UNIT	CONTACT	HOURS
III	Computer Aided Process Planning: Traditional Process Planning, Retrieval process planning system, Generative Process Planning, Machinability data systems, computer generated time standards.	4
	Group Technology: Introduction, part families, part classification and coding, coding system and machining cells.	4

1. COMPUTER AIDED PROCESSPLANNING

1.1 Introduction to ProcessPlanning

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 operation sheet. The operation sheet is a listing of the production operations and associated machine tools for a work part or assembly. Process planning is an important stage of product development since production tooling like jigs, fixtures, special tools etc. can be designed only after the process is finalized.

1.2 Role of processplanning

1. Interpretation of product designdata
2. Selection of machiningprocesses.
3. Selection of machinetools.
4. Determination of fixtures and datumsurfaces.
5. Sequencing theoperations.
6. Selection of inspectiondevices.
7. Determination of productiontolerances.
8. Determination of the proper cuttingconditions.
9. Calculation of the overalltimes.
10. Generation of process sheets including NCdata.

1.3 Approaches to Processplanning

1. Manualapproach
2. Computer Aided ProcessPlanning
    i. Variant or retrieval type CAPPsystem
    ii. Generative CAPPsystem

CAPP and CMPP (Computer Managed Process Planning)

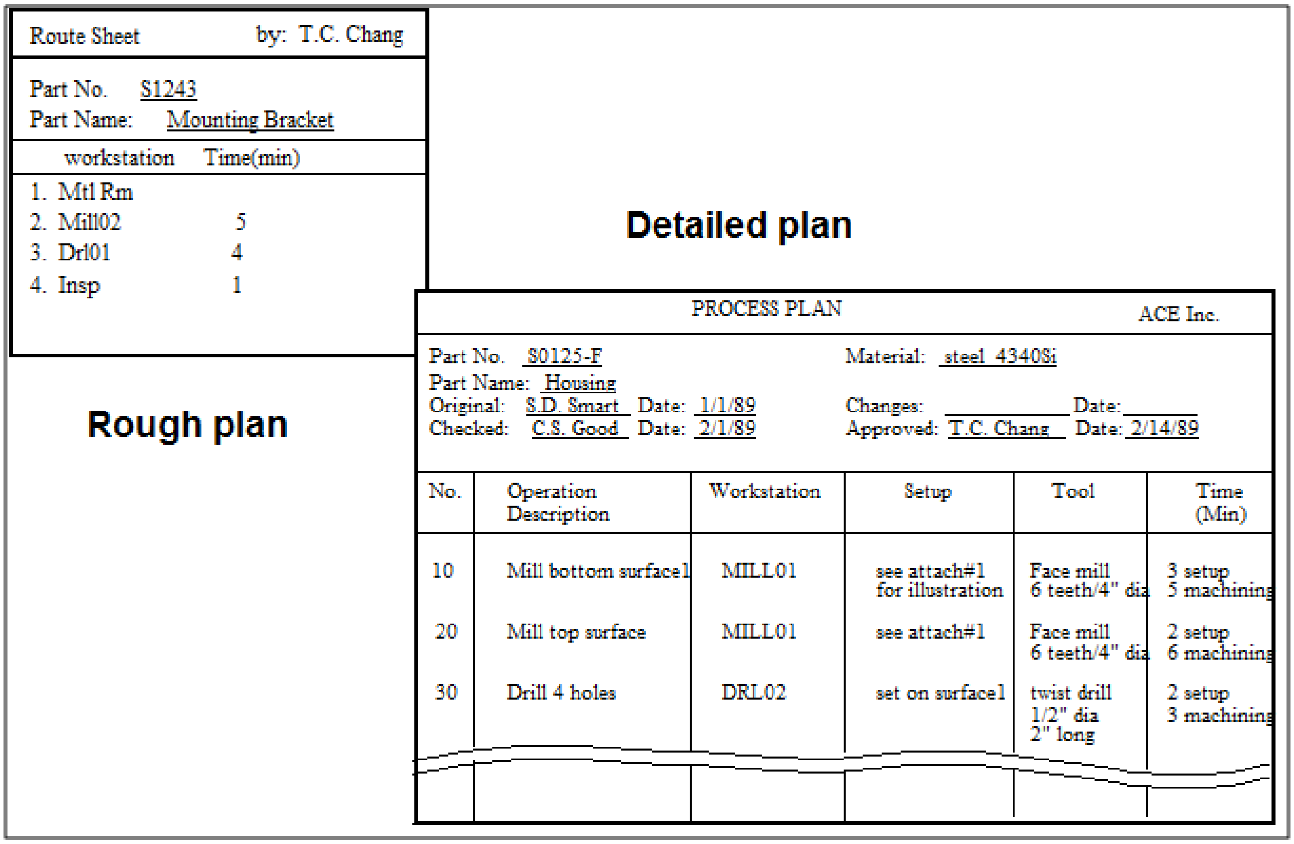
1.3.1 Process Planning (Manualapproach)

Manufacturing planning, process planning, material processing, process engineering and machine routing are a few titles given to the topic referred to here as process planning. Process planning is that function within a manufacturing facility that establishes which machining process and process parameters are to be used to convert a work material (blank) from its initial form (raw material) to a final form defined by an engineering drawing. Process planning is a common task in small batch, discrete parts metal working industries. The process planning activity can be divided into the following steps:

- Selection of processes andtools
- Selection of machine tools/Manufacturingequipment
- Sequencing theoperations

- Grouping ofoperations
- Selection of work piece holding devices and datum surfaces (setups)
- Selection of inspectioninstruments
- Determination of productiontolerances
- Determination of the proper cuttingconditions
- Determination of the cutting times and non-machining times (setting time, inspection time) for eachoperation
- Editing the processsheets.

All the information determined by the process planning function is recorded on a sheet called process plan. The process plan is frequently called an operation sheet, route sheet or operation planning sheet. This provides the instructions for the production of the part. It contains the operation sequence, processes, process parameters and machine tools used. Fig shows a typical process planning sheet.



In conventional production system, a process plan is created by a process planner. It requires a significant amount of time and expertise to determine an optimal routing for each new part design. However, individual engineers will have their own opinions about what constitutes the best routing. Accordingly there are differences among the operation sequences developed by various planners. Efficient process planning requires the service of experienced processplanners.

Because of the problems encountered with manual process planning, attempts have been made in recent years to capture the logic, judgment and experience required for this important function and incorporates them into computer programmes. Based on the features of a given part, the program automatically generates the sequence of manufacturing operations. The process planning software provides the opportunity to generate production routings which are rational, consistent and perhaps even optimal.

It has the following advantages:

i. Reduces the skill required of aplanner.
ii. Reduces the process planningtime.
iii. Reduces the process planning and manufacturingcost.

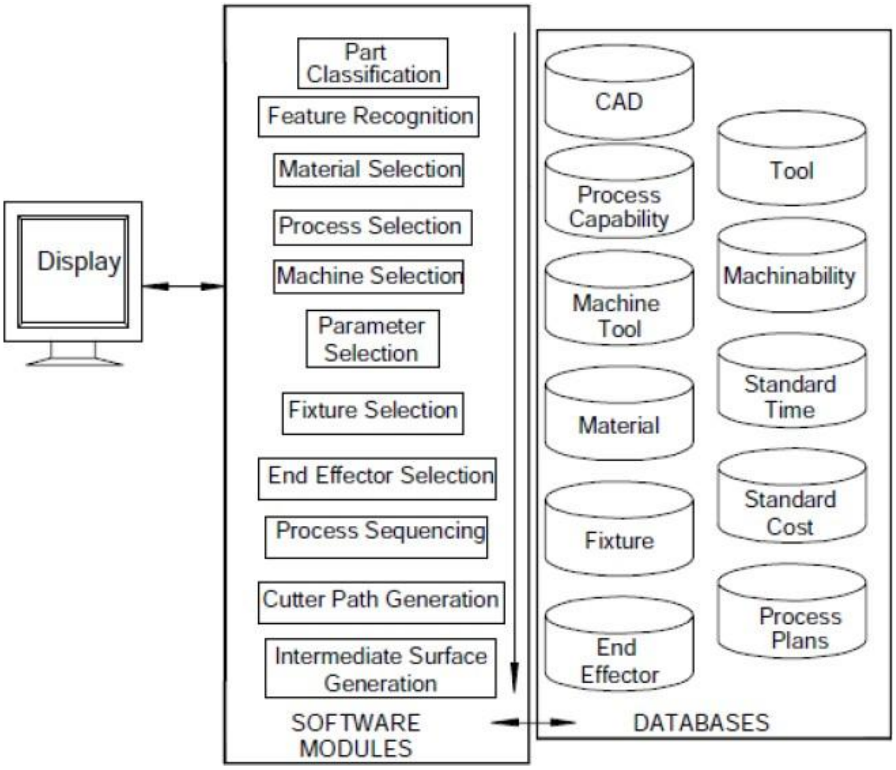
iv. Creates more consistentplans.
v. Produces more accurateplans.
vi. Increasesproductivity.

1.3.2 Computer Aided ProcessPlanning

The current approaches for computer aided process planning can be classified into two groups:
i. Variant
ii. Generative

Structure of a Process Planning Software

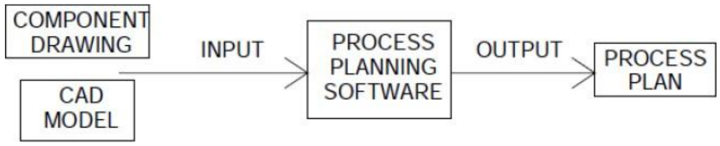
Fig. represents the structure of a computer aided process planning system. In Fig. the modules are not necessarily arranged in the proper sequence but can be based on importance or decision sequence. Each module may require execution several times in order to obtain the optimum process plan. The input to the system will most probably be a solid model from a CAD data base or a 2-D model. The process plan after generation and validation can then be routed directly to the production planning system and production control system.



Structure of a Computer Aided Process Planning System

Information required for Process Planning

The geometric model of the part is the input for the process planning system. The system outputs the process plan (Fig.). The input to the process planning system may be engineering drawing or CAD model. The other prerequisites for process planning are given below:
- Partslist
- Annual demand/batchsize
- Accuracy and surface finish requirement (CADDatabase)
- Equipment details (Work centreDatabase)
- Data on cutting fluids, tools, jigs & fixtures,gauges
- Standard stocksizes
- Machining data, data on handling andsetup



Activities in Process Planning

In a computerized process planning system a formal structure and a knowledge database are required in order to transform the engineering design information into the process definition. A brief description of the operation of a computer aided process planning software is given in the following section.

Methods of Computer Aided Process Planning

The ultimate goal of a system is to integrate design and production data into a system that generates useable process plans. As already mentioned there are two approaches:

i. Variant processplanning

ii. Generative processplanning

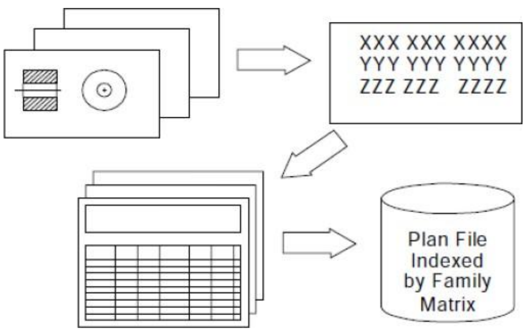
1.3.2.1 Variant ProcessPlanning

A variant process planning system uses the similarity among components to retrieve the existing process plans. A process plan that can be used by a family of components is called a standard plan. A standard plan is stored permanently with a family number as its key. A family is represented by a family matrix which includes all possible members. The variant process planning system has two operational stages:

• A preparatory stageand

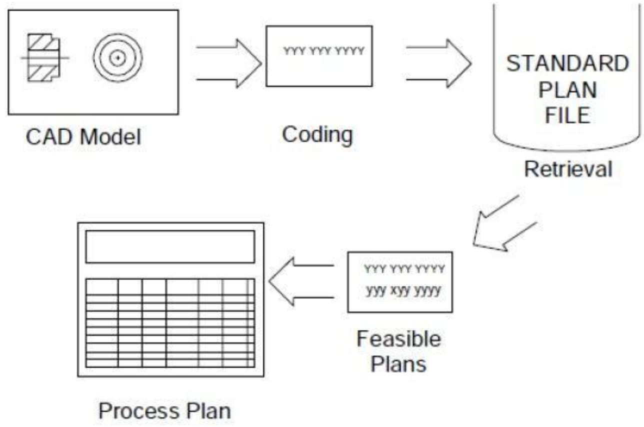
• A productionstage.

During the preparatory stage, existing components are coded, classified, and subsequently grouped into families. The process begins by summarizing process plans already prepared for components in the family. Standard plans are then stored in a data base and indexed by family matrices(Fig.).



Process Family Matrix

The operation stage occurs when the system is ready for production. An incoming part is first coded. The code is then input to a part family search routine to find the family to which the component belongs. The family number is then used to retrieve a standard plan. Some other functions, such as parameter selection and standard time calculations, can also be added to make the system more complete (Fig). This system is used in a machine shop that produces a variety of small components.



Part Search and Retrieval

Design of Variant Process Planning System

The following are the sequences in the design of a variant process planning system:

i. Familyformation
ii. Data base structuredesign
iii. Search algorithm development andimplementation
iv. Plan editing and Process parameterselection/updating

i. FamilyFormation

Part family classification and coding were discussed earlier. This is based on the manufacturing features of a part. Components requiring similar processes are grouped into the same family. A general rule for part family formation is that all parts must be related. Then, a standard process plan can be shared by the entire family. Minimum modification on the standard plan will be required for such familymembers.

ii. Data Base StructureDesign

The data base contains all the necessary information for an application, and can be accessed by several programs for specific application. There are three approaches to construct a data base: hierarchical, network, and relational.

iii. SearchProcedure

The principle of a variant system is to retrieve process plans for similar components. The search for a process plan is based on the search of a part family to which the component belongs. When, the part family is found, the associated standard plan can then be retrieved. A family matrix search can be seen as the matching of the family with a given code. Family matrices can be considered as masks. Whenever, a code can pass through a mask successfully, the family is identified.

iv. Plan Editing and ParameterSelection

Before a process plan can be issued to the shop, some modification of the standard plan may be necessary, and process parameters must be added to the plan. There are two types of plan editing: One is the editing of the standard plan itself in the data base, and the other is editing of the plan for the component. For editing a standard plan, the structure of the data base must be flexible enough for expansion, additions, and deletions of the data records.

A complete process plan includes not only operations but also process parameters. The data in the process parameter files are linked so that we can go through the tree to find the speed and feed for an operation. The parameter file can be integrated into variant planning to select process parameters automatically.

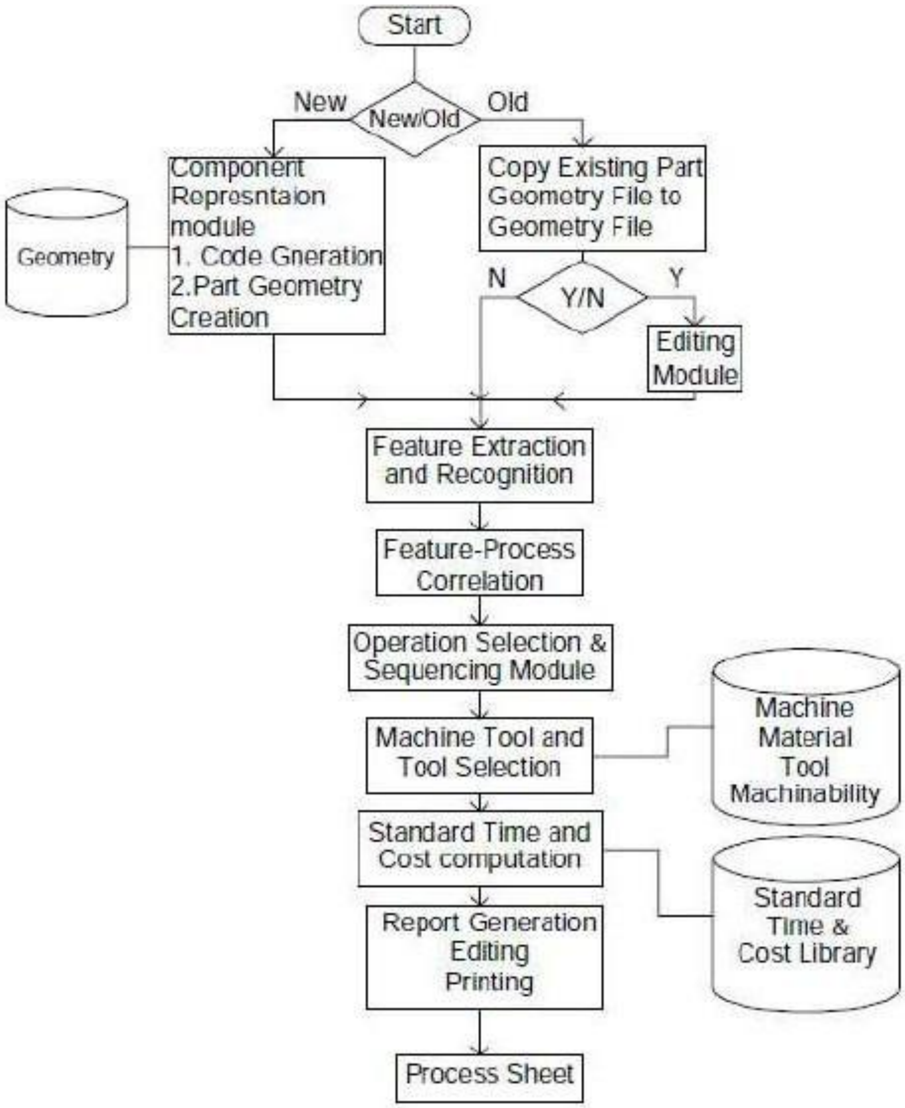
1.3.2.2 Generative Process Planning

Generative process planning is a system that synthesizes process information in order to create a process plan for a newcomponentautomatically.Inagenerativeplanningsystem,processplansarecreatedfrominformationavailable in manufacturing data base without human intervention. Upon receiving the design model, the system can generate the required operations and operation sequences for the component. Knowledge of manufacturing must be captured and encoded into efficient software. By applying decision logic, a process planner's decision making can be imitated. Other planning functions, such as machine selection, tool selection, process optimization, and so on, can also be automated using generative planning techniques. The generative planning has the followingadvantages:

i. It can generate consistent process plansrapidly.

ii. New process plans can be created as easily as retrieving the plans of existingcomponents.

iii. It can be interfaced with an automated manufacturing facility to provide detailed and up-to-date control information.



Shows the modular structure of a generative CAPP system.

The generative part consists of:

- Component representationmodule
- Feature extractionmodule
- Feature process correlationmodule
- Operation selection and sequencingmodule
- Machine tool selectionmodule

• Standard time / cost computationmodule
• Report generationmodule

1.4 Other methods

In order to generate a more universal process planning system, variables such as process limitations, and capabilities, process costs and so on, must be defined at the planning stage. Several of methods have been proposed for creating generative process plans. A few methods that have been implemented successfullyare:
i. Forward and backwardplanning
ii. InputFormat
iii. CAPP based on CADmodels
iv. CAPP based on decision logic either using decision trees or decisiontables
v. CAPP based on artificialintelligence

Forward and Backward Planning

In generative process planning, when process plans are generated, the system must define an initial state in order to reach the final state (goal). The path taken represents the sequence of processes. For example, the initial state is the raw material and the final state is the component design. Then a planner works in modifying the raw workpiece until it takes on the final design qualities. This is called forward planning.
Backward planning uses a reverse procedure. Assuming that we have a finished component, the goal is to go back to the un-machined work piece. Each machining process is considered a filling process. Forward and backward planning may seem similar. However they influence the programming of the system significantly. Planning each process can be characterized by a precondition of the surface to be machined and a post condition of the machining (the end result). For forward planning, we must know the successor surface before we select a process, because the post condition of the first process becomes the precondition for second process. Backward planning eliminates this problem since it begins with the final surfaces from and processes are selected to satisfy the initial requirements. In forward planning, the steps to obtain the final surface with the desirable attributes must be carefully planned to guarantee the result. On the other hand, backward planning starts with the final requirements and searches for the initial condition.

1.5 Process PlanningSystems

The majority of existing process planning systems is based on variant process planning approach. Some of them are: CAPP, MIPLAN, MITURN, MIAPP, UNIVATION, CINTURN, COMCAPPV, etc. However, there are some generative system, such as METCAPP, CPPP, AUTAP, and APPAS.

2. CONCEPT OF GROUPTECHNOLOGY;

Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to take the advantage of their similarities in manufacturing and design. Similar parts are arranged in to part families.
Advantages of group technology

- Product design benefits- 10 % reduction in the number ofdrawings
- Tooling and setup benefits – 69 % reduction of setuptime.
- Materials handlingbenefits
- Production and inventory controlbenefits
- -70 % reduction in productiontime
- -62 % reduction in work in process inventories
- -82 % reduction in overdueorders
- Employeesatisfaction
- Process planningprocedures

2.1 Group technology(GT);

Group technology (GT) is a manufacturing philosophy to increase production efficiency by grouping a variety of parts having similarities of shape, dimension, and/or process route.

Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to take the advantage of their similarities in manufacturing and design.

2.2 Partfamily;

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.

Design attributes:

- Part configuration (round orprismatic)
- Dimensional envelope (length to diameterratio)
- Surface integrity (surface roughness, dimensionaltolerances)
- Materialtype
- Raw material state (casting, forging, bar stock,etc.)

Manufacturing attributes:

- Operations and operation sequences (turning, milling,etc.)
- Batchsizes
- Machinetools
- Cuttingtools
- Work holdingdevices
- Processingtimes

2.3 Benefits of Group Technology

Group technology, when successfully implemented, offers many benefits to industries. GT benefits can be realized in a manufacturing organization in the following areas:

1. Productiondesign
2. Tooling andsetups
3. Materialshandling
4. Production and inventorycontrol
5. Process planning Management andemployees.

1. Benefits in productDesign

The main advantages of GT for product design come in cost and time savings, because design engineers can quickly and easily search the database for parts that either presently exist or can be used with slight modifications, rather than issuing new part numbers.

A similar cost savings can be realized in the elimination of two or more identical parts with different part numbers. Another advantage is the standardization of designs. Design features such as corner radii, tolerances, chamfers, counter bores and surface finishes can be standardized with GT.

2. Benefits in Tooling andSetups

In the area of tooling, group jigs and fixtures are designed to accommodate every member of a part family. Also work holding devices are designed to use special adapters in such a way that this general fixture can accept each part family member. Since setup times are very short between parts in a family, a group layout can also result in dramatic reductions in setuptimes.

3. Benefits in material handling:
GT facilitates a group layout of the shop. Since machines are arranged as cells, in a group layout, the materials handling cost can be reduced by reducing travel and facilitating increased automation.

4. Benefits in production and inventoryControl
GT simplifies production and planning control. The complexity of the problem has been reduced from a large portion of the shop to smaller groups of machines. The production scheduling is simplified to a small number of parts through the machines in that cell.

5. Benefits in ProcessPlanning
The concept of group technology – parts classification and coding – lead to an automated process planning system. Grouping parts allows an examination of the various planning/route sheets for all members of a particular family. Once this has been accomplished, the same basic plans can be applied to other members, thereby optimizing the shop for the group.

6.Benefits to Management andEmployees
It is understood that GT simplifies the environment of the manufacturing firm, which provides significant benefit to management.

- Simplification reduces the cumbersome paperwork.
- Simplification also improves the workenvironment.

In the GT work environment, the supervisor has in – depth knowledge of the work performed and better control.

2.4 General methods used for part families;
1. Visualinspection,
2. Production flow analysis,and
3. Parts classification and codingsystem

A. Production Flowanalysis;
Production Flow analysis (PFA) is a method for identifying part families and associated machine groupings that uses the information contained on production route sheets rather on part drawings.
Various steps ofPFA
1. Datacollection
2. Part sorting androuting
3. PFAchart
4. Analysis

B. Parts classification and codingsystem
1. system based on part designattributes
2. system based on manufacturingattributes
3. system based on design and manufacturingattributes

2.5 Code structures used in GT application;

- Attribute codes (or polycodes or chain typestructure).
- Hierarchical codes (or monocodes or treestructure).
- Decision-tree codes (or hybrid codes or mixedcodes).

2.5.1 Coding systems;

Coding is the systematic process of establishing an alphanumeric value for parts on selected part features. Classification is the grouping of parts based on code values. This method is the most time consuming of the three methods, in parts classification and coding, similarities among parts are identified and these similarities are related in a codingsystem.

Three categories of part similarities can be distinguished 1. Design attributes which are concerned with part characteristics such as, geometry, size and material, and 2. Manufacturing attributes consider the processing steps required to make a part.3.system based on both attributes.

There are three basic coding structures

1. Hierarchical codes (ormonocodes)
2. Attributes codes (orpolycodes)
3. Decision tree codes (or hybrid codes)

Coding systems

Through more than 100 coding systems are available, the following coding systems are widely recognizes in industries

1. Opitz classification system
2. DCLASSsystem
3. CODEsystem
4. MICLASSsystem
5. KK-3system
6. CUTPLANsystem
7. COFORM
8. RNC system
9. Part analogsystem
10. Brish system.

2.6 Cellularmanufacturing;

Cellular manufacturing (CM) is an application of group technology in which dissimilar machines have been aggregated into cells, each of which is dedicated to the production of a part family.

The machines in a multi station system with variable routing may be manually operated, semi-automatic, or fully automated. When manually operated or semi automatic the machine groups are often called machine cells, and the use of these cells in a factory is called cellular manufacturing.

2.6.1 Design considerations guiding thecell-formation.;

- Parts/products to be fully completed in thecell.
- Higher operatorutilization.
- Fewer operations thanequipment.
- Balanced equipment utilization in thecell.

Types of cell design

1. Single machine cell
2. Group machine cell with manual handling
3. Group machine cell with semi-integrated handling
4. Flexible manufacturingsystem

Determining the best machine arrangement

Factors to be considered:

- Volume of work to be done by thecell
- Variations in process routings of the parts
- Part size, shape, weight and other physicalattributes