CHAPTER II

THEORETICAL ASPECTS AND LITERATURE REVIEW

To solve the problems presented in the first section, the solution can be divided into two parts. First, the company has to develop computer database system in order to improve the efficiency of data maintenance. Second, the company has to establish a classification and coding system in order to support the database system. However, before the computer database system can be constructed, the classification and coding system should be established first. Thus, this thesis will present literatures concerned to the classification and coding system and database management respectively.

2.1 Group Technology

2.1.1 Introduction to Group Technology

In fact, humans have been unofficially applying group technology concept for centuries. However there is no formal description of group technology application in manufacturing until Mitrofanov [1] published his book in 1959. He defined group technology as

"A method of manufacturing piece parts by classification of these parts into groups and subsequently applying to each group similar technological operations. The major result of this method of manufacture is to obtain economies which are normally associated with large scale production in the small scale situation and it is therefore of fundamental importance in batch production and jobbing sections of industry". After that, many books related group technology were published. Group Technology was therefore defined in many terms such as

"The realization that many problems are similar, and that by grouping similar problems, a single solution can be found to a set of problems thus saving time and effort" Soloja [2]

"A technique that concerned with discerning underlying similarities in products, parts, processes and production resources by structuring these entities into clusters based on common attribute values" Gallagher [3]

Thus, we can conclude that group technology is related with discerning underlying likenesses in products, parts, processes and production resources by structuring these individuals into groups based in ordinary attribute value. One significant principle of group technology requires separating the manufacturing facility into small group of machines and each group is dedicated to a specified set of part types. Often, the term cellular manufacturing can be used in this regard. The connotation of a group is a small group of one or two machines but seldom more than five. It might contain a machining center, monitoring device, tool and part storage, a robot for part handling, and the associated control hardware.

2.1.2 Part Family Development

Naturally, person's mind cannot readily work with the large amount of data at one time. Alike human mind, computer is then created in order to manipulate considerably more data. However, computer also has limits on the amount of data that can be manipulated at one time. For this and other reasons, it is advantageous to find ways to organize data in order that only related items need be retrieved and analyzed at a specified time. To accomplish this, methods of structuring data have been devised such as data structures used in large computer data bases, data listing words alphabetically in a dictionary, and the coding and classification of books in library catalog. More elaborate systems have been devised, such as the taxonomy used in biology to classify all living things. This last example illustrates how thousands of items can be organized so that reasoning can be applied to small group with some similar attributes.

The complexity of materials flow has been identified as a major production management problem in batch manufacturing companies. A company may make thousands of different parts in environment that becoming more complex as lot sizes get smaller and the variety of parts increases. When they are examined closely, however, many parts are similar in some way. Items with similar geometric features

should have similar designs. Therefore, firms will often find that these parts fall into families based upon their manufacturing characteristics, and a group of perhaps ten products could require very similar processing in terms of machinery, process sequence and operation times.

According to Bedworth [4], part families can be defined as a group of parts based on their attributes. Usually, these attributes are based on production process or geometric characteristics shown in figure 2.1. Production process classification shown in figure 2.2 is normally based on sequence, type, and number of operation such as method of processing, the tooling, and the conditions of processing.

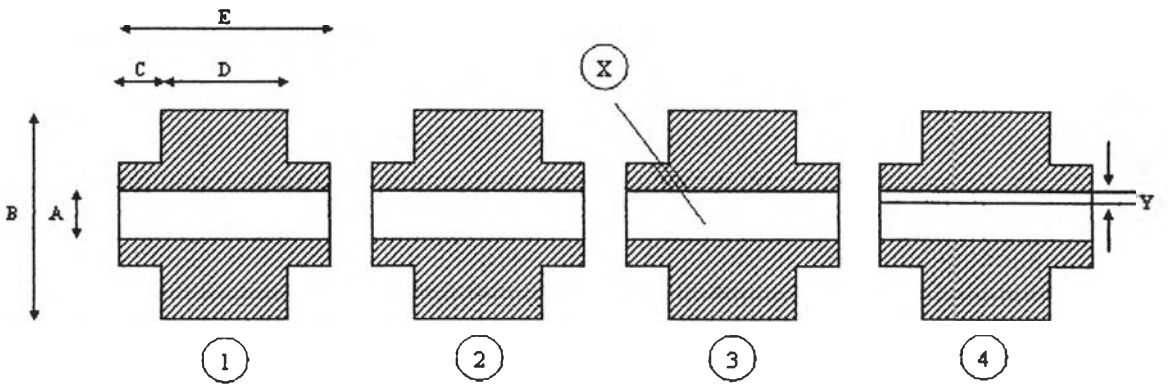

Figure 2.1: Parts grouped by geometric shape [4]

Geometric classification shown in figure 2.1 is generally based on size and shapes of parts. The recognition of a family of parts having resemblance permits the economies of scale usually related with mass production to be applied to batch production.

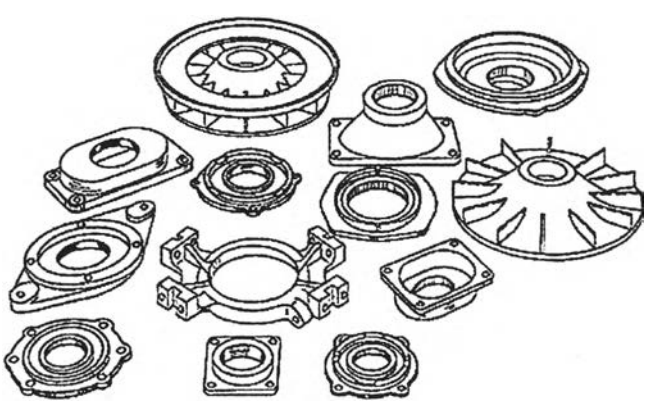

Figure 2.2: Parts grouped by manufacturing process [4]

As a result, a key to implementation of group technology philosophy is the successful grouping of associated parts into families. Generally part families can be formed by three basic ways, which are

1. Manual visual search,
2. Production flow analysis
3. Classification and coding

1. Manual visual search

Commonly, Manual visual search is the easiest method; however, it is rarely applied in formal group technology application. As people having different knowledge, the result of grouping is inconsistent. Moreover, when the number of parts significantly increases, the efficiency of this method will be limited. For that reason, Production Flow Analysis (PFA) and Classification and Coding are more widely concerned.

2. Production flow analysis

Developed by Burbidge [5], Production flow analysis (PFA) is a method used for analysis the operation sequence passed by parts or products during manufacture. Since parts are grouped into part families, the machine used to operate them should be grouped as well. Anyway, to apply PFA, the organization should have enough reliable information about the operation sequences. The advantage of PFA is that the organization does not have to classify and code parts. Conversely, the reliable of information is the weak point of it. PFA technique will turn a number of parts and machines into a matrix called machine-component chart shown in the following figure 2.3. According to the figure, parts with similar operation can be grouped by sorting the rows and columns. When the chart is small, user can manually group them. On the contrary if it is very large, computer procedure should be used to perform this work. In general the successful of machine-component chart is depended on the accuracy and efficiency of each part's routing, which do no exist in common firms. If they do, however, they are often inaccurate from lack of maintenance, or they are inconsistent. Moreover since some parts cannot be grouped

into a family when one or more unique operations are required, judgment of users is then involved.

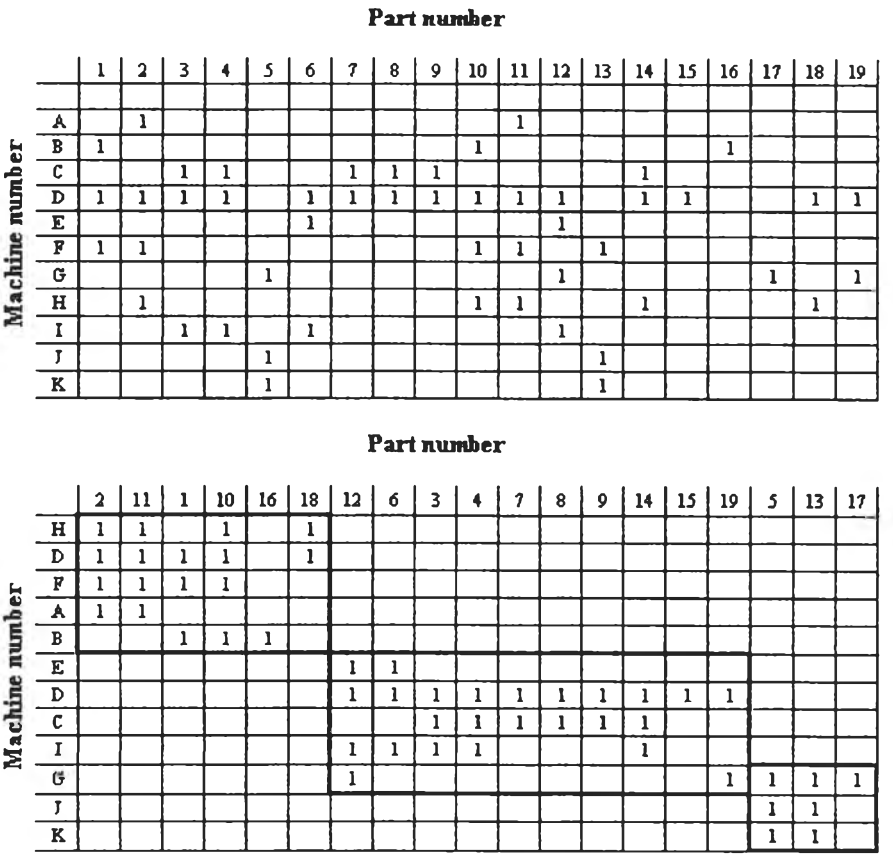

Figure 2.3: Component-machine chart [5]

2.1.3 Classification and Coding System

2.1.3.1 Classification

According to Bakewell [6], classification part is the basis cognitive process of arranging parts into classes or categories. The basis objective of classification are that parts having similar attribute should be classed together while those are dissimilar should be differentiated. The intent of the part is to describe characteristic or any attribute of each part that will facilitate determination and retrieval of similar parts. In general, when a part is required, the other related parts are also required. Therefore, the classification system will allow user to maintain and utilize everything that relates to each other quickly and easily.

Significant issues for effective classification system

Sadar [7] has summarized the significant issues that the efficient classification system should have as follows:

1. System has to cover all existing and future parts totally.
2. System has to provide benefits to user realistically. This means when the system is activated, user will be able to find a target object and also return it to the same location.
3. System has to arrange main category and sub-category logically and theoretically
4. System has to specify appropriate code for both categories.
5. Code developed by the system should not be too complex and long because it will be difficult to use. If a code is short and meaningful, user will be familiar with it more quickly.

Classification Scheme

According to Sayers [8], classification scheme is a method used for classify objects such as books. If a method can specify remarkable characteristic, the company will be able to divide objects into appropriate category efficiently. Generally, the characteristic of effective classification scheme are listed as follows;

1. It can immediately determine a category to a part.
2. It should have apparent meaning. A user does not have to interpret it again.
3. It should be proper to the target size of database.

2.1.3.2 Coding system

According to Askin [9], coding system is a system that used to determine code for each part. Coding system can be guided by four major issues, which are population, code detail, code structure, and digital representation.

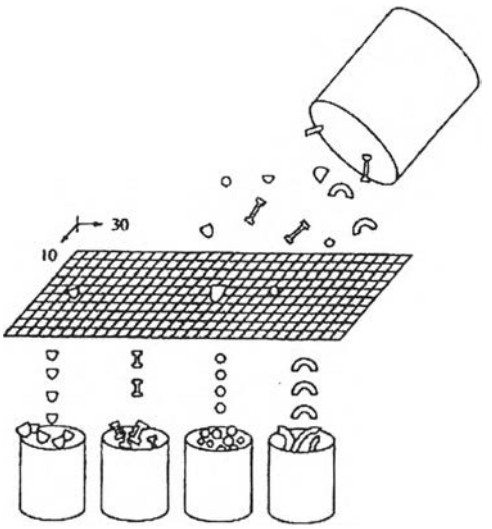

Figure 2.4: Classification Scheme [8]

I) Population

In general population of parts or entire class should be enclosed when coding system is developed. The scope of part types such as part rotational, prismatic, or other attributes has to be acknowledged. The coding system should be flexible to handle future parts. It should discriminate between parts with dissimilar values for key attribute. For example, part having different size may require different machine tools, while some parts may need threading, turning, grinding, or reaming whereas others do not.

II) Code detail

The second issue of coding is code detail. The level of code detail is one of the most significant subject to the success of coding scheme. Using of extra details brings firm unwieldy codes and waste of resource in data collection whereas using too few details result s in useless code.

Normally it is better to have code that can uniquely identify the specific part and also describe a part from design and manufacturing viewpoint. All information essential for classing the part for manufacture should be included. Features related to a main part like external shape and internal shape, protrusion, and hole are typically included in the coding scheme. Besides, features likely to change with time such as

demand is normally not included in the primary code, even if it may be significant. The secondary shape such as chamfer and thread are also needed to be considered whether it should be included or not. Consequently the code developer has to consider all trade off such as cost, time consuming of all shapes before contain it into the code.

III) Code structure

The third issue of coding is code structure. Generally codes are classified into three basic types, which are Hierarchical or Monocode, Attribute or Polycode, and Hybrid or mixed.

• ***Hierarchical Code***

Supporting that people have been classifying and coding things for a long time, the hierarchical code coding system was originally developed for biological classification by Linnaeus in the 1700s. The structure of hierarchical code shown in figure 2.5 exists when the meaning of a digit in the code depends on the values of preceding digits. This means each character amplifies the information of the earlier character. It provides a large amount of information in a relatively small number of digits. This advantage will become more apparent when we look at an attribute coding system.

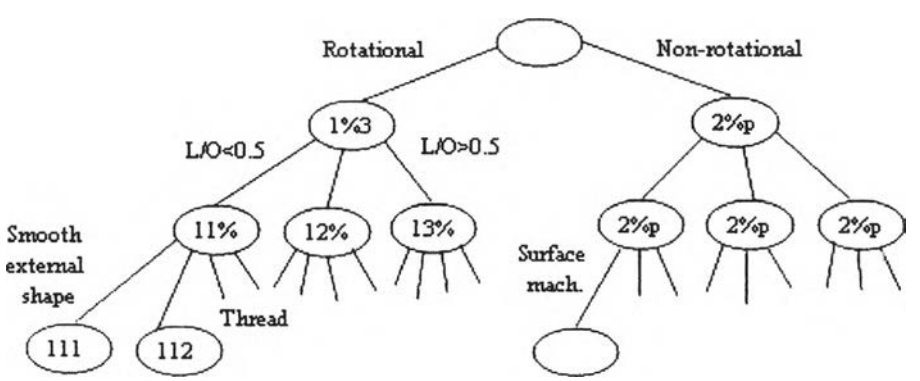

Figure 2.5: Hierarchical Code [9]

A Hierarchical code is efficient in that only relevant information need be considered at each digit. The values for each digit can be used to convey meaningful data in all instances. However, hierarchical codes are difficult to learn because of the large number of conditional inferences. Furthermore, to determine the meaning of each digit in the code, each preceding digit has to be decoded first. For instance, the value of 0 in the second place of code value 1034 may indicate the existence of internal threads in a rotational part. Whereas the value 0 of code value 2034 may refer to a smooth internal feature of rectangular part. Frequently, the design department uses hierarchical coding system for part retrieval since it can capture shape, size, and material information effectively. On the contrary, the manufacturing department does not require this type of coding system since it cannot analyze and retrieve process-related information. As a result, it is difficult to apply it usefully for both design and manufacturing group.

• ***Attribute Code***

Different from Hierarchical Code, Attribute code or polycode is easier to learn but less efficient. In the code, each value for each digit has a consistent meaning. The meaning of each character is independent of any other character, so each attribute of a part will be assigned to a specific position in the code. The structure of attribute code is shown in the figure 2.6.

Code Digit Feature	1 Outside shape	2 Inside shape	3 Holes	4 Surace Mac.	....
Value	None	None	No	None	
1					
2	Smooth	Smooth	Smooth ax.	External grv.	
3	Stepped ends	Stepped ends	Smooth rd.	External spl.	
4	Stepped and threads	Stepped and threads	Axial and radial	Internal Cuv.	
⋮					

Figure 2.6: Attribute Code [9]

For example, the value of 0 in the second place of code value 1034 and 2034 will indicate the same attribute. As a result, certain digits may be almost meaningless for

some parts. In general, this type of coding system is well-accepted by manufacturing department as it can identify similar feature that require similar operation. On the other hand, since a position in a code has to be reserve for only one attribute, the final code may turn out to be a very long code.

• ***Hybrid Code***

Since both hierarchical and attribute codes have different advantages, most coding system then become a hybrid or mixed coding system. This code type can utilize all advantages of them. Shown in the figure 2.7, Hybrid code naturally utilizes a section of code that is chain in nature and then switches to several hierarchical digits to additional detail the specified individuality.

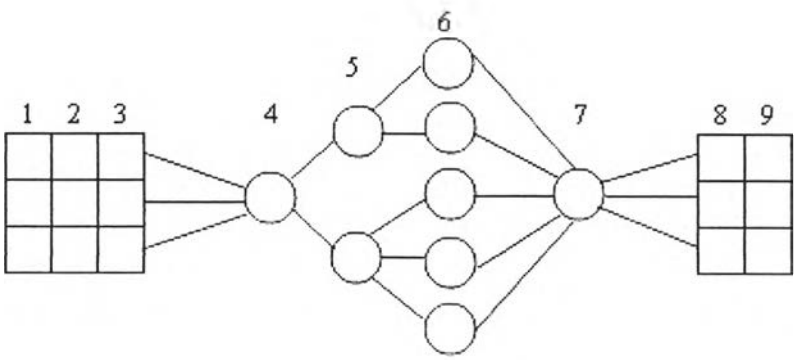

Figure 2.7: Hybrid Code [9]

IV) Code representation

The last issue of coding is code representation. Since representation is the issue that closely associates to the users, it should offer detailed meaning or information. In common computer speaks binary best, and the many parts coded justify consideration of storage and retrieval efficiency. Besides, humans are more familiar with alphanumeric characters especially if characters convey meaning such as use of "S" for smooth or "T" for thread. Therefore, the presentation can be divided into three types, which are numeric, alphabetic, and alphanumeric. The selection of representation types is usually depended on the desired number of categories for each digit. Significantly, in order to facilitate comprehension of code and interpersonal communication, organization should consider the standard industrial terminology and grouping.

2.1.4 Example of coding systems

Since all issues of coding system were presented and we have already known that many coding system have been developed, this section will provide three examples of famous coding systems, which are OPITZ, DCLASS, and MICLASS.

2.1.4.1 OPITZ Coding System

Developed by Opitz [10], the Opitz system uses nine-digit hybrid code that can be extended by adding four more digits. The first five-digit code specifying the geometric characteristics of the part, and a four-digit supplementary code giving the diameter or edge length, the type of material and its initial form, and the accuracy to which the part is manufactured. Depended on the particular firm, the extended four-digit are referred to as the "secondary code" and are intended to represent manufacturing data. Figure 2.8 illustrates an overview of the Opitz code.

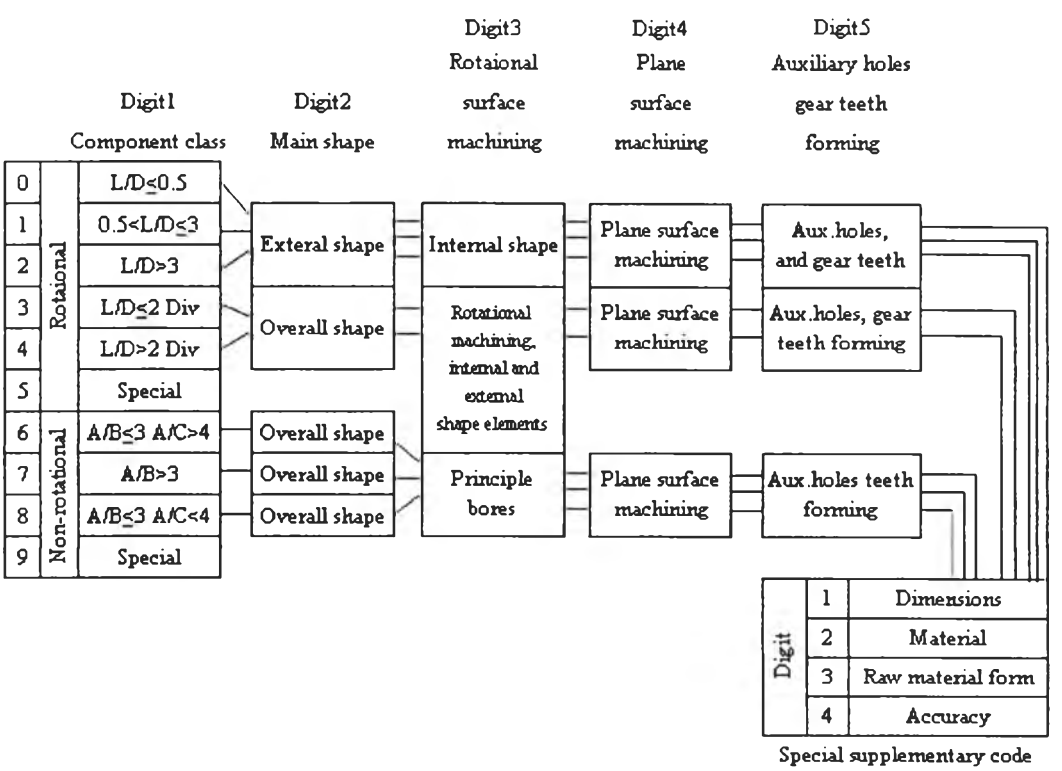

Figure 2.8: OPITZ code structure [9]

The Opitz classification for a particular component might take form:

In this code, the first digit (1) identifies that firm is dealing with rotational component whose ratio of length to diameter is less than 0.5. The second digit (1) specifies that there is no external shape element. The third digit (0) indicates that there is no through bore exists. The fourth digit (0) specifies that no surface machining is required. The fifth digit (1) shows that the component contains axial holes related by a drilling pattern.

The first digit (4) of the secondary code represents that part has diameter between 160 and 200mm. The second digit {3} identifies the steel type. The third digit (0) presents the initial shape as a round bar. The fourth digit (1) signifies the requirement for accuracy level 1.

Since the required machining set-up characteristics can be figured out from the code, by searching for parts whose code suits a particular set of criteria, parts that should be machined within the similar set-up can be recognized and the total demand for this family can be examined with regard to the throughput capacity of the available machines.

2.1.4.2 DCLASS Coding System

Developed by Brigham Young University, DCLASS (Design and Classification Information System) is a coding system provided for educational and research purposes. Although its was primarily used in university environment, many companies are using it for prototype development. According to the Computer Aided Manufacturing Laboratory [11], the following premises were adopted and used as the basis for the development of the DCLASS Coding System.

1. The best characteristic of a part is its basic shape, especially its most apparent attribute.

2. A part may be completely characterized by basic shape, precision features, material type, size, condition, and form.

3. The basic shape can have many features such as threads, slots, holes, and grooves.

4. Short code segments can be associated to establish a part classification code, which in human-recognizable and adequate for human monitoring.

5. More detailed information can be pointed by each of these code segments.

The structure of DCLASS code is contained by eight digits illustrated in figure 2.9. These digits are separated into five segments, which are basic shape, form features, size, precision, and material.

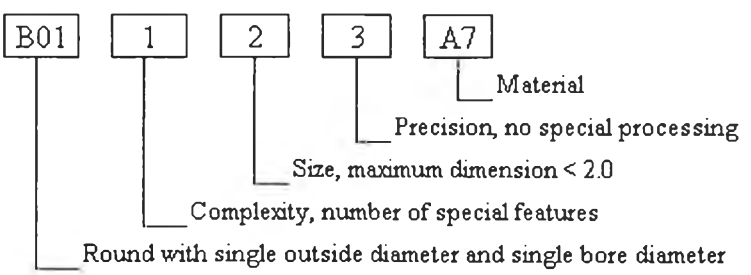

Figure 2.9: DCLASS code structure [4]

The first segment or basic shape segment composed of three digits. Normally these digits are identified by answering questions posed by an interactive computer program. However, to code part manually and easily, DCLASS part family classification chart is structured as a logic tree shown in figure 2.10. This sample logic tree is just one of many such charts in DCLASS Coding System.

The second segment or form feature segment is contained of one digit. It is used to specify the complexity of the part such as features, heat treatment, and special surface finishes. The various code of this complexity of the special feature is provided in table 2.1

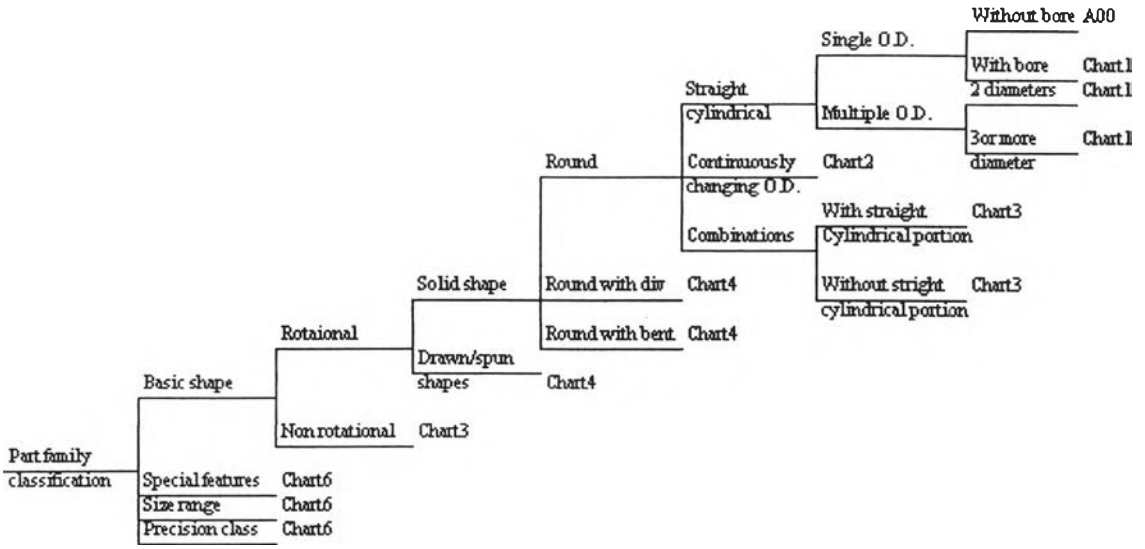

Figure 2.10: DCLASS logic tree [4]

Feature complexity code	No. of special features
1	1
2	2
3	3
4	5
5	8
6	13
7	21
8	34
9	>34

Table 2.1: Complexity code for special features [4]

Consisted of one digit, **the third segment** denotes size of a part. Several of size is specified in code shown in table 2.2.

Size code	Maximum dimension		Description	Examples
	English(in)	Metric(mm)		
1	0.5	10	Subminiature	Capsules
2	2	50	Miniature	Paperclip box
3	4	100	Small	Large matchbox
4	10	250	Medium small	Shoebox
5	20	500	Medium small	Bradbox
6	40	1000	Medium large	Washing machine
7	100	2500	Large	Pickup truck
8	400	10000	Extra large	Moving van
9	1000	25000	Giant	Railroad boxcar

Table 2.2: DCLASS size code [4]

The fourth segment refers to the precision of the part being coded. The precision represents a composite of tolerance and surface finish. Five classes of the precision are listed in table 2.1.3. Class 1 illustrates very tight tolerances and a precision-ground or lapped surface finish, while Class 5 represents loose tolerances and rough-cast surface. Thus a part classified in Class1 normally requires cautious processing with careful inspection.

Class code	Tolerance(in)	Surface Finish (rms)
1	≤ 0.0005	≤ 4
2	0.0005-0.002	4-32
3	0.002-0.010	32-125
4	0.010-0.030	125-500
5	>0.030	>500

Table 2.3: DCLASS precision class code [4]

The last segment or material segment composed of two digits. Like basic shape segment, material segment are normally identified by answering questions posed by an interactive computer program. However it is easier to be identified by using logic tree.

Since DCLASS Coding System would be easy to computerized, Dell Allen [12] at Brigham Young University has developed a general-purpose computer system for processing classification and decision-making logic. It is available for many types of computer such as micros, minis, and mainframe.

2.1.4.3 MICLASS Coding System

According to Chang [13], MICLASS (Metal Institute Classification System), one of the most popular commercial systems available in the state, was developed by the Netherlands Organization for Applied Scientific Research. MICLASS Code is consisted of 12-digit code that can be extended by adding more digits, which are normally depended on the desires of a company.

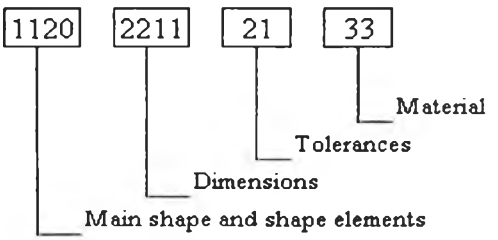

Figure 2.11: MICLASS code structure [4]

The first 12-digits code is used to classify the engineering and manufacturing characteristics of part that are main shape, shape elements, position of elements, main dimensions, ratio of the dimensions, an auxiliary dimension, tolerances, and material. The additional code can be added when the first 12-digits code does not offer enough information. They can be vendors, costs, or lot sizes. Since it is specified by a firm, it can contain as many as 18-digits. Therefore, the final code of MICLASS can be comprised of 30-digits.

Obviously it will be a very tedious and time consuming task if a user has to construct MICLASS code by manually. Certainly more human errors are able to be made. As a result, several interactive computer programs were developed in order to assist the user. Users have to answer the questions respectively while the program collects all data and codes a part. Since the reply is shown in "yes" or "no", users do not need to have depth computer knowledge. Furthermore, there are many subjects that can be done by these programs. For instance, they can be applied for design classification, improving control and speed of material, elimination of design duplication, optimization of machine tool purchase and use, and manufacturing standardization. Consequently these programs are the reason why MICLASS Coding System has been so successful.

Once some of famous coding systems were presented, the way to select the most suitable one for each company is going to be presented in the next section.

2.1.5 Coding System Selection

In accordance with Bedworth [4], there are 8 factors that should be considered when selecting a system. Anyway, there may be other factors that could be added to the below list. Even if none are added, the problem of selecting the system may not have a trivial solution. Before a particular system is select, therefore, a thorough evaluation should be performed of what is available.

• Objective

Firstly, a firm has to set the objective of installing coding system. The objective is normally depended on the requirements of a user. For example, from the engineering perspective, some typical objectives are:

- Offer an efficient retrieval system for similar parts
- Offer information of a part in a standard form
- Offer and efficient means to establish manufacturing capability and producibility

However, from the manufacturing perspective, some typical objectives are:
- Offer information required to form part families
- Offer for efficient retrieval of process plans
- Offer an efficient means to form machine groups or cells for part families.

• Robustness

A company should select a system that can handle both current and future parts. Planned group technology application and part attributes that might be needed will be involved in this analysis.

• Expandability

As it is difficult to design a coding system that can handle everything during indefinite future time period, one of the most important characteristic that it should have is expandability.

• Differentiation

The coding system should provide differentiation among its codes. For example, once all parts produced by a firm are coded, they might be classified as being in one family. On the other end of the spectrum, after all parts are coded, each part might represent a distinct family. These cases show that the coding system did not provide the appropriate amount of differentiation.

• Automation

At present, most coding and classification systems have been implemented by using a computer. Thus, when evaluating a potential system, code developer should spend time to evaluate how well the system has been automated. This evaluation should not be restricted only to the coding and classification, but it should consider the associated data base methodology and retrieval and analysis functions.

• Efficiency

Code developer should evaluate the number of digits required to code a general part, the code efficiency. If it is too small, determine if this number can be increased.

• Cost

Certainly, cost is one important factor that should be concerned. It includes the initial cost of the system, cost of modifying the system, cost of using the system, and cost of integrating the system to existing computer system.

• Simplicity

People who are going to use the system must be considered. Because some of them may not familiar with computer systems, ease to use is necessary for their acceptance, training considerations, and cost of use.

2.1.6 New Coding System Development

Although this section will provide the general steps of creating coding system, developing a new coding system is something that cannot be done in a short period of time.

Step 1: A company has to choose a sample of parts. Since the system should accommodate all parts, purchased parts should be included in this sample.

Step 2: Drawings of the sample parts will be assembled. It can be sorted into families by manually examining each drawing and grouping together those having similar features. This step will allow code developer to identify which part features have a high frequency of occurrence. After that machine tools used for manufacturing these parts can be identified. Also the company can link the groups of parts to existing machines in the factory. Certainly, purchased parts cannot be linked to the manufacturing capabilities. Anyway, they should be considered since the company may have to produce them in the future. Furthermore, the system can be used to select vendors when the machining capabilities of the vendors are known.

Step 3: To minimize the time required to code a part, once the part features are identified, a hierarchy of them should be established. If certain attributes are identified before others, a part can be coded in less time. For instance, if the company identifies the part as rotational, then all attributes that apply only to non-rotational parts can be ignored.

Step 4: After the system has been developed, the next step is to test it. The company can done it by coding the sample of parts. After that the results will be analyzed how well it the part can be grouped into families. This step involves several iterations before the company is satisfied with the system. Since it is required so much effort to do this process, some companies have decided to purchase a coding system and then modified it to meet their special needs.

2.1.7 Application of Group Technology

According to Burbidge [5], Group Technology is quite general, and has applications in many areas of manufacturing systems: Design Data Retrieval, Machine Cell Formation, Jig and Fixture Development, Computer Aid Production Planning, Group Scheduling, and Raw-material Management.

Design Data Retrieval

Generally, group technology can be viewed in many ways. The design engineer can view group technology as an attempt to standardize products and process plans. Parts with similar geometric features should have similar design. The design of new part is begun by retrieving the design for similar, existing part. If the new part is truly required, the new plan can be easily and quickly developed by relying on previous decisions and documents of similar part. Therefore, the company will get the resulting plan that matches the current manufacturing procedures Askin [9].

Machine Cell Formation

At the same time the manufacturing engineer can view group technology as an attempt to gain the advantages of flow line systems in environments that previously ruled by job shop procedures. A company can aim toward a product-type layout within each group, in stead of a large process layout with each job being designed. Because the resultant groups are dedicated to a family of parts, new parts will be designed to be compatible with the processes and tooling of it. Consequently, people are experienced on part families while standard process plans and tooling can be developed for this restricted part set.

According to Bedworth [4], there are three basic ways to arrange machines in a factory: by function, by line, and by group. ***In a function-type layout*** shown in figure 2.12, machines of a specific type are grouped together, as a lathe section, a grinder section, a drill section, etc. This layout can result in important amounts of material handling, a large amount of work-in-process inventory, unnecessary setups, and long manufacturing lead times. All of these raise costs. Additionally, function-type-

layouts are more complicated to manage because of the complexity of part routings. For example, knowing the capacity of manufacturing facility is fundamental to scheduling when parts are to be made. Anyhow, determining the capacity of a function-type layout involves considering all items that need the use of each type of machine, which can involve a great amount of data.

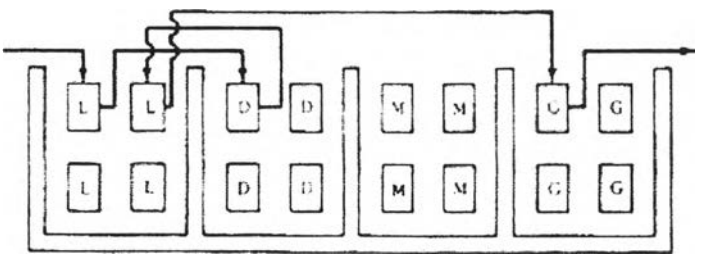

Figure 2.12: Functional-type layout [4]

In a line layout shown in figure 2.13, the machines and other work-centers are arranged in the sequence where they are used. The work content at each position is balances do that materials can flow through the line in a continuous manner. This kind of layout is generally used in simple process industries, in continuous assembly, and for mass-produced components used in large quantities

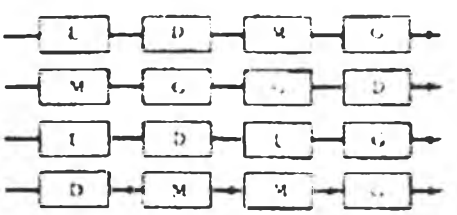

Figure 2.13: Line layout [4]

In a group-type layout shown in figure 2.14, machines are arranged as cells. Each cell is able to perform manufacturing operations on one or more families of parts. Therefore, the capacity of a cell can be determined by considering only the family of parts that utilize that cell. Accordingly, this layout should be easier to manage. If a group-type layout is desired, it will be reasonable to identify processes that correspond to one or more families of parts. As a result, machines used to produce a family of parts might be grouped together in a cell. The process of grouping cell is sometimes called machine-component grouping. As noted in chapter 2.1.2,

production flow analysis in a technique used to group parts and to locate machines in a plant. However PFA can require considerable judgment. Thus, additional techniques have been proposed to support in machine-component grouping. One of these is the single-linkage clustering algorithm.

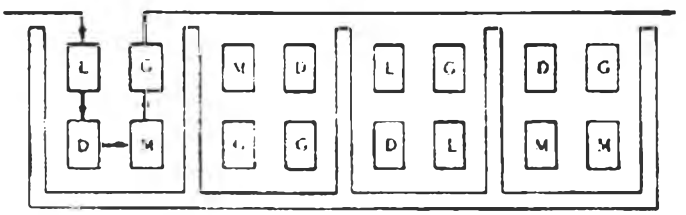

Figure 2.14: Group-type layout [4]

Jig and Fixture Development

Sometimes we use the same jigs, fixtures, and cutting tools with products classified in the same categories. These equipments may be the old equipments or are needed to be created particularly. In order to build them, the company usually applies the concept of composite part. The composite part is a representative of its category. To produce that part, the company may have to increase or decrease its operation steps, which are depended on each part. Finally, the production step of that category will be concluded principally. In reality, it is difficult and complicated to complete this procedure because of the different sizes of parts. However, composite part concept is one of significant concepts that provide advantage to the Machine Cell Formation.

Computer Aid Production Planning

Computer Aided Process Planning (CAPP) is a system that uses computers for improving manufacturing environment production procedure of a part. It reduces difficulties of data collection and lead-time, capacity planning, assembly planning, test planning, production scheduling, and manufacturing equipment programming. It also raises the accuracy of data and cost estimation and allows organisation to construct standardised systems. In addition, it enhances the ability of document's maintenance. The production planning normally requires the classification and

coding system. However this system has to determine the standard production planning of each part first. When the production planning of a part is needed to be adapted, its code is going to be an index for searching.

Group Scheduling

To develop Group Scheduling, the production steps are classified into group. Parts having similar production steps will be grouped and manufactured at the same period of time. Then the production planning of each part will be created. This procedure can reduce preparation time and cost since special equipment can be used with all parts. Moreover, it is easier to control the production because there are only parts having the same operations. Although Group Scheduling may not provide efficiency as much as the Machine Cell Formation does, it provides more flexibility and lower cost of system adjustment.

Raw Material Management

Using Group Technology in Raw Material Management can be done by determining code of supplier and also cost of items. It will help a company in expenditure calculation by using old record in the database system. Because expenditure calculation is one of the most important issues since there are many types, grades, costs, characteristics, and others, it is necessary to select the most suitable one.

2.1.8 Group Technology Advantages/Disadvantages Summarized

According to Bedworth [4], advantage and disadvantages of Group technology can be concluded as follow:

Advantages

1. An efficient classification and coding system provides design engineering with system that facilitates efficient retrieval of similar parts, development of database containing effective product design data, standardization of designs, avoidance of design duplication, forming of part families, use of producibility tips, and

incorporation of engineering design changes into the engineering and manufacturing systems.

2. An efficient classification and coding system provides manufacturing engineering with system that facilitates development of a computer-aided process planning system, retrieval of process plans for part families, development of standard routings for part families, and development of machining cells.

3. Production planning and control and scheduling can be simplified.

4. Standard routings facilitate the development of tooling groups, numerical control program groups, and standard setups for part families.

5. Machining cells can reduce in-process inventory, resulting in shorter queues and shorter manufacturing through-put times.

6. Improved machine utilization yields shorter setup times and better scheduling.

7. Part family data improving plant layout, which in turn can reduce materials handling costs.

8. Purchasing can be more effective. It is easier to choose the proper vendor because the many different parts and materials have been grouped into families, which reduces the complexity of the problem.

9. Management can be more effective because the environment has been simplified.

Disadvantages

1. Installing a classification and coding system requires a large amount of time and effort; it is expensive.

2. If communication between design engineering and manufacturing is poor, as is often the case, difficulties may be encountered in installing a classification and coding system. It may not be very successful.

3. There are no accepted group technology standards. Consequently, there is no common implementation approach, and implementation is often difficult.

4. Groupings of machines may lead to poor utilization of some machines in the group. This is difficult for management to accept even though overall costs are reduced.

5. Large costs may be incurred in rearranging the plant into machine cells or groups.

6. Group technology concepts require changing how people work; therefore, employee resistance may be encountered.

7. Without strong form top management, implementation of group technology will be difficult.

2.1.9 Conclusions

For many years, a number of classification and coding system were developed. Anyhow, because the information used for classification and coding varies from a company to another, there is no system that has received universal acceptance. This seems reasonable if one understand that the design retrieval and group production are two greatest uses of group technology, and that each firm has some unique needs for these functions. Although all of these needs are not unique, enough are to prohibit the development of universal system. Consequently though classification and coding systems can be purchased, they have to be tailored to the specific needs of a particular company.

2.2 Cataloging System

Catalogue is a system developed for sorting and queuing assets logically as a company has planned. For many years, catalogue system has been used in many sectors such as library, book store, and other. It allows users to search a required object by using the available information they have and also อย่างเป็นระเบียบ provides all information of all objects that users need. Furthermore, it can reduce working and searching time of users and people involved in the system.

2.2.1 Types of Catalogue

According to Kumer [14], there are three types of catalogue: Dictionary Catalogue, Classified Catalogue, and Alphabetico-Classed Catalogue.

Dictionary Catalogue

Dictionary or Alphabetic Catalogue is a system that queuing objects by using a series of alphabetic. Although it is easy to be used for grouping objects into families, the increase of the objects can bring more difficulty. Therefore, before applying this system, significant working conditions should be considered.

Classified Catalogue

Classified Catalogue is a system that lines up objects by using specific subjects. Thus it may be called as Subject Cataloguing. This type of cataloging will provide many advantages to a user if he comprehends its scheme. However, the weakness of Classified Catalogue is the difficulty to determine the requirement of users.

Alphabetico-Classed Catalogue

Since two types of the above catalogue systems have different advantages and disadvantage, the third type is a designed by merging their advantages together. Therefore, Alphabetico-Classed Catalogue is a system that uses both Dictionary and

Classified Catalogue concept. A company may classify principle type by using Classed Catalogue first and then classify secondary type by using Dictionary Catalogue.

According to Bakewell [15], to select the most suitable type of catalogue, cataloguing developers have to understand characteristic of things that will be lined up deeply. They must comprehend all significant attributes and sort them into subjects within a short period of time and without too much necessary effort. Moreover, the relationship of other related things is a subject that should be considered. They have to know whether any cataloguing systems exist in any departments or not. If they are, current catalogue cards should be considered. Types of training and comments of users are the significant issues that should not be passed over.

2.2.2 Organization Structure

Since efficiency of cataloging system is depended on the management of the department where the system will be applied, the department has to concern some important issues, which are objective, types of user, size of organization, investment funds and necessary equipment, the number and type of cataloging system. Generally, organization structure can be divided into two types, which are Centralization and Cooperative.

Centralization: This is the procedure which the activities of an organization, especially those concerning decision-making, become concentrated within a particular location or group.

The objectives of centralization are to avoid repeatedly procedures, reduce the cataloguing system cost, enhance the quality of cataloguing, increase work efficiency of correlated people, and provide the effectiveness of service to users.

Cooperative: In cooperative organization, each department will be able to develop its own cataloging system. One advantage of this structure is the ease to cataloguing system implementation. Because a department can organize cataloguing system by

using its own scheme, it is unnecessary to develop center cataloguing system that has to be used by a whole company. Anyhow, the repetition and accuracy of data record is a significant disadvantage of Cooperative system.

2.2.3 Cataloguing System Preparation

According to Kumer [14], the development of cataloging system can be divided into three sections, which are system administrator selection, system type selection, and catalogue code model selection. The company has to select the appropriate system administrator who has to comprehend all features of product or part that will be classed. He also has to recognize the requirement of system users because it will guide him to develop system that direct to the user's needs. If the system cannot support the needs of users, it will be a useless system that does not provide any compensation to the company. The company also has to select the appropriate type of cataloguing system as presented above. Another important thing that must be concerned is a model of catalogue code since it can increase the convenience of user. Therefore, to select code model, it is necessary to consider the limit of time, working condition, the number of users and others.

2.2.4 Advantages of cataloguing and classification system cooperation

• Once all items have been classified into categories, they could be lined up easier.

• Because Classification System has to build the cross reference, it can reduce works of cataloguing developer.

• As Classification System generally applies chain procedure, items will be classified divisionally. Accordingly, they are able to be queued easily and quickly.

• Cataloguing System usually splits items into factions, while Classification System can gather them into a group. Thus, applying both systems together will diminish this problem.

• The characteristic of Classification System is unidimensional. This means an item can have only one item number even though some items can be classified into more than a group. Thus, Cataloguing System can be applied to solve this situation.

• Classification System generally uses principle subject to classify items first. Other themes such as supplier, manufacturer become divided. Thus, Cataloguing System can be applied to solve this condition.

2.3 Product Data Management

2.3.1 Introduction to Product Data Management

Since many industries around the world have implemented IT, such as CAD, CAM, CAE, and CIM in order to control product life cycle, it revealed that the control and handle costs of these technology has been extremely increasing. Thus, most of them have changed their ideas from investing for new technologies to be controlling the old technologies with high efficiency. Then, EDM represented as the adjunct functions of CAD/CAM/CAE tools has been invented for providing configuration management to engineering data sets. However, it was used for managing only CAD/CAM/CAE data, consequently Product Data Management (PDM) system was established in order to manage all types of application data.

According to Warwick's documents [16], PDM is defined as "*a tool that enables engineers and others to manage and control engineering information and the product development process*"

Another definition of PDM described by Uninova [17], is "*Electronic handling and control of product information throughout the whole product life cycle across system and organization boundaries by means of vaulting, workflow, and product structures*"

Capabilities of PDM are separated into five sections, which are

1. Data vault and document management.
2. Process/Workflow management.
3. Product structure management.
4. Classification and retrieval.
5. Program and project management.

Since then, PDM system was well accepted by many organisations that it can enable implementation of different management, for example, process re-engineering, concurrent engineering(CE), and ISO certification, and etc. Hence, the advantages of

PDM may be noticed from the result of CE implementation. In manufacturing industry, many drawing, data, documents are created. All of them are easy to be lost, since many people from different departments are able to manage them. In the past, members have to wait for a drawing from the previous member. Some documents are lost while they were transported. Engineers solve the problems that have been solved before. The reference data is lost. Communication among members is too slow. Documents wait to be approved for a long time. These are the problems that occur in a company who don't have an effective data management. In order to improve data management methodology, PDM system, which can handle all problems, should be implemented.

2.3.2 PDM Vault

The most important capability of PDM system is "Vault". Principle data of organisation, especially automotive industry, is usually used by many people from different departments. Most of them are neglect to record what they have done with it. Many copies are generated and overwritten the old one. Finally, firm will lost the principle data, and there will be no reference. Hence, the PDM vault is brought to solve all these problems. The main duty of PDM vault is to keep the principle data in 'vault' where all changes are monitored, recorded, and controlled all the time. The vault allows users to copy the principle data, and copies can be freely modified, changed by anyone in organisation. Afterward, the modified data, including changing details, such as date, users, and sign, are sent back to the vault and recorded alongside the principle data, which remains in it old form., are recorded. As a result, the principle data will never be accidentally overwritten anymore. People are able to trace the changes and find the reference data. Furthermore, Vault is able to backup and recover data, support product and document structure, enable only one user to modified data, while others can review it at the same time, automate design review and release method, distribute data in disk resources for preventing overload storage capacity, and etc.

Computer system is the most important of a large company which invests new technology such as CAD/CAM/CAE/CIM. Security system of data access is very necessary. PDM vault also provide the security system, which is set and monitored

by system administrator. Because access & change permissions and password are needed, stranger who are not involved in the system cannot access into the system.

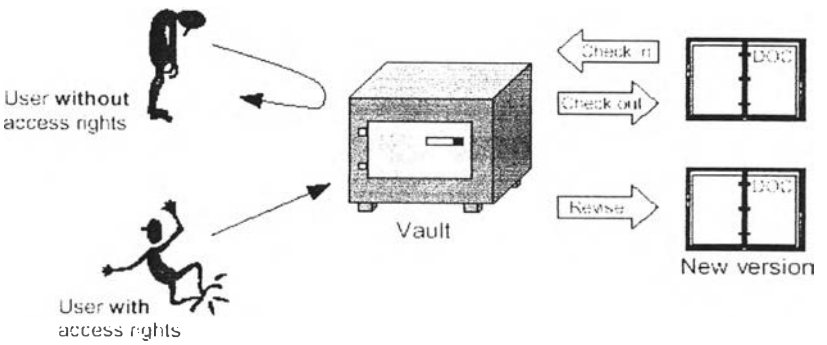

Figure 2.15: Security of PDM Vault [17]

2.3.3 PDM Management

Automotive products, such as car, motorcycle, etc are consisted of numerous parts and components. Most of them and their assemblies have to be sketched into drawings, such as 2D drawing, 3D drawing, and solid modelling by designers. Then, each drawing has to be analysed, approved, and clarified by many people from different departments, such as engineer, researcher, and others. Therefore, the analysed and related documents, such as finite element analysis documents are established. When a number of documents continuously increase, it will be difficult to manage all of them. Accordingly, a technique to manage these documents, such as PDM needs to be invented.

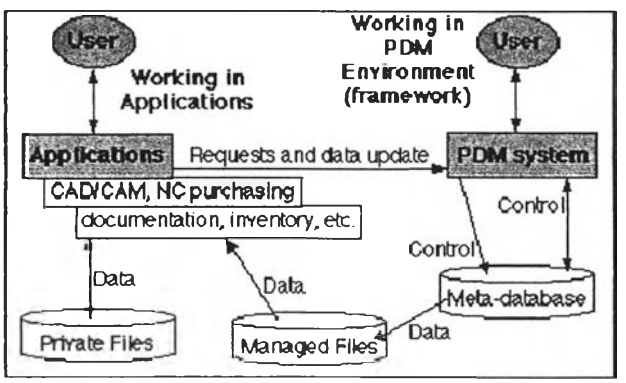

Figure 2.16: Functional view of a PDM system [18]

PDM system offers data management and process management. Data management is the system that can manage attributes and documents of products. Process management is the system that organizes the way people form and edit data.

2.3.4 Data management

The classification of components and documents is one capability of PDM system. In manufacturing industry, all components and documents have to be classed, before entering to the database. The ways to classification depends on each company's requirement. For example, some companies separate parts by their types of machining. The similar components and documents will be kept together at the same class in and easily traceable hierarchical network structure, which is easy for querying the data, and invaluable for Bill of Material (BOM). The following figures [17] show the sample classification and structure of components in Bike industry

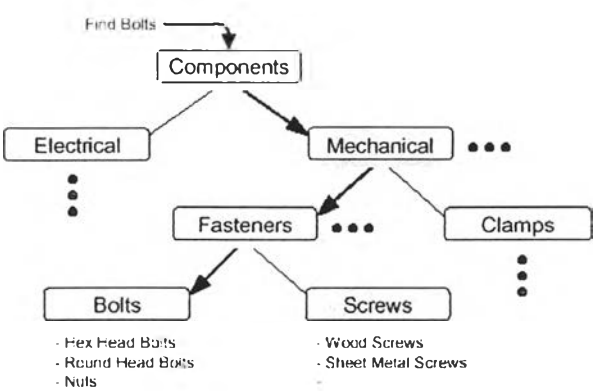

Figure 2.17: Sample classification of bike's components [17]

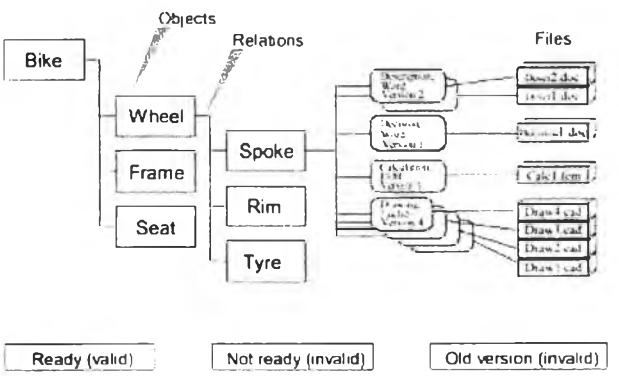

Figure 2.18: Sample structure of bike's components [17]

At manufacturing process, people can find the assembly drawing of each component easily. They can see the structure of components in details. Subsequently, when some components have wrong dimensions, the manufacturing can all effects that occur to related components by looking from this structure.

2.3.5 Process management

Process management can be divided into three sections: Work Management, Workflow Management, and Work History Management.

Work Management

Work Management is administration of changing data. Since designs and manufacture have to be repeatedly changed, the details of changes can be recorded and maintained by PDM system. PDM offers "user packets", which allows users to manage the many different principle documents, and provides reference documents. For instance, at design process, when principle wheel design is modified by one user, the copies of it will be sent to others people's packets. So, all of them can give comments on this modification.

Workflow Management

In manufacturing industry, a number of components require to be designed. Then, documents, drawing, data, and CAD/CAM/CAE files are formed. All of them have to be approved, viewed, and rectified by different people. Thus, organisation may need systems that allow it to support this workflow. Packets provided by PDM make it possible to transfer works from individual to individual, department to department in organisation, even in different countries.

PDM can establish online-conference among members of different departments, or different countries. In online-conference, all members can make conversations by sitting in front of their computers. In the conference, there is leader, or server, who is able to control the graphic on display. Leader can explain, rotate, mark, change, and move a component in 3D graphic on his computer display, while others can see them on their own display. Without permission from leader, all members cannot control

this graphic. This technology increases teamwork's skill in organisation, because everyone can offer their own ideas to the conference. Moreover, the progress of project can be controlled by a leader. The leader can flow works to members or groups by computer. All members have to check their job every morning on their computer. As a result, they cannot refuse that they didn't receive the tasks. They have to represent the state, such as initiated, submitted, checked, approved, and release, because works cannot move from one member to others without changing state.

In addition, the web browsers now impact to the PDM industry. PDM applications are developed to use with the Internet. Users can access many source of data, such as purchasing, finance, shipping, shop floor, MRP, and legacy systems. Hence, PDM vendors are now developing the program to let browser technology to be one of the product suites.

Work History Management

Work History Management provided by PDM can manage and record the tracks of each component. Therefore, when problems occur, firm is able to find the source of them by searching for 'back-track'. Not only comprehensive database record of the present project that is recorded, but also the states that project have been passed. Hence, PDM is the key capability for time-critical project, and is a valuable source of audit trial data, which required for conformance to international quality management standards such as ISO9000 and EN29000.

For example, according to Continental Automotive systems (CAS) [19], suppliers of system and components for the automobile industry, CAS has spent a lot of money for testing with the repeated expensive test. Therefore, they decided to apply *mySAP PLM* for the development step.

As a result, employees can find the information they need for daily work and repeated tests are disappeared. In addition, using *mySAP PLM* allows employees to access graphical drawing and get an overview of product development status at any time. CAS employees also can deal with the increasingly shorter development cycles of manufacturers.

2.3.6 Advantages of PDM System

Increased design and manufacturing correctness

PDM allows all members of project operate the same latest data. Thus, using wrong or old data is eliminated. PDM permits only one user to work on principle data, and provide the copies of latest data to member's packet, the overlapping or inconsistent designs are removed.

Reduction of time-to-market

Since PDM system can provide the right data to the right person, and it also assure the users that the data is the latest version, firm can reduce the design time, waste time between tasks, and time lost in rework. The reduction affects to the total production time. When the total production time decrease, it means firm is able to speedily launch a new product.

Enhanced design output

Since PDM system can remove the wasting time of designer, for instance, searching, retrieving, and waiting for the data, then productivity of design will be increased. In addition, PDM encourage user to reuse existing design, so it can eliminate the situation that problems are repeatedly solved, which save more time.

Comfortable to use

In the past, people had to spend a lot of time for accessing the data. At present, all data and information are rapidly loaded, whenever users want.

Better use of creative team skills

Since PDM allocates the data to the right person and other members, support the team problem solving, and keep track of data, the possibility of failure is diminished.

Better control of projects

Normally, the project is late, because members usually go out of control. When the competitive time pressure increases, the inconsistent scope also increases. The quantity of data that is created exceeds the scope of conventional project. Because PDM provide the product structure, change management, configuration control, and traceability, it can assure members that the scope of data is firmly controlled.

Better management of engineering change

As PDM can keep the any versions of design, all designers are able to design, modify, and revise drawing, documents, and others without scaring of data lost. Additionally, date and sign have to be recorded with the documents, so the ambiguity about design is removed, and users can trace the details of change.

Data security

For the reason that PDM vault allows system administrator to monitor the system, stranger who are not involved in the system cannot access into the system.

A major step toward total quality management

PDM is the key capability for time-critical project, and is a valuable source of audit trial data, which required for conformance to international quality management standards such as ISO9000 and EN29000 and Total Quality Management (TQM).

2.3.7 Conclusions

In large organisations, like manufacturing industry, data management is very essential. Since the automotive product consisted of many components, many documents will be generated. These document are also come from different departments continuously increase. Hence, it is indispensable for organisation to

have the management that can control all types of data, and let users access to the data easily, quickly, and correctly.

PDM is the system that can manage all data in automotive industry. At design process, it manages data that concerns with the product design such as drawing, CAD/CAM/CAE files, BOM, FEA, and others. The entire data is systematically linked together, so the overlapping, principle data lost, revision, ambiguity, time of rectify, confirm, approve, and modify, are eliminated. During the manufacturing process, it keeps all tracks of each part. As a result, if there is one part that has wrong dimensions, controller can discover the source of this failure. PDM system provides the security to organisation. The principle data is kept in the PDM vault, which all changes are monitored and controlled by the system. Moreover, PDM system does not allow strangers to access data without permission, so the problems about data can be eliminated. Online-controlled is one capability of PDM that speed up the communication. It also supports the teamwork, which permits all problems easily and correctly to be solved.

2.4 Conclusions

According to the first chapter, the statement of problems was mentioned earliest and then the objective of the study was figured out. To accomplish them, three major theories presented in this chapter will be applied. The first theory, group technology, concerns how to group items systematically in the industry having a large amount of items. It states about the classification and coding system, the system that used to categorize and code these items. Thus, we can apply this idea to construct a suitable classification and coding system to the case company. Once the benefits of applying cataloguing system with the classification and coding system were presented, it can be used to construct the system as well. To improve the effectiveness of the classification and coding system and solve the data management problems, the computer database system should be introduced. Therefore the Product Data Management presented as the third theory and other literatures related to the database management will be applied in the construction of computer database system.