CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter intended to review on the literature focusing on the topic of Group Technology (GT) and part standardization, Classification and Coding (C&C), and Data base Development in order to select or apply the most appropriated model to the design process of radial tire components in a tire manufacturing.

2.2 Group Technology (GT)

The small-lot manufacturing environment has been studied extensively since World War II. This environment is very difficult to manage well. From a casual observer's viewpoint, manufacturing activities seem to occur randomly. In the 1960s and early 1970s, some people thought that operations research (management science) techniques, such as queueing theory and mathematical programming, had the potential to improve management of an environment of this type. However, none of these techniques was practically successful. Until the late1970s, no approach received widespread acceptance; in fact, very few new approaches were even proposed. In the late 1970s, however, a consensus emerged in the manufacturing countries that group technology provides a basis for better management of the small-lot manufacturing environment. Some people had advocated this philosophy since the early 1950s.

2.2.1 Definition of Group Technology

Bedworth (1991), "An engineering and manufacturing philosophy that groups parts together based on their similarities in order to achieve economies of scale in a small-scale environment normally associated with large-scale production."

2.2.2 Function of Group Technology

Group technology has three major strengths that can be utilized to enhance the positive characteristics just discussed and to help in overcoming the negative ones.

2.2.2.1 The first, and perhaps the most important, is giving a structure to the entry and utilization of the wide range of data needed to control and operate a manufacturing facility. The data bases are actually one form of corporate asset that can provide a significant competitive edge to a company in terms of the ability to react faster and produce more quickly at less cost with better quality. The data entry structure is generally created through the use of coding and classification. The utilization structure is a product of the decision logic that is built into the data retrieval and analysis process. This total structure leads directly to the second and third major strengths of group technology.

2.2.2.2 The second is standardization. Since the data is stored and used within a set of decision rules that have been pre-established, everyone who uses the system to develop alternative solutions to problems will be provided with a standard set for each problem chosen. This greatly reduces the tendency of people to choose random or personally preferred solutions that lead to non-standardization.

2.2.2.3 The third major strength is that group technology improves communication. Data transferred between individuals is based on the set of decision rules that deals with characteristics of items. This keeps communications on a more factual basis, eliminating the confusion that is created when people use their own coined terms.

2.2.3 Benefits of Group Technology

The improvements that group technology can make based on the three major strengths can best be described by reviewing some of the major activities or functions that occur in the manufacturing process.

2.2.3.1 Design standardization

Group technology is applied in design by having design engineers code and classifies their designs based on a predetermined selection of characteristics. These characteristics can be functional as well as physical. When a new design is to be developed, the engineer can interrogate the data base developed for previous designs, review the alternative choices presented to him, and possibly locate an existing design that will satisfy some, if not all, of the new design needs. In this way, the number of new designs can be reduced, the parts that are used to make the products become standard, and the designs can become optimum as improvements are incorporated into already existing parts.

2.2.3.2 Manufacturing cell layouts

The logic behind forming group technology manufacturing cells is to create a production line environment for a batch manufacturing product base. This requires that the product be analyzed for a selection of a family of parts whose manufacturing parameters are similar enough to each other to permit processing with minimum process change. Once the family has been formed and the volume is sufficient, the cell can be established as a production line and the parts processed. The benefits derived from this type of manufacturing include reduced queues at the machines, reduced inventory, improved product quality, reduction in scrap and product damage, easier scheduling, better visibility of product schedule status, and quicker feedback of manufacturing deficiencies as they occur.

2.2.3.3 Process planning

Group technology and process planning form a natural partnership. In group technology, products are formed into families based on their characteristics. Process plans or routings can then be generated for the families and groups of families. The benefits of this partnership are reduction in the number of process plans, increased speed in developing the process plans, improvement in the plans over time so that they become optimum, and the application of the optimum plan for each part.

2.2.3.4 Purchasing

The use of group technology in the purchasing function is a more recent application as compared to design retrieval, cell formation, or process planning. The idea is to form families of items that Purchasing buys across the product base manufactured. These families will yield larger quantities thus creating large quantity buy discounts. In addition, buyers can be assigned to families thus enabling them to become experts in the purchasing of these families. This expertise can be transferred one step further to the categorization of vendors for families of commodities.

2.2.3.5 Manufacturing technology system design

Group technology is a manufacturing system technology; but the interesting thing is that it can also be used to aid in the design process for new manufacturing technology systems. What group technology provides to the designer is the ability for target selection of opportunity through a quick analysis of the product or commodity that the system is being designed to handle. By identifying and designing to certain characteristics of the product, the manufacturing system designer is able to apply the Pareto rule and create a design that will handle the majority of the product with a minimum system cost. This is extremely beneficial since it speeds up the system design, usually results in an easier system to implement, and forms a scientific basis for the economical justification analysis that is always required of the designer.

2.3 Part Standardization

The traditional technique of part identification within a company is by part name and number. This makes part design standardization difficult, since different names are used for the same type of part and part numbers do not contain the intelligence needed to identify similar parts. This causes a significant number of part duplications to exist because design engineering has no efficient way of retrieving previous designs and using them again. This problem can be fixed by developing a parts design database that is classified and coded by significant part attributes. The designer can then code the part he is trying to design, compare it to the classified and coded database, and retrieve designs that are at least partially equivalent to the one he is designing."

Standardization implies the use of preferred previously selected choices in place of the freedom of creating unique choices. In design, this has historically meant the use of old designs by the engineers and draftsmen during the creation of the new designs. Typically, the designer, or drafters "remember" an old part they have designed before and look it up in their files to use again. This method works fine as long as they remember the old part. Unfortunately, the system is totally based on memory. It is also limited to each person's experience, with very little possibility that previous designs by all designers will be considered for any one application.

The increased need for cost reduction in design and manufacturing during the last decade was triggered a major emphasis by industry on significantly increasing standardization. This emphasis has spawned several techniques that are extremely useful in reducing the number of "different" parts to be manufactured.

2.3.1 Design Retrieval

The limitation of the memory system for design standardization is lessening by the concept of group technology and design retrieval. The classical image of design retrieval is that of an engineer who is designing a simple rotational part. In this process, he rapidly generates a code for the part he needs, interrogates a parts data base with his code, and is immediately presented with three choices of similar parts, one of which matches completely. Unfortunately, such occurrences are the exception rather than the rule.

2.3.2 Steps to Develop Classical Design Retrieval Systems

1) Creation of a classification and coding scheme designed to accommodate the part attributes considered necessary for design engineers to use in design retrieval.
2) Once the scheme has been developed, the data base of coded designed parts is created. Each part has its part number identity that ties it to a family of parts whose attributes are similar, within prescribed limits.

3) When a new part is being designed, the engineer creates the basic part requirements and then uses these requirements to code and classify his conceived part. This coded group technology number is then used to identify a family of similar parts in the existing parts data base.
4) Once the engineer has identified the family, he can retrieve the actual drawings of the parts in the family and determine if any of them:
   - "HIT" – Find a part that can be used with little or no modification
   - "Partial HIT" – Find existing part, but requires significant modification
   - "MISS" – None of the existing designs are applicable

The design and implementation of a design retrieval system should follow the same procedure as classification and coding described previously in this chapter.

2.4 Classification and Coding (C&C)

Classification of parts is the process of categorizing parts into groups or families, base upon a set of rules or principles. The objectives are to group together similar parts and to differentiate among dissimilar parts. Coding of a part is the process of assigning symbols to the part. In order to facilitate data analysis, these symbols should have meanings that describe:

- Design attributes of a part: Dimensional aspect, material, etc
- Manufacturing attributes of a part: Process, sequential of process, etc

2.4.1 Definition of Classification and Coding

Snead (1989) gave definition of classification and coding with its functionality.

"Classification is defined as the process of grouping together like things. As such, it is really a process of separating things. Classifications can be monothetic, where the items in the formed group have all attributes in common, or polythetic, where each member has a majority of the characteristics of interest, but not necessarily all. It is important to note that in a polythetic classification, no single feature is essential nor sufficient for membership in the group.

"Coding is a technique of allocating predetermined symbols to provide for meaningful communications. In group technology classification and coding systems, the code is the identifier that is used to establish the identity of the classified group. Coding is an idea method to convert data from its natural state into a shorthand notation that is easy for computers to store, retrieve, and manipulate. This strength is one of the major reasons for the popularity of these systems."

2.4.2 Function of Classification and Coding

Classification and coding systems have the three primary functions.

2.4.2.1 Identification and filing

Classification systems can be viewed as natural or artificial based on the attributes or characteristics chosen to be identified.

- Attribute Classification
- System Ranges

2.4.2.2 Basis for inference and prediction

Forming a basis for inference and prediction about group members certain coexistent properties of a family may be predicted based on the likenesses and differences of the attributes used to form the family.

2.4.2.3 Explanatory information

Providing explanatory information about the family groupings

2.4.3 Benefits of Classification and Coding

1) Formation part families and machine cells
2) Reduce introducing unnecessary similar part
3) Increase quality and reliability in manufacturing process
4) Increase productivity in:
   - Design modification
   - Process planning
   - Tooling setup
5) Increase accuracy in:
   - Estimating tooling and machine utilization
   - Estimating cost of design and manufacturing
6) Support activities:
   - Design retrieval
   - Process planning and cell manufacturing
   - Development of tooling design
   - Construct program for NC machine
   - Part data base management

2.4.4 Type of Systems

Classification is the process of reducing a population of items into sub-divisions by arranging the items into groups based on an inverse hierarchy of selected attributes to be evaluated. Snead (1989) described, "This systematic process of developing a hierarchy of groups produces taxonomy. This term, usually associated with the classification of animals and plants, is certainly a proper one to use in referring to natural divisions within a manufacturing complex. Thus phrases such as material taxonomies, process taxonomies, etc. are coming into being in manufacturing jargon."

Classification system can eventually be separated into 2 major types as following:

2.4.4.1 Logic Trees

Taxonomies are created by making choices at decision points much like the traversal of logic or decision trees. An example of a binary logic tree is shown in Figure 2.1 (Left). A binary tree is constructed by using an “either/or” strategy at each node in the tree, such as shown by the dotted line in Figure 2.1 (Left). Classification using a binary tree is relatively easy since the user is only given two choices to make at each node. However, the tree can become quite lengthy in covering all alternatives. The poly tree, shown in Figure 2.1 (Right), may be shorter than the binary tree, since multiple choices can exist at any node. This, however, makes the use of the tree may have binary branches as well as poly branches, but the path chosen must still be an exclusive one, as shown by the dotted line in Figure 2.1 (Right). The binary tree and poly tree are both mutually exclusive path trees and “E-trees”. The E-tree is well suited for rapidly dividing large populations into small manageable groups. A third type of tree is the N-tree or non-mutually exclusive tree. The format of the N-tree is the same as either the binary tree or poly tree, but the logic allows multiple selections at any node so that several paths may be traversed concurrently. This permits the concurrent selection of independent attributes and eliminates the need to place them in a hierarchical form, thereby reducing or eliminating the “citation-ordering” problem of deciding which attribute precedes which.

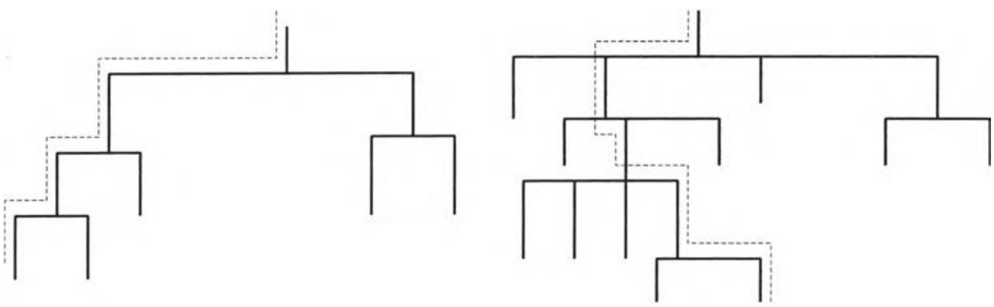


Figure 2.1 Example of Binary tree (Left), Poly tree (Right)

2.4.4.2 Code Types

Three basic types of codes are used in classification and coding systems. While they resemble the logic decision trees, the transition from trees to code types is not a clean one.

2.4.4.2.1 Monocode

The code type that comes the closest to matching a decision tree is the monocode. This code type takes the form of the E-tree where each node in the sequence is dependent on the selection made at the previous node. The structure of such a code is shown in Figure 2.2. As with the E-tree, a monocode can be used to rapidly subdivide a population into small groups with relative ease. It is much more difficult to determine the meaning of any particular digit. To do this, the entire code preceding the digit in question must be decoded in order to determine which particular branch of the tree the item is located in. An analogous problem would be to try and determine the significance of an "8" as the seventh digit of a telephone number if the first six digits were not known.

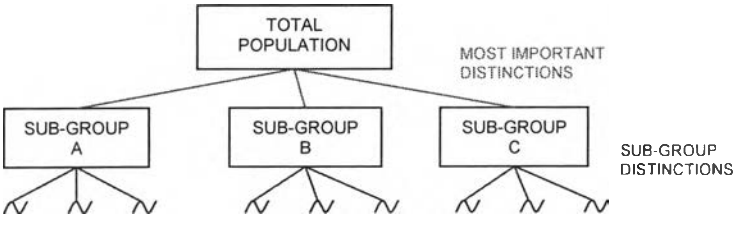


Figure 2.2 Example of Monocode structure Brisch Birn and Partners, Division of SABCO, Inc.

2.4.4.2.2 Polycode

The second major code type is the polycode shown in TABLE 2.1, which has each digit position totally independent of all other digits. In other words, each digit is used to completely classify some feature of the item being classified through the use of a multiple-choice question. Unlike the monocode, each digit of a polycode has a significance of its own and can be used to extract a definition of the item from the data base independent of any other digit.

The polycode is not structured like logic trees. In fact, there is little logic used in constructing such a code except that the features are usually listed and queried in order from the most important to the least important. This lack of logic transition creates the problem of attempting to describe every conceivable item in the population in detail. To accomplish this, the same questions must be asked about each item, even though some of the questions will not apply to the item. The result is that polycodes can become quite long in order to cover all aspects of the population and the coding can be very tedious.

TABLE 2.1 Example of Polycode Structure

DIGIT	FEATURE	POSSIBLE VALUES			
		1	2	3	4
1	External Shape	Shape 1	Shape 2	Shape 3	Shape 4
2	Number Holes	0	1-3	4-5	Above 6
3	Type Hole	Axial	Cross	Axial / Cross	Other
4	Gear Teeth	Spur	Helical	-	-
5	Splines	-	-	-	-

2.4.4.2.3 Hybrids

Most codes that are used in industry are neither monocode nor polycode, but are a hybrid of the two.

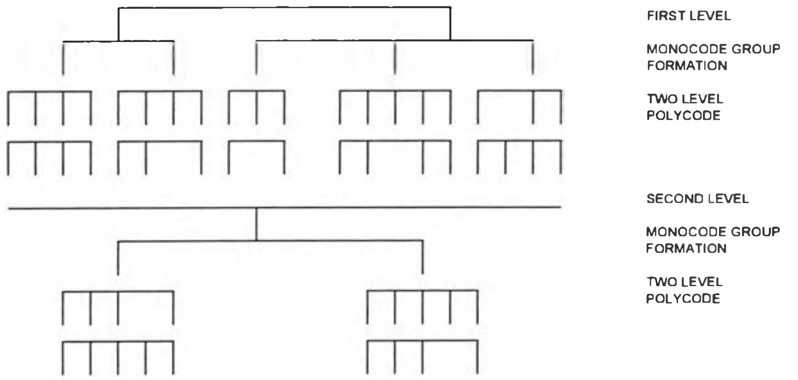


Figure 2.3 Hybrid code structure

A common form of hybrid coding is to divide the population into small groups using one or two monocode3 digits and then place a polycode series in each branch where the polycode series of question have significance to the group in the branch. Some systems, such as Optiz system to be described later, actually rejoin again to form a second monocode/polycode structure. This type of code, shown in Figure 2.3, is a series of small polycodes within a monocode structure where the digits within each polycode are independent.

2.4.5 Commercial Systems

2.4.5.1 Optiz

The Optiz classification system is a hybrid type consisting of five basic digits and four supplemental digits. The overall geometry of the code, shown in Figure 2.4, depicts the basic code used for machine components.

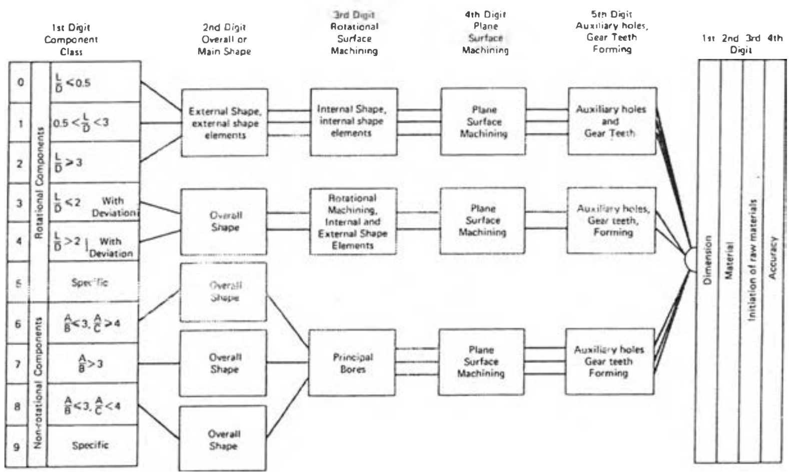


Figure 2.4 Optiz code structure

The first digit is monocode used to divide the population of parts into major families. The second digit further defines the shape factor and is quasi-polycode. The third through fifth digits are polycode in their respective branches. The four digits in the supplemental code are used to classify size, material type, raw material initial form, and tolerance class. The system was initially designed to code machined piece parts but has been expanded to cover other nonmachined parts such as castings, tools, assemblies, and materials. The code is well suited to design retrieval in its basic form, but it can also be expanded to include secondary codes of operation type and sequence, which improve its ability to address manufacturing applications.

2.4.5.2 MICLASS

The MICLASS classification and coding system owned by OIR (Organization for Industrial Research, Inc.) was developed out of the work done by the Organization for Applied Scientific Research in the Netherlands (TNO) in the 1960s and 1970s to develop a system for both design and manufacturing needs. MICLASS is an expandable hybrid code system that has the first twelve digits standardized. These digits relate to shape, form, dimensions, tolerances, and materials, as shown in Figure 2.5. The system can be enlarged to thirty digits to cover any classification attribute desired by the user.

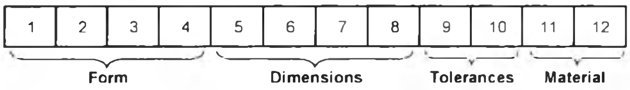


Figure 2.5 MICLASS code structure

OIR has made two significant technological changes in their coding system since the introduction of MICLASS. The first is the creation of a new system called MULTICLASS. Instead of a fixed decision tree format such as MICLASS, MULTICLASS is flexile and will only traverse the decision tree branch required for the item being coded. MULTICLASS is a general range system that can be set up to code any item desired. OIR has complementary software systems to MULTICLASS that are sued for process planning (MULTICAPP) and group technology manufacturing applications (MULTIGROUP). The second major change is a new generation of applications identified as the MULTI-II Family. MULTI-II is a set of integrated systems operating with the use of a relational data base that addresses engineering, production, and business applications.

OIR provides a full range of consultant services and will assist a company in planning and implementing a full range of group technology systems. Their main office is located in Bedford, Massachusetts, USA.

2.4.5.3 DCLASS

The DCLASS system was developed in the Computer-Aided Manufacturing Laboratory of Brigham Young University in 1976. DCLASS is an acronym for Decision and Classification Information System. It is not a fixed code classification and coding system but is a computer software system designed to rapidly and efficiently traverse decision tree logic. The software is able to process the various decision tree types. As it traverses the decision tree, the program sets a string of binary digits that is a code to the computer but is transparent to the user. This binary set code can then be used to compare the information with data bases of other coded information.

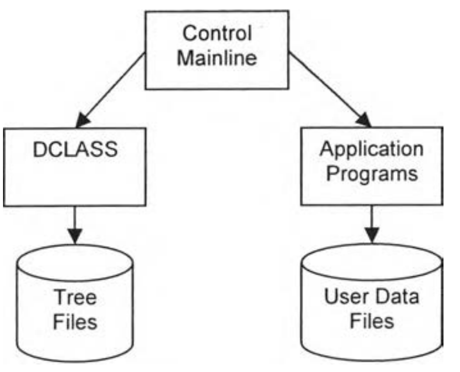


Figure 2.6 Integrated computer hierarchy with DCLASS

The system is designed to work within an integrated computer hierarchy shown in Figure 2.6. The control mainline and application programs are created by the user. DCLASS is used as the data base management software system. The user can prepare decision trees for any item to be coded; hence the system is a general range system. The system can process through E-trees or N-trees to form a monocode system, a polycode system, or a hybrid system. Another very important feature of DCLASS is that the software can link between branches of different trees. These capabilities make DCLASS well suited for design retrieval and manufacturing applications.

DCLASS is written in ANSI Fortran IV and is operational on several mainframe and personal computers. It is supported by CAM Software, Inc., Provo, Utah, USA. CAM Software, Inc. provides a full range of group technology application consultant services, as well as ongoing software support and training for DCLASS.

2.4.5.4 Brisch Birn

The Brisch system of classification and coding was first originated in England in 1948. The present system has carried forth the early Brisch system basic theory of providing a classification and coding system to introduce order, system, and control into the total manufacturing complex. Brisch has been a leader in pushing for a general range classification system. The Brisch Birn code is all-numeric and is not fixed, but is tailored by Brisch to meet the needs of the company implementing it. Each application becomes a fixed number of digits that provides a unique place for each part. A typical breakdown of the first digit subclasses is shown in Figure 2.7.

The Brisch code is well suited for design retrieval. The company has developed software to provide for the integration and retrievability of data necessary to produce a company's product. The software, called "The Alpha Graphics System" (TAGS0, functions as a minicompiler which can be operated on a central processor to provide for data management.

The Brisch organization is composed of Brisch, Birn & Partners Ltd., located in Marlow, Bucks, England and Brisch, Birn & Partners, Inc., located in Fort Lauderdale, Florida, USA. The company provides a full range of consulting services, and will develop a scope of work and a projected cost and benefits analysis of the project at a nominal cost.

0 – Organization and operation
1 – Primary or raw material
2 – Commodities
Commercially available catalogue items
3 – Components
Own design
4 – Subassemblies and assemblies
Own design
5 – Products
6 – Tools and portable equipment
7 – Productive plant and supporting spare part
8 – Auxiliary plant, services, and utilities
and supporting spare part
9 – Reserved for future needs

Figure 2.7 Brisch major subclasses-typical

2.4.5.5 CODE MDSI

CODE is the name of the classification and coding system provided by Manufacturing Data Systems, Incorporated.

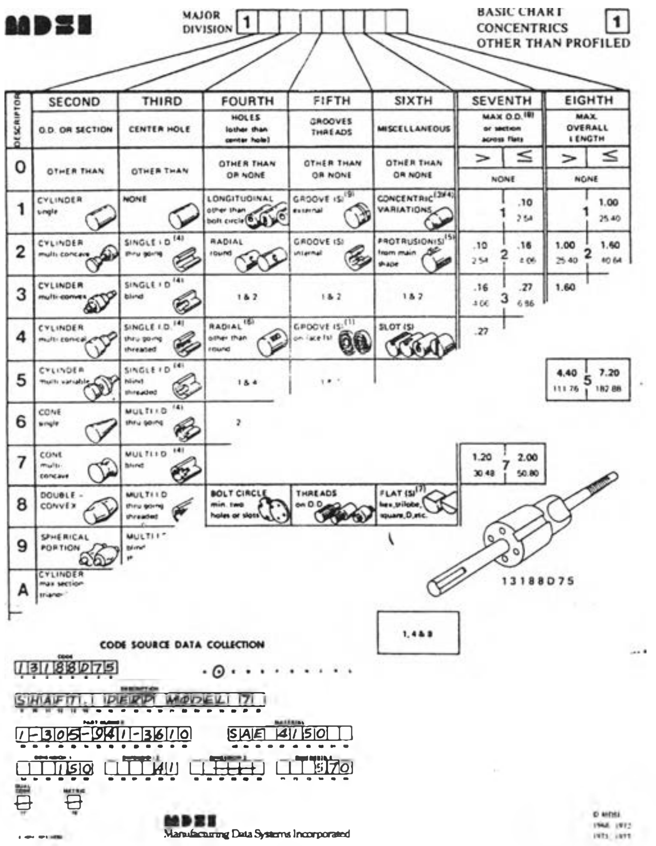


Figure 2.8 MDSI “code” polycodes

It is and eight digit hybrid code used primarily to classify and code mechanical piece parts. Each digit uses 16 characters: zero, one through nine, and A through F. This is known as hexidecimal notation. The first digit of the code is a monocode used to identify the major divisions. These divisions, while historically having been mechanical parts, will be modified by MDSI to meet the needs of the company installing the system. The major divisions are developed by MDSI based on a sampling of the parts to be classified and coded. The remaining seven digits are division specific polycodes used to describe the part shape, features, and dimensions, as shown in Figure 2.8.

MDSI has developed their system to operate on mainframe computers such as those made by IBM. The software system is designed to handle the code of the part, as well as other relevant part information such as tooling, routings, standards, tolerances, etc. This data can be stored by CODE into data bases or the CODE software can be adapted to retrieve this information from other established data bases in the company. This additional data combined with the code provides a good base for the system. To be used in design retrieval, as well as manufacturing applications such as cellular manufacturing and process planning. MDSI provides a full range of consultant services including application engineering, systems design, training, software development, and on-going system maintenance. Their main headquarters are located in Ann Arbor, Michigan, USA.

2.4.6 General Criteria of Selecting a Classification and Coding System

Even though several classification and coding systems have been developed, and many people have tried to improve them, there is no system receiving universal acceptance. The information that is to be represented in the classification and coding system will vary from one company to another because each company has some unique needs according to its local environment even the needs of the system are the same. As a result, classification and coding systems can be purchased but the system has to be modified to fit the specific needs of a particular company.

The basis upon which to select the classification and coding system must be well assessed by cross functional team of a company. The attribute analysis technique is recommended for use in the selection process. The major performance attributes that should be considered can be derived from the set of principles of classification accumulated by Dr. Dell Allen of Brigham Young University. The essences of these principles are repeated here.

1) Principle of Utility: Any classification system must be capable of readily and reliably filing and retrieving useful information in accordance with the intended application.
2) Principle of Efficiency: There must be a balanced efficiency in coding and in retrieval. A simple classification system usually provides rapid coding but inefficient retrieval while a complex system is usually the opposite.
3) Principle of Attribute Selection: Each item has many attributes; however, the ones chosen for classification should be based on ease of identification, significance, and performance.

4) Principle of Relationships: Relationships between characteristic attributes in the classification hierarchy should progress from general to specific and from abstract to concrete.
5) Principle of Inclusiveness: The classification hierarchy will provide for grouping within a family of every item to be included in the system.
6) Principle of Discrimination: The classification system is to provide the user with significant relationships and attributes that can aid in readily and accurately selecting the attribute choices placed before him.
7) Principle of Flexibility: Each classification system will accommodate existing and additional related families with minimum restructuring. It should be product independent and not customized to particular products.
8) Principle of Standardization: Recognized and accepted industrial terminology, connections, and groupings will be used as long as they do not interfere with enumerated principles and rules.
9) Principle of Citation Order: Citation order of engineering processes will flow from general subject or thing to specific. For example, a dependent facet must follow the one upon which it is dependent.
10) Principle of Conversion: When a classification in one format is converted to another format, opportunities for improvements in the classification almost inevitably present themselves.

It is possible that the team would want to add some other elements to be evaluated, such as cost, modifications required to make a fit, type of computer system required, etc. Once the elements are chosen, the weighting analysis must be completed. At this point, the team is prepared to begin the detailed data search that will eventually lead to the receipt of formal system proposals to be evaluated.

2.4.7 Implementation plan

The implementation plan should be created during the early educational data gathering phase, and be reviewed through to the actual implementation itself. The minimum items to be covered are:

- Plans for data base development,
- Hardware installation,
- Software testing and debugging,
- Documentation of the system,
- Operating procedures, and
- Training.

Flexibility is a key element required. Users will often have their own view of how to accomplish some phase of the implementation and it is to the team's best interest to try and incorporate these views into the process as long as the ultimate goal is not compromised.

Snead (1989) suggested, "The implementation plan should be broken down into subsets of activities with due dates and responsibilities assigned to the lowest level. Users should be assigned these responsibilities wherever possible so that they actually become part of the implementation team. One technique that can greatly enhance the probability of success is to implement the classification and coding process in concert with the group technology application sequence so that the data developed by the users will be used in a production mode as rapidly as possible. An immediate payback, no matter how small, can have a significant positive impact on how the total system is received by the users."

2.4.8 Pitfalls to Avoid

The following are just a few of the pitfalls that should be avoided when implementing the system.

1) System too narrow and too expensive to expand: The initial system that is installed will probably be rather expensive. If it is designed too narrow and is expensive to expand, it will never be used for any applications except the original one for which it was designed. Flexibility should be designed into the system even if the first application is narrow. A good rule of thumb is to design the system to last for a minimum of twenty-five years.
2) Never-ending project: Set some definite boundaries around the initial project to help in controlling its growth. Invariably, the team members will want to expand the system as it is being designed. Some growth can be accommodated, but a definite cut-off should be made at some point and an implementation made of what exists.
3) Lack of data development resources: The implementation of a system is only the beginning of its life. Provisions must be made before implementation for the proper resources to be available to operate the system. One resource that is often overlooked is the data base development resources which in this case are the classification and coding people.
4) No practical use of data: The implementation of the classification and coding system will produce classified and coded items. What is this data going to be used for? There should be a definite application for the data that will have a payback in two ways. The first is a financial one to the company. The second payback is that the data should help someone in the organization to do his job better and easier.
5) Communications breakdown: Whatever else the team does, it should never cease to communicate with others outside of itself about the project. Open communications on a regular basis with all levels within the company is necessary for acceptance of the system.
6) Team longevity: The team leader and the system creator should always make plans to dissolve the team as the system comes on line and is put in production. The members can leave gradually as the need for their services declines but there should never be an attempt made to keep the team intact to continue running the

project long-term. If a new organization is required, disband the team and have management change the structure to provide for the new resources.

2.5 Data Base Development

Part of the new trend in corporate data creation is to develop data bases that identify and describe the products, processes, capabilities, and resources available to combat the competition. These data bases can also fulfill the data base needs for group technology. Database is necessary for the decision process to take place in a group technology application.

2.5.1 Data Base Development Methods

Companies that have practiced group technology in the past usually have developed the data bases independent of other corporate data base endeavors. The methods used to acquire the data have been designed to yield the desired results with a minimum expenditure of resources. These desired results have been centered on the three major applications of the design retrieval of parts, manufacturing cell formation, and process planning. This narrow selection of applications has restricted the data acquisition to parts information and/or process information, with little attention being paid to other manufacturing elements.

2.5.1.1 Peripatetic or Ocular

The formation of part families through the process of sight stimulation is perhaps one of the fastest and least expensive methods available. It is also one of the most restrictive, since the data collected is not in a form that is easily transferred to other applications. One of the most famous examples of ocular data collection is the example of the Langston Company in Camden, New Jersey. Langston formed product groupings by taking photographs of the parts and then sorting them into families based on part size and configuration.

2.5.1.2 Production Flow Analysis

Production Flow Analysis (PFA) is a technique used to simplify material flow and to develop group manufacturing of parts.

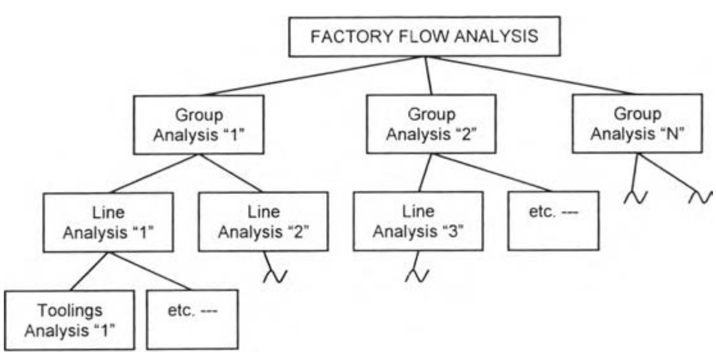
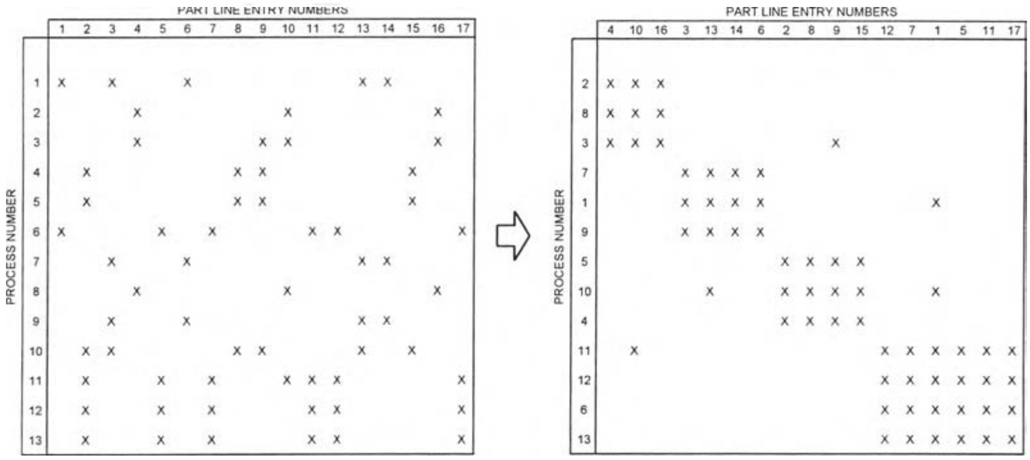


Figure 2.9 Production flow analysis hierarchy



2.5.1.3 Classification and Coding

The third method of developing group technology data bases is classification and coding. The terms classification and coding are used interchangeably, but in reality are two separate and distinct operations.

Classification is the technique of grouping like things. The idea is to key on specific attributes or characteristics of the items in a population and extract from the population as a class those that have the same specific attributes selected. Classification is not a new process, as some group technology enthusiasts may believe, but is one that has been used for years to logically form groups of like objects.

While classification has existed for many years, its usefulness in today's manufacturing enterprise is severely limited unless it is tied to a coding or shorthand notation system that will permit the development of a data base of the classified objects. This data base can then be handled with present-day computer capabilities to sort the data into desired groupings, to make comparisons between sets of the data, and to synthesize information from the logic of the data, thus providing the capability to plan and implement new manufacturing technologies.

The use of classification and coding in developing data bases of manufactured parts has grown in popularity as group technology has advanced. A study conducted in 1976 of metalworking companies in the United States revealed that 50 percent of the companies that practice group technology use classification and coding to develop their data bases. Classification and coding has several strengths that lead to the popularity over ocular and production flow analysis data-gathering techniques. The first is that a wide range of data can be collected in one data base dealing with the entire manufacturing complex. This is not true of production flow analysis, which deals strictly with the manufacturing process of parts. A second strength is that the data is in a format that is easily handled by the computer. This permits significant data sorting and analysis to be done rather quickly. The third strength is that the data is created in a structured way following a defined set of rules. This tends to make the data more consistent from person to person and lends more capability to the entire process.

2.5.2 Trends in Group Technology Data Base Development

The tendency of group technology implementers has been to sue the group technology concept for very specific applications. This tendency has carried over into the development of the data bases. Regardless of whether ocular, production flow analysis, or classification and coding have been used, the typical result has been to restrict the data to that addressing the specific application in mind. This trend seems to be reversing itself, and modern group technology implementers are beginning to expand the data bases to be more generic. This is particularly true where classification and coding is involved. Often the process followed is to structure the data base to be more encompassing, but to initially only capture a part of the data. This at least allows for one integrated data base structure that can be added to as resources are available to develop the data.