings even after the machine is repaired. For these reasons and others, a significant proportion of the total number of process plans used in manufacturing is not optimal.

4.7.2 Automated Process Planning

Because of the problems encountered with manual process planning, attempts have been made in recent years to capture the logic, judgment, and experiences required for this important function and incorporate them into computer programs.

Based on the characteristics of a given part, the program automatically generates the manufacturing operation sequence.

A computer-aided process planning (CAPP) system offers the potential for reducing the routine clerical work of manufacturing engineers. At the same time, it provides the opportunity to generate production routings that are rational, consistent, and perhaps even optimal.

Two alternative approaches to computer-aided process planning have been developed. These are:

1. Retrieval-type CAPP systems (also called variant systems)
2. Generative CAPP systems

4.8 Retrieval Type Process Planning Systems

Retrieval-type CAPP systems use parts classification and coding and group technology as a foundation. In this approach, the parts produced in the plant are grouped into part families, distinguished according to their manufacturing characteristics.

For each part family, a standard process plan is established. The standard process plan is stored in computer files and then retrieved for new work parts which belong to that family.

Some form of parts classification and coding system is required to organize the computer files and to permit efficient retrieval of the appropriate process plan for a new work part.

For some new parts, editing of the existing process plan may be required. This is done when the manufacturing requirements of the new part are slightly different from the standard. The machine routing may be the same for the new part, but the specific operations required at each machine may be different.

The complete process plan must document the operations as well as the sequence of machines through which the part must be routed. Because of the alterations that are made in the retrieved process plan, these CAPP systems are sometimes also called by the name "variant system."

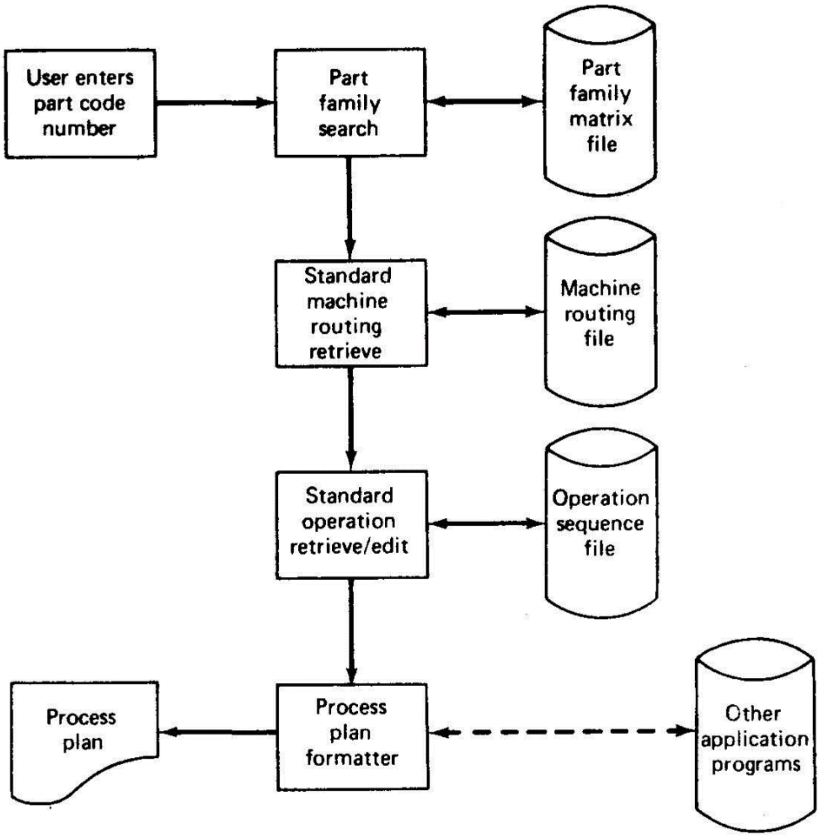

Fig.4.9 - Information flow in a retrieval-type computer-aided process planning system

Fig.4.9 will help to explain the procedure used in a retrieval process planning system. The user would initiate the procedure by entering the part code number at a computer terminal. The CAPP program then searches the part family matrix file to determine if a match exists.

If the file contains an identical code number, the standard machine routing and operation sequence is retrieved from the respective computer files to display to the user.

The standard process plan is examined by the user to permit any necessary editing of the plan to make it compatible with the new part design. After editing, the process plan formatter prepares the paper document in the proper form.

If an exact match cannot be found between the code numbers in the computer file and the code number for the new part, the user may search the machine routing file and the operation sequence file for similar parts that could be used to develop the plan for the new part.

Once the process plan for a new part code number has been entered, it becomes the standard process for future parts of the same classification.

In *Fig.4.9*, the machine routing file is distinguished from the operation sequence file to emphasize that the machine routing may apply to a range of different part families and code numbers.

It would be easier to find a match in the machine routing file than in the operation sequence file. Some CAPP retrieval sys¬tems would use only one such file which would be a combination of operation sequence file and machine routing file.

The process plan formatter may use other application programs. These could include programs to compute machining conditions, work standards, and standard costs. Standard cost programs can be used to determine total product costs for pric¬ing purposes.

Several retrieval-type computer-aided process planning systems have been developed. These include MIPLAN, one of the MICLASS modules, the CAPP system developed by Computer-Aided manufacturing International, COMCAPP V by MDSI, and systems by individual companies.

4.9 Generative Process Planning Systems

Generative process planning involves the use of the computer to create individual process plans from scratch, automatically and without human assistance.

The computer would employ a set of algorithms to progress through the various technical and logical decisions toward a final plan for manufacturing. Inputs to the system would include a comprehensive description of the work part.

This may involve the use of some form of a part code number to summarize the work part data, but it does not involve the retrieval of existing standard plans.

Instead, the generative CAPP system synthesizes the design of the optimum process sequence, based on an analysis of part geometry, material, and other factors which would influence manufacturing decisions.

In the ideal generative process planning package, any part design could be presented to the system for the creation of the optimal plan.

In practice, current generative-type systems are far from universal in their applicability. They tend to fall short of a truly generative capability, and they are developed for a somewhat limited range of manufacturing processes.

4.10 Benefits of CAPP

Whether it is a retrieval system or a generative system, computer-aided process planning offers many potential advantages over manually oriented process planning.

1. **Process rationalization**: Computer-automated preparation of operation routings is more likely to be consistent, logical, and optimal than its manual counterpart. The process plans will be consistent because the same computer software is being used by all planners. We avoid the tendency for drastically different process plans from different planners. The process plans tend to be more logical and optimal because the company has presumably incorporated the experience and judgment of its best manufacturing people into the process planning computer software.
2. **Increased productivity of process planners**: With computer-aided process planning, there is reduced clerical effort, fewer errors are made, and the planners have immediate access to the process planning database. These benefits translate into the higher productivity of the process planners. One system was reported to increase productivity by 600% in the process planning function.
3. **Reduced turnaround time**: Working with the CAPP system, the process planner can prepare a route sheet for a new part in less time compared to manual preparation. This leads to an overall reduction in manufacturing lead time.

4. **Improved legibility**: The computer-prepared document is neater and easier to read than manually written route sheets. CAPP systems employ standard text, which facilitates interpretat ion of the process plan in the factory.
5. **Incorporation of other application programs:** The process planning system can be designed to operate in conjunction with other software packages to automate many of the time-consuming manufacturing support functions.

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