CHAPTER III

PRINCIPLE CONCEPTS AND SYSTEM DEVELOPMENT

3.1 Organization review

Founded in 1996, the case company is a small manufacturing company. It produces and also designs canning spares parts such as punch, die, seaming roll, seaming chuck, and etc. Quality Control is monitored throughout the entire production process in order to meet standard requirements set by the original design and prototype. It has integrated the use of modern computer, CAD/CAM in its designing and has incorporated CAM System directly with the machine's CNC. Since 1996 the company has improved the quality of products, increased a number of machines, and employed new staffs. At present it has 16 staffs, 3 lathes, 2 milling machines, 2 grinding machines, and a CNC-milling machine.

3.1.1 Organization Structure

The case company is separated into three major departments, which are production department, accounting department, and design department.

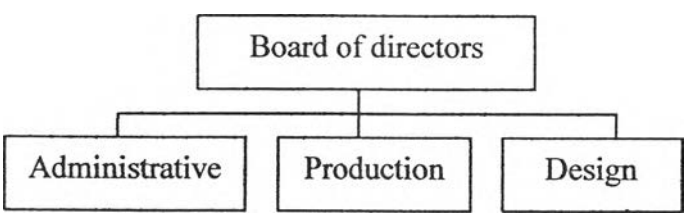

Figure 3.1: Organization Structure

Administrative department

The most powerful in the company, the department is responsible for many issues such as financial management, personal management, and data management. Generally, company data, product data, and computer system are kept and controlled by them. Therefore, they can be called information and technology department.

Production department

Production department is the main department of the company. When drawing is created, it will be sent to the production department. The principle duty of them is to build product as specified in the drawing. They are consisted of four sections: lathe, milling, grinding, and assembly section.

Design Department

All activities concern with drawing is responded by design department. They are responsible for making and maintenance all product's drawings. When customers have their own drawing, design department has to verify and approve the correctness of them. When customers do not have their own drawings, design department have to create a new drawing by themselves.

3.1.2 Production Process

Production process of the company is divided into major four steps: Quotation, Manufacture, Quality Control, and Delivery.

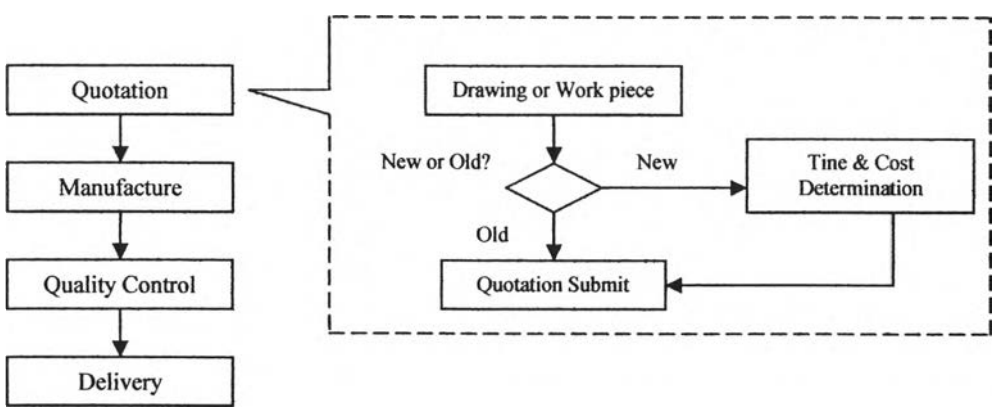

Figure 3.2: Major Production Process

At the beginning of the quotation process shown in figure 3.2, a customer will ask for the price of his work piece. Normally, a customer can request for the quotation by two ways. He may forward a drawing that has already identifies all product details,

or transport the real work piece to the company. In case of drawing, administrative department verifies whether that product has ever been produced or not. If it has, the latest quotation will be submitted. If it has not, its production time and cost will be determined by the production and administrative department first. Then the new quotation is submitted to the customer. Once the quotation is accepted, the real work piece will be sketched and the drawing will be copied by the design department. Next, Work Order Sheet (WOS) of the product will be created and sent to the production process.

WOS is a document that contains of all details about a product such as product name, drawing number, product drawing, customer name, material, production time, etc. The identification number of WOS is called CT No. As a result, a product can have a lot of WOS since it can be ordered more than one time. After that, the new WOS will be sent to the production department in order to let the production workers to fill out all details while the product is manufactured. Normally, when the production department received the WOS, the production manager will decide whether he needs the old WOS of that product or not. Since latest WOS can guide him to plan a production process, it can reduce his working time. Significant, we have to realize that the company currently have no production plan, thus the old WOS seems to be useless if the product is seemed uncomplicated. Consequently, it is rarely to see the production manager requests old WOS from the administrative department currently.

After the product is manufactured, it has to be checked all dimensions and characteristics at the quality control step. If there is a mistake that can be rectified, the product will be sent to the production step again. However, if the mistake that cannot be solved, the administrative department will inform the customer and find the solution together. Finally, the finished product will be delivered to the customer.

3.2 Principle concepts

According to the figure1.1 in the first chapter, we should realize that if the company does not have an efficient data management, they will not be able to find a standard time used in the production planning. Consequently, the study will focus on the data management system problems that can be concluded as follows:

1. The current data management system of the case company does not have enough efficiency to determine standard time of products. WOS which is keep in documents are easy to be lost and damaged.

2. Using documents allows the company to find a target WOS by only few ways. For example, since the first three letter of product name are used to be an index, it is difficult to find the required WOS without recognition of the product name.

Both problems are the major problems that obstruct the company to approach the source of the delay in submitting product problems. Therefore, to solve them, the company has to improve the data management system as follows.

1. The data management system should increase security of keeping WOS and provide more ways to approach it. All data should be maintained systematically. Although a user cannot remember the product name, he can use other information to reach the target WOS. Once the company can reach the require data used to find the standard time, the standard time of all products will be formulated. In addition, Product Data Management and Database Management theories presented in chapter 2.3 and 2.4 should be applied in the new system analysis and determination parts.

2. With the purpose of building a new data management system, Classification and Coding system must be concerned. Since there are many types of product, products should be classified and coded. Classification and Coding system increase the ability of communication, when a product is referred. Employees can use product code instead of product name, which can be repeated. Products are classed into categories logically and users can approach a target data faster. Accordingly, we can conclude that these benefits will improve the ability to keep and search of the data management system that will be constructed. Of course, Classification and Coding system and Cataloguing system theories presented in chapter2.1 and 2.2 will be used in this part.

3.3 Classification and coding system development

This section is divided into 11 parts

1. Objectives of the system
2. User and administrator
3. Requirements of user and administrator
4. Organization structure
5. Resource analysis
6. Current system analysis
7. Product analysis
8. Concept of classification system
9. Concept of coding system
10. System development of Non-assembly product
11. System development of Assembly product
12. Result of applying the system
13. Examples of the system
14. Additional code

3.3.1 Objective of the system

At present, employee usually use product name for communicating. Obviously it is difficult to identify product having resemble name. Therefore if product code is used instead of product name, the correctness of communication will be improved and time using will be decreased. However to use product code efficiently, code should provide some information such as product shape and size. This information will allow employees to visually check product. For example, mistakes of using wrong material can be noticed from code before a product is passed to the next operation. Moreover if code can identify required precision, it will remind employee to produce product carefully, while production manager will be able to give the right job to the right employee. Consequently the objective of using code can be concluded as follows:

1. To increase efficiency and provide another way of communication among employees.
2. To illustrate significant characteristics related to the production time of a product.

3.3.2 User and administrator

Before we can determine the user of the classification and coding system, it is necessary to explain more about the relationship between classification and coding system and database management system for the case company. Generally, both system may be used by different users and controlled by different administrators since they normally have dissimilar operations. Classification and coding system may be suitable to be managed by production or design department, while database system may be appropriated to be managed by information and technology department. However, for the case company user and administrator of both systems is going to be the same person. The reason is that the case company currently has no production manager or chief who can responsible for manage the classification and coding system. There are only general workers who fully work with machines for a whole day. This mean the company director cannot determine a person who will completely responsible for classification and coding system at current period. Consequently, the only person who can responsible for this mission becomes a chief of the information and technology department. Finally, she is going to be the user and administrator at the same time. For conclusion, the user and administrator of the system are

1. Director of the company who currently act like a production manager.
2. The chief of information and technology department
3. Chief's assistant who becomes a user then the chief cannot perform her duty.

3.3.3 Requirement of user and administrator

According to Sadar (1979) [7], one of the significant issues (presented in chapter 2.1.3.1) that the efficient classification system should have is that the system has to provide benefits to user realistically. This means when the system is activated, user and administrator will be able to find a target object and also return it to the same location. Moreover Bedworth (1991) [4] also mention about the coding system objective (presented in chapter 2.1.5), which is normally depended on the requirements of the users and administrators. As a result, system developer has to consider all needs of users in order to convince them and build the system that direct

to the user's requirement. The requirement of the system user and administrator can be concluded as follows:

1. The product attributes used for classification should be simple attributes. Since she is unfamiliar with all symbols in a drawing, attributes used in code should be uncomplicated for her to judge.

2. The classification system should not consume a long time. Since users have other responsibilities, this process should be done quickly.

3. Product code should not be too longs and easy to understand. Because long and complex code is difficult to use, short and meaningful code allow users to be familiar more quickly.

3.3.4 Organization structure analysis

According to Kumar (1979) [14], there are two types of organization: Centralization and Cooperative or Decentralization.

Centralization is the process by which the activities of an organization, particularly those regarding decision-making, become concentrated within a particular location and/or group. In centralization, a limited amount of authority is delegated. This means there will be only one classification and coding system, which is by all departments in the organization. It is controlled by a particular department. The objectives of centralization are to avoid repeated works, reduce cost of cataloging system since it will be managed by a particular department, enhance the quality of cataloguing, improve the working efficiency of officer who is responsible for the system, and provide better service to users since the repeated work and working time are reduced

In decentralization, a significant amount of authority is delegated to lower levels. This means each department will responsible to establish its own classification and coding system.

The advantage of decentralization is that each department can determine rules by using their own experiences. However, decentralization can increase repeated works and inaccuracy of information. For example, if a product can be coded differently, it will be difficult to communicate about it between each department.

Since the authority is given to a particular department, all changes can be done without repetitions. Classification and coding can be determined and changed quickly and correctly.

The case company is a small factory and has less than 20 employees; it is unsuitable to decentralize the system. Therefore, the most suitable structure for the case company should be centralization.

3.3.5 Resources analysis

Classification and coding system development is the activity consuming a long time and high cost, especially items that have high details and quantity. To determine how deep of detail that system should have, therefore, time and cost issues should be concerned.

Obviously the case company cannot afford those famous systems investment. Thus the best way to develop the system is to select one of the famous classification and coding systems and adapt it into our own system.

3.3.6 Current system analysis

If other working systems exist in the organization, they have to be considered. To avoid problem in the future, the developed system has to be analyzed whether it can go along with the old system or not.

At present the case company has no classification system but has already got a coding system set up by the administrative department. Since dictionary or alphabetic catalogue is easy to use for grouping products and the code is not used by anyone, the current coding system is a cataloguing system. After having discussion, the system administrator prefer to keep her own code if it possible. Therefore system developer may have to combine it into the new coding system.

3.3.7 Product analysis

In the case company, there are two types of product.

1. Non-Assembly Product
2. Assembly Product

Non-Assembly Product is s single part that does not need any assembly process. In opposition, Assembly Product is a product that is assembled by more than one part. It requires assembly process such as weld, nut and bolt, etc. Obviously, attributes of both types will be different. Therefore part attributes should be considered separately.

3.3.8 Concept of classification system

To classify products into a group, part attributes have to be determined. Part attributes defines part classification structures using significant characteristics, such as material, dimension, operational parameters, etc. According to Bedworth (1991) [4], there are two basic attributes used for different condition.

1. Design attributes
2. Manufacturing attributes

Design attributes that are widely used are overall shape, internal shape, external shape, length to diameter ration, surface finish, tolerance, material, and hole pattern. Manufacturing attributes that are popular used are major process, minor operations, operation sequence, machine tools, cutting tools, jig and fixtures used, and batch size. Therefore, the company has to consider whether it should focus on design or manufacture.

Consistent with the current system administrator and user, it may suitable to use design attributes. Design attributes can be determined immediately from drawing by the system administrator, while manufacturing attributes have to be decided by a person who has high experience with a manufacturing operation. Moreover, some of

manufacturing attributes such as machine tools, cutting tools, jig and fixtures, and batch size can be varied by the time.

3.3.9 Concept of coding system

According to Wynar (1976) [29], coding system can be divided into two types: Incessant code, and significant code.

Incessant code is a coding system that does not concern form and meaning of each digit. It codes parts by arranging figure continuously. The advantage of incessant code is that figures are worthwhile used while disadvantage is that it cannot illustrate anything for users. This means users cannot get any information for code they saw. Consequently this system may not suitable for the case company since product code should provide some information of the product to the user.

Significant code is different from incessant code because each figure will provide information of the part. When a firm plans to establish significant code, three issues, which are code structure, digit quantity, and code appearance, have to be considered.

Code structure

About the code structure, code structure can be divided into three types: Hierarchical, Attribute, and Hybrid. For the case company, the first digit of the code structure has to demonstrate whether next digits go along with assembly or non-assembly product. Therefore, the code structure might initially be hierarchical type.

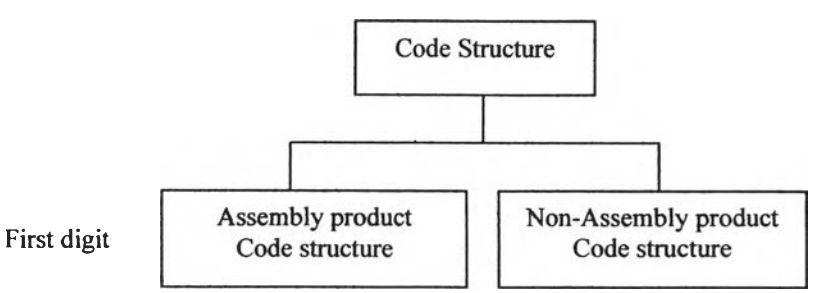

Figure 3.3: The first digit of code structure

Since features of assembly and non-assembly product are dissimilar, it is necessary to establish proper code structure for each of them. In order to determine code structure of assembly and non-assembly product, the hierarchical structure may not suitable. According to Gallagher (1986) [3], it is inappropriate to use hierarchical type with the assemble product. Since one part must have only one code, it will be difficult to assign code for a part that can be a component of an assembly product or can be a non-assembly product. This means the same part may have different code, which can make confusion for users. Therefore, the most suitable structure for both assembly and non-assembly products should be attribute code. Furthermore, refer to the Opitz coding system, flexibility is one of the most important features because each digit can be changed. The case company will receive this benefit when computer database system is applied. As a result, the complete code structure will become the hybrid structure like the Opitz code. The structure of coding system can be illustrated as follows:

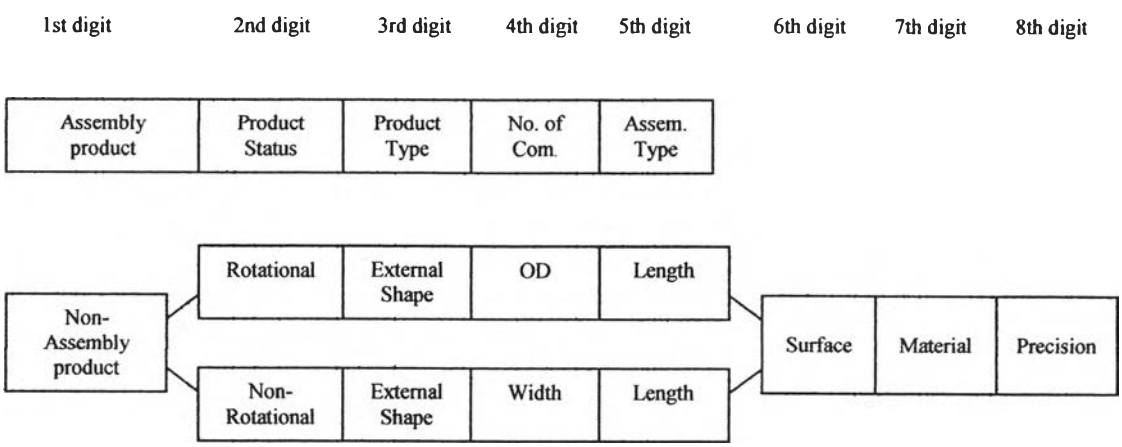

Figure 3.4: Developed code structure

In this code, the first digit identifies that firm is dealing with assembly or non-assembly product. The second digit is depended each product type. In case of non-assembly product, the second digit specifies that company is dealing with rotational or non-rotational product. For rotational product, the third and fourth digits present sizes of raw material, and the fifth digit illustrates external shape of finish product. For non-rotational product, the third, fourth, and fifth digits specify each size of

rectangular raw material. The sixth, seventh, and eighth digit provide surface, thread and slot, and holes information of both rotational and non-rotational products that are all explained in the part attributes of non-assembly product section. The following figures show sample of code detail for assembly and non-assembly product respectively.

The number of digits

Issues that influences the number of digits are

1. Code structure: Each code structure provides the different number of digits. For example, the number of digits for hierarchical code is less than that of attribute code. Since the code structure of the case products are hybrid structure, the product code may short or long depended on the other issues.

2. Information detail: Obviously, the more detail code provides, the more number of digits code have.

3. Working condition: Although code having several digits can provide more information, it might be too long to be remembered. It also brings confusion and mistakes to users. As a result, the number of digits should be depended on the information detail that user and administrator needs.

4. Working system: If coding system is operated by human, it is unsuitable to use long code. If it is operated by computer system, the disadvantages of long code may not seriously affect. For the case company, computer system is planned to be applied, thus product code can be long or short depends on the information details. In the case company, as we know that the current user and administrator prefer to combine her own code into the new coding system, thus the number of digit will be the combination of them. The current product code has 7 digits, which are contained of alphabets and figures. Therefore when we combine the current code and the number of part attributes together, the number of digits of non-assembly and assembly product will be 19 and 14 digits respectively.

Issues		Product code	
		Long	Short
Code structure	Hierarchical		X
	Attribute	X	
Information detail	A lot	X	
	A few		X
Working condition	Convenience		X
	Inconvenience	X	
Working system	Human		X
	Computer	X	

Table 3.1: Influent issues for the number of digit

Code appearance

According to Kumer (1979) [14], there are three types of code appearance: Dictionary or Alphabetical, Numerical or Classified, and Alphabetico-Classed Catalogue. To select one of them, working system should be concerned. If human are participate with code more than computer does, alphabetical will provide more benefits. For instance, using T instead of thread is more recognizable for users. Accordingly, to determine the code appearance for the case company, requirements of the administrative department will be used.

3.3.10 System development of Non-assembly product

About 80% of all products in the case company are non-assembly products. Most of them are machine tools such as die cutter, punch cutter, etc. To determine suitable attributes used for classifying products, all design attributes will be provided to all users. All of them have to weight the importance point to have each attribute in the product code. This method is done by giving them a card, which allows them to fill score based on their idea. The result of scoring method is shown in table 3.2.

The result shows that four attributes, which are overall shape, external shape, size, and surface finish, are seriously required, while it is unnecessary to have internal shape, hole pattern, and thread pattern in code. They have commented that overall shape, external shape, size, and surface finish attributes could be used to describe an

image of a product already. Moreover they are too difficult for the assistant to determine.

Attribute	Director	Chief	Assistant	Total score
Overall shape	3	3	3	9
External shape	3	3	3	9
Internal shape	2	1	1	4
Size	3	3	3	9
Surface finish	3	3	3	9
Precision	2	2	2	6
Material	3	2	2	7
Hole pattern	2	1	1	4
Thread pattern	2	1	1	4

Score = 3: This attribute must be involved in code

Score = 2: It is ok to have this attribute in code.

Score = 1: This attribute is unnecessary to be involved.

Table 3.2: Attributes determination

Another two necessary attributes should be concerned are material and precision. Although material cannot be figured out visually, it is one of the most important attribute that stimulate workers to carefully check types of material before producing a work-piece. As well as material, precision is also necessary for them to class product having high risk to be lost. Finally, attributes that will be considered are

1. Overall shape
2. External shape
3. Size
4. Surface finish
5. Material
6. Precision

Overall shape

If the company wants to group finished products having similar shape, overall shape such as internal and external shape could be applied. If the company wants to group product having same size, raw material size may be used. In relation to the three popular coding systems, initial digits usually allow user to identify that firm is dealing with rotational part, non-rotational part, or other part.

For rotational part, the advantage of using external and internal shape is to describe user product shape. This will provide benefits to design department when a new product is designed. However, since the administrator is responsible for purchasing raw material, details of raw material size are important for her. Therefore, attributes used for grouping by shape should contain of raw material size and some significant external shape.

The following table presents 592 sample products classified by applying rotational and non-rotational of finished product and raw material concept.

Shape	Number of products (pieces)		
	Rotational	Non-rotational	Both
Finish product shape	415	120	57
Raw material shape	428	164	0

Table 3.3: Classification by overall shape of product and raw material

From the table, we realize that all products can be classed by using overall shape attribute. Anyway, it reveals that 57 parts were can be identified as both rotational and non-rotational products when shape used to determine is the shape of finish product. This situation occurs since the system administrator or the accountant could not decide whether a part should be grouped as rotational or non-rotational part. Thus, if finish product shape is selected, the accountant will face with this confusion repeatedly.

To avoid the confusion, raw material shape should be used. Since raw material shape is normally divided into two types that are rectangular and rotational shape. Once

raw material shape was applied, all parts could be separated into only two categories. The reason that accountant could determine shape of raw material was come from drawing. Since a drawing generally specifies raw material type and size, it eases the accountant to determine class of product. Consequently, overall shape attribute can be concluded in table 3.4.

Code	Description
0	Product having rotational raw material
1	Product having non-rotational raw material

Table 3.4: Overall shape of products

External shape

Currently rotational and of the case company have different external shapes shown in figure 3.5.

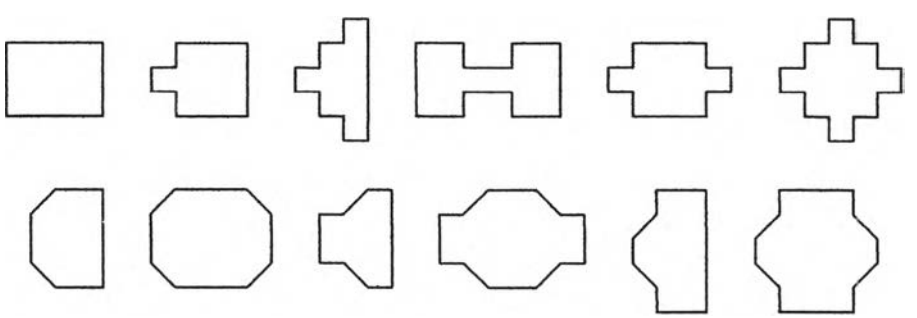

Figure 3.5: Side-view shape of rotational product

From the figure, we should notice that some shapes can be group together since their characteristics are likely to be the same. To separate them into groups, main concept of three famous classifications and coding system presented in chapter 2 will be applied. The key elements that those systems use to classify external shape are step and slope or taper. Therefore, we will use them to determine classify rotational product shape. Finally rotational product will be classified into 8 types as shown in figure 3.6.

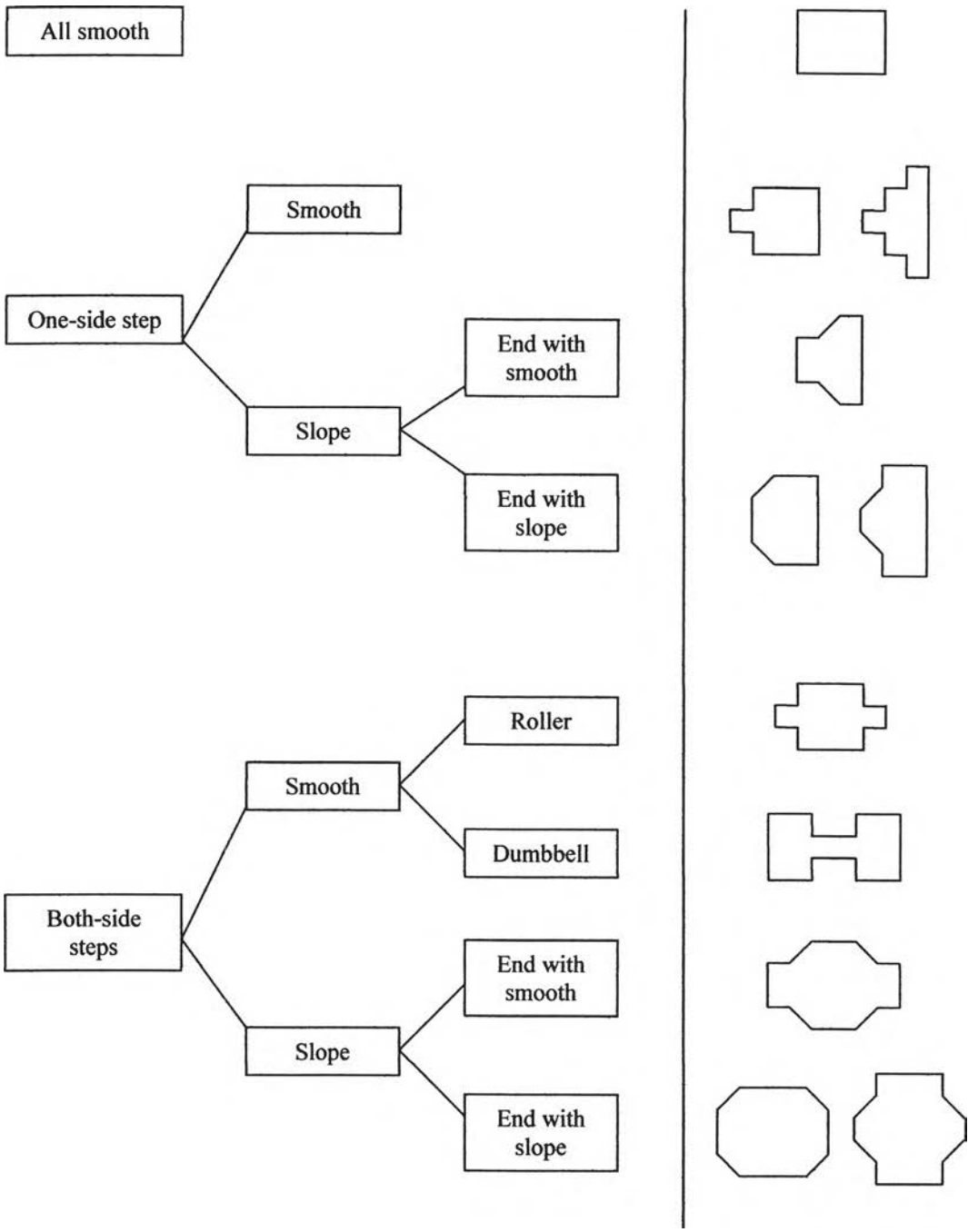

Figure 3.6: External shape of rotational product

About non-rotational product, it normally has complicate shape, which is difficult to be applied with the elements. Thus shape of raw material will be used. Raw material shape of non-rotational product can be divided into 6 types. Shown in figure 3.7, the first type has rectangular shape used for common part, and the other has O, I, U, L, and C shape used for structure work.

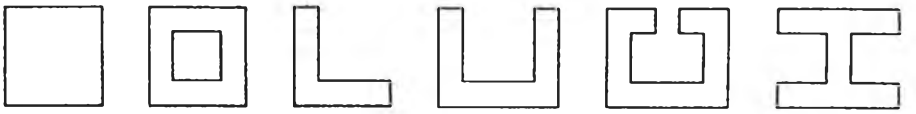

Figure 3.7: External shape of non-rotational product

Consequently, external shapes of rotational and non-rotational product can be concluded in table 3.5.

Code	Description		
0	All smooth		
1	One side step	Smooth	
2	One side step	Slope	Smooth end
3	One side step	Slope	Slope end
4	Both sides steps	Roller	
5	Both sides steps	Dumbbell	
6	Both sides steps	Slope	Smooth end
7	Both sides steps	Slope	Slope end
8	Others		

Code	Description
0	Rectangular
1	O shape
2	L shape
3	U shape
4	C shape
5	I shape
6	Others

Table 3.5: External shape code

Size

Once shape attributes have been determined, it becomes the basis of the size attribute. For rotational part, diameter (Ø) and length (L) or ratio of them can be used as the key elements to determine the size attribute. For non-rotational product, height (H), width (W) and length (L) of raw material are often used to show the product configuration.

For the case company, since diameter of products varies from 10 millimeter to more than 1000 millimeter, using ratio may not illustrate the exact size of the product. Accordingly, diameter (Ø) and length (L) are more appropriate to be used. To specify

diameter, some confusion occurred from a product having more than one diameters or deviation. Therefore, to avoid it and also provide benefit to the users who involve in purchasing process, the largest diameter or outside diameter of raw material should be used. To specify size of diameter and length, we firstly determine ranges of them as shown in table 3.6

Code	Description
0	$Ø \leq 10$
1	$10 < Ø \leq 50$
2	$50 < Ø \leq 100$
3	$100 < Ø \leq 150$
4	$150 < Ø \leq 200$
5	$Ø > 200$

Table 3.6: Diameter code (initial)

After 428 rotational products were grouped by using this rule, the result can be presented in table 3.7.

Product code	No. of products (Pieces)
1 - 0 - x 0 x - x x x	21
x 1 x - x x x	52
x 2 x - x x x	72
x 3 x - x x x	123
x 4 x - x x x	145
x 5 x - x x x	15
Total	**428**

Table 3.7: Rotational products classified by diameter (initial)

We can see that most products have diameter between 150 and 200 mm, and 100 and 150 mm. It presents that more than 50% of all products still be grouped together, which obstruct people to imagine the exact size of products. This situation occurs because the ranges of size were too wide to use with the case company products.

Therefore, we should narrow them in order to distribute products that were grouped tightly. The new range then becomes

Code	Description
0	Ø ≤10
1	10 < Ø ≤ 50
2	50 < Ø ≤ 75
3	75 < Ø ≤ 100
4	100 < Ø ≤ 120
5	120 < Ø ≤ 135
6	135 < Ø ≤ 150
7	150 < Ø ≤ 165
8	165 < Ø ≤ 185
9	Ø > 185

Table 3.8: Diameter code (modified)

Once new ranges were applied, table 3.9 shows the result of classification.

Product code	No. of products (Pieces)
1 - 0 - x 0 x - x x x	21
x 1 x - x x x	52
x 2 x - x x x	37
x 3 x - x x x	35
x 4 x - x x x	53
x 5 x - x x x	21
x 6 x - x x x	49
x 7 x - x x x	65
x 8 x - x x x	58
x 9 x - x x x	37
Total	**428**

Table 3.9: Rotational products classified by diameter (modified)

From the table we can see that the new range can illustrate size of product better than the old one can. About length of rotational product, we will use the same method to

determine suitable length of product. Subsequently, the suitable length of rotational product, and width and length of non-rotational product can be show as follows:

Code	Description
0	$L \leq 10$
1	$10 < L \leq 30$
2	$30 < L \leq 40$
3	$40 < L \leq 50$
4	$50 < L \leq 80$
5	$80 < L \leq 100$
6	$100 < L \leq 150$
7	$150 < L \leq 200$
8	$200 < L \leq 300$
9	$L > 300$

Code	Description
0	$L \leq 50$
1	$50 < L \leq 100$
2	$100 < L \leq 200$
3	$200 < L \leq 400$
4	$400 < L \leq 700$
5	$700 < L \leq 1000$
6	$1000 < L \leq 1100$
7	$1100 < L \leq 1200$
8	$1200 < L \leq 1500$
9	$L > 1500$

Code	Description
0	$W \leq 30$
1	$30 < W \leq 50$
2	$50 < W \leq 70$
3	$70 < W \leq 90$
4	$90 < W \leq 100$
5	$100 < W \leq 130$
6	$130 < W \leq 150$
7	$150 < W \leq 170$
8	$170 < W \leq 190$
9	$W > 190$

Table 3.10: Length of rotational product and non-rotational product

Surface finish

Surface is one of the most important attributes that manufacturer and customer put emphasis on. Products having different surfaces are manufactured by different equipment in different working conditions. Therefore if products having similar surfaces are grouped together, manufacturer will be able to prepare and arrange proper machines or equipments used for manufacturing them. In the case company, there are five kinds of surface

1. Polishing surface
2. Grinding surface
3. Coating surface
4. Standard surface
5. Raw material surface.

Polishing surface means that a part must be polish until it is shiny like a mirror. This part is used in serious work that does not need any scratch. Certainly, it requires a long time for polishing. The company usually performs this grinding operation by itself.

Grinding surface means that a part is also needed to be polished. However it does not needed to be shiny like the polishing product. Grinding surface is usually required by a part used in cutting work like die and punch cutter. As well as the polishing surface, the grinding surface is usually done by the company itself.

Part having **coating surface** is normally coated by chromium. Since the shiny surface is the result of the characteristic of chromium, thus it can reduce polishing time of workers. Generally, the coating surface is not needed in the working operation, but the reason of this kind of surface is to make part looking more beautiful. Commonly, Chromium coating has to be carried out by supplier.

Standard surface means a part has to have smooth surface. In this type of part, the surface is not a significant attribute that should be put emphasis on. However, since the surface of raw material is rough. it should be machined slightly.

Raw material surface (no surface machining) means by itself. It is unnecessary to do anything about the part surface. Normally parts having this surface are structure components of a large machine. Consequently surface finish can be concluded in table 3.11.

Code	Description
0	Polishing surface
1	Grinding surface
2	Coating surface
3	Standard surface
4	Raw material surface
5	Others

Table 3.11: Surface finish code

Material

Material is one of the most important things that customers put emphasis on. Since some products require high hardness, it has to be made from material that can provide the target hardness. In the case company, there are 9 main types of material used to produce products: MS, S45C, SCM4, SKD11, 2379, 7225, Stainless class, Brass class, and Aluminum class.

MS is raw material used for general product that hardness is not required. It is usually used with machine structure. S45C, SCM4, 2379, and 7225 are material that harder than MS class. It is usually used with small tools, jig, and fixture. Providing hardness around 60-62 HRC, SKD11 is the hardest material used in the case company. It is generally used with cutting tools such as die cutter and punch cutter. Stainless, brass, and aluminum are also be used for some products. The reason that we use class is that stainless, brass, or aluminum also has its own grade. Thus, we will group all grade together and call them stainless, brass and aluminum class. Consequently material code can be concluded in table 3.12.

Code	Description
0	MS
1	S45C
2	SCM4
3	SKD11
4	2379
5	7225
6	Stainless class
7	Brass class
8	Aluminum class
9	Others

Table 3.12: Material code

Precision or tolerance

Precision allows production department to prepare suitable tools and workers. It also reminds production manager to carefully check and pay attention to the workers who

involved in the manufacturing operation. At present precision is divided into 6 classes depended on tolerances specified in drawing.

Class1: < 0.005 mm
Class2: 0.005 - 0.01 mm
Class3: 0.01 – 0.025 mm
Class4: 0.025 – 0.05 mm
Class5: 0.05 – 0.1 mm
Class6: >0.1 mm

Generally, the case company can guarantee customers that it can effectively produce product having precision around 0.025-0.05 millimeters. 0.005 millimeters or 5 micron is the highest precision that machine and tools in the company can handle. Product in this class frequently makes loss for the company since it requires very great condition tools. Consequently precision code can be concluded in table 3.13.

Code	Description
0	≤ 0.005
1	$0.005 < P \leq 0.01$
2	$0.01 < P \leq 0.025$
3	$0.025 < P \leq 0.05$
4	$0.05 < P \leq 0.1$
5	> 0.1

Table 3.13: Precision code

3.3.11 System development of Assembly product

About 20% of all products of the case company are assembly products and most of them are small machines and large machines. Generally, significant attributes that used to differentiate them in the case company are

Product status

Assembly product can be compounded of a group of non-assembly products or a group of assembly products. To know whether it is the finish product or it has to be used for assembly again, product status should be determined. Therefore, there will be two types of product status:

1. Wait for assembly
2. Finished product

Consequently, product status can be concluded in table 3.14.

Code	Description
0	Wait for assembly
1	Finish product

Table 3.14: Product status code

Product type

There are two major types of assembly product: Machine and Component. An assembly product may be one component of a machine or it can be a machine. Thus, knowing product type will allow administrator and user to classify products into proper groups, and understand their responsibility. Product types can be divided into 4 types

1. Tools set
2. Component set
3. Small-medium machine
4. Large machine

Consequently, product type can be concluded in table 3.15.

Code	Description
0	Tools set
1	Component set
2	Small-Medium Machine
3	Large Machine

Table 3.15: Product status code

Quantity of components

The number of component parts can show how complicate that product are. The product having a lot of component may require more assembly time and is needed to be kept carefully. Consequently, quantity of components can be concluded in table 3.16.

Code	Description
0	≤ 5
1	$5 < Qty \leq 10$
2	$10 < Qty \leq 20$
3	$20 < Qty \leq 40$
4	$40 < Qty \leq 60$
5	> 60

Table 3.16: Product status code

Assembly type

Since parts can be put together by many ways such weld, screw, or insert, the assembly types is an important attribute that used to distinguish parts. The production manager will be able to determine suitable workers who specialize in each assembly type. Currently there are 4 types of assembly.

1. Welding
2. Insert
3. Nut and bolt
4. Thread

Consequently, assembly type can be concluded in table 3.17.

Code	Description
0	Welding
1	Insert
2	Nut and bolt
3	Thread

Table 3.17: Assembly type code

3.3.12 Sample results of applying the system

Once the classification and coding system was developed, 592 samples of non-assembly products of the case company will be classified and coded.

After applying overall shape

Once the rule is applied, 428 products of the case company are classed as rotational product, and 164 products are classed as non-rotational product.

Product code											No. of products (Pieces)
Product type		Overall shape									
1	-	0	-	x	x	x	-	x	x	x	428
		1	-	x	x	x	-	x	x	x	164
Total											592

Table 3.18: Products classified by overall shape

After applying overall shape and external shape

According to product size previously presented, three attribute used for non-rotational product are height (H), width (W) and length (L). However, it may not suitable to add three digits to support all sizes because the number of digit will be too long and will not go along with that of rotational product. Since there are two additional digits added in code of rotational product, the additional digits of non-rotational should be the same. Therefore, height (H) should be included into the external shape attribute and create two new digits corresponding to width and length.

Subsequently, the external shape of non-rotational product (Table 3.5) is adapted into the following table.

Figure	Description
0	Rectangular H < 15 mm
1	Rectangular 15< H < 30 mm
2	Rectangular 30< H < 50 mm
3	Rectangular H > 50 mm
4	O shape
5	L shape
6	U shape
7	C shape
8	I shape

Table 3.19: External shape of non-rotational product (modified)

When products were classified by overall shape and external shape, the result can be shown in table 3.20.

Product code													No. of products (Pieces)
Product type		Overall shape		External shape									
1	-	0	-	0	x	x	-	x	x	x			58
				1	x	x	-	x	x	x			96
				2	x	x	-	x	x	x			58
				3	x	x	-	x	x	x			126
				4	x	x	-	x	x	x			51
				5	x	x	-	x	x	x			27
				6	x	x	-	x	x	x			7
				7	x	x	-	x	x	x			5
1	-	1	-	0	x	x	-	x	x	x			65
				1	x	x	-	x	x	x			26
				2	x	x	-	x	x	x			10
				3	x	x	-	x	x	x			2
				4	x	x	-	x	x	x			8
				5	x	x	-	x	x	x			29
				6	x	x	-	x	x	x			12
				7	x	x	-	x	x	x			7
				8	x	x	-	x	x	x			5
Total													592

Table 3.20: Products classified by overall shape and external shape

After applying overall shape, external shape, and size

The result of classifying products by using external shape and size will be demonstrated in Appendix A. Most products were classified into very small groups. Moreover, some codes have already got only one product. This explains that the developed classification and coding system has ability to classify and code products of the company and product code is able to illustrate product. Therefore, when employees see a code, they will be able to demonstrate a product, verify surface finish, material types, and others. However, after applying surface finish, material, and precision attributes, some products having very similar characteristics were classed in the same product code. This happened because these products are slightly different from each other only on their sizes and other special features that were not included in the system such as cut edge angle (die cutter and punch cutter). Therefore, two resolves can be applied.

1. First, we may add these attributes into the code, which make code to become longer and more complicate.

2. Second, we may apply concept of cataloguing system that is currently used by the old classification system. The concept is to use first three letters of product name to classify product.

Both way have their own advantage and disadvantages depended on the number of these products. According to the case company product, there are three largest groups of products having the same code: 1-0-374, 1-0-384, and 1-1-052. These groups have product around 2 to 5 products in their groups. This shows that adding new attributes may not proper because one attribute can be used with only one type of product and there are only few products in each group.

Therefore, to make it universally, it is better to apply the concept of cataloguing system. Finally, there will be another five additional digits add into the coding system. The conclusion of developed classification and coding system can be concluded in figure 3.8.

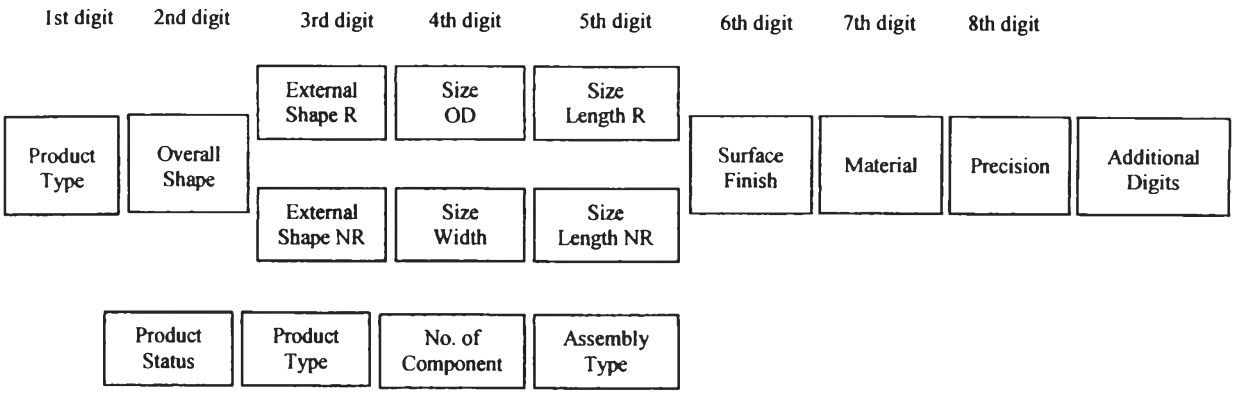

Figure: 3.8: Coding system structure (Final)

3.3.13 Examples of the system

To provide examples, two situations will be presented. The first situation occurs when employee see a product code. The example will illustrate what information provided to them are. Conversely, the second situation occurs when a new product is needed to be coded. Example will show how to classify and code it step by step. Products that will be used are listed below.

No.	Product name	Overall shape	Drawing No.	OD/Width	Length
1	Sealing arm	Rotational	022-MC-09	19	80
2	Connector	Rotational	018-AD-11	32	58
3	Punch Cutter 202	Rotational	TL6-218	77	62.5
4	Cover 307	Rotational	021-CV-04	144	10
5	Clamping Screw	Rotational	SP82-1367	20	38.5
6	Lower Blade No.L2	Rectangular	03575-CP018	43.56	259
7	Clamping plate	Rectangular	SP80-1365	25	70
8	Side Plate B -RH	Rectangular	0075-FS-02-E	230	1030
9	U-Support	U shape	0085-MC-01-G	75	1113
10	Square Bar	O Shape	0065-HF-01-I	50	982

Table 3.21: List of sample products

Example 1: When code 1-0-114-365-Sea-0001 is found

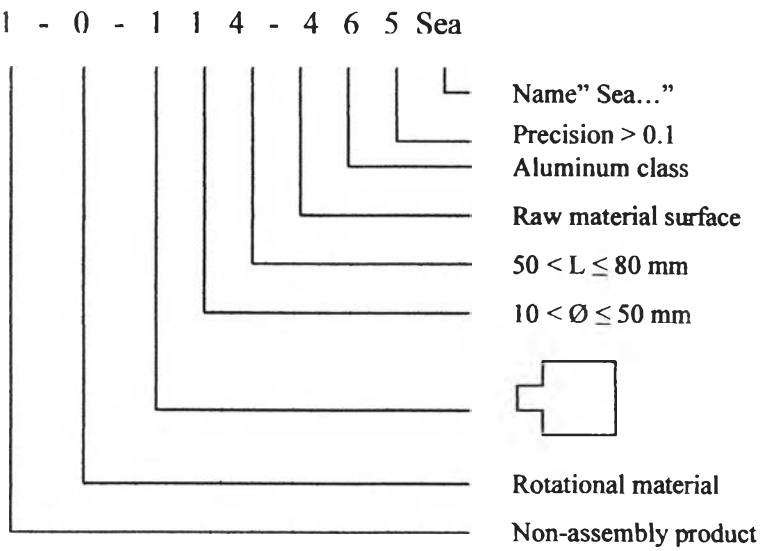

Figure 3.9: Code for sealing arm

From the code, employee will pay attention to 10-50mm rotational part made of aluminum. If more than one product were found, he will be able to get the target part by checking product name and size. We can compare above information with actual drawing shown in the following figure.

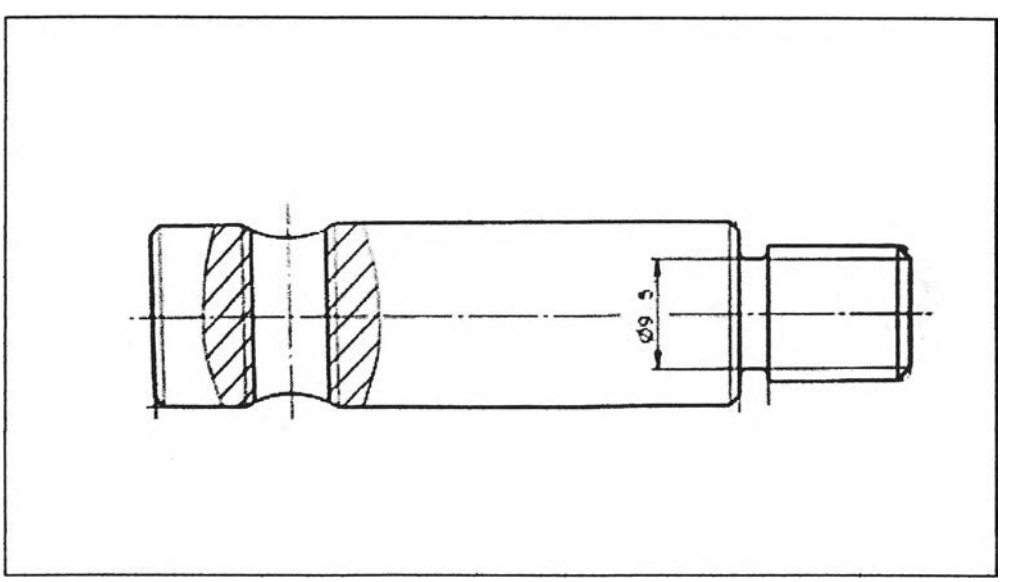

Figure 3.10: Drawing of sealing arm

Example 2: When code 1-0-514-375-Con-0001 is found

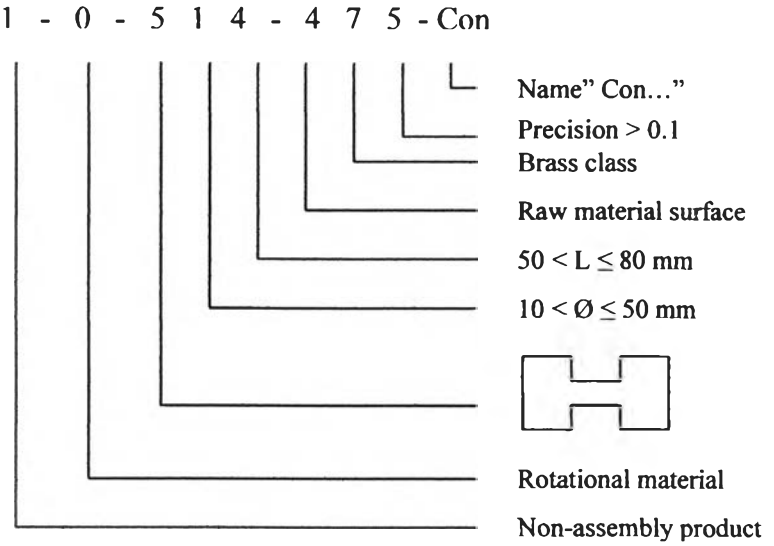

Figure 3.11: Code for connector

From the code, employee will pay attention to 10-50mm rotational part made of brass. If more than one product were found, he will be able to get the target part by checking product name and size. We can compare above information with actual drawing shown in the following figure.

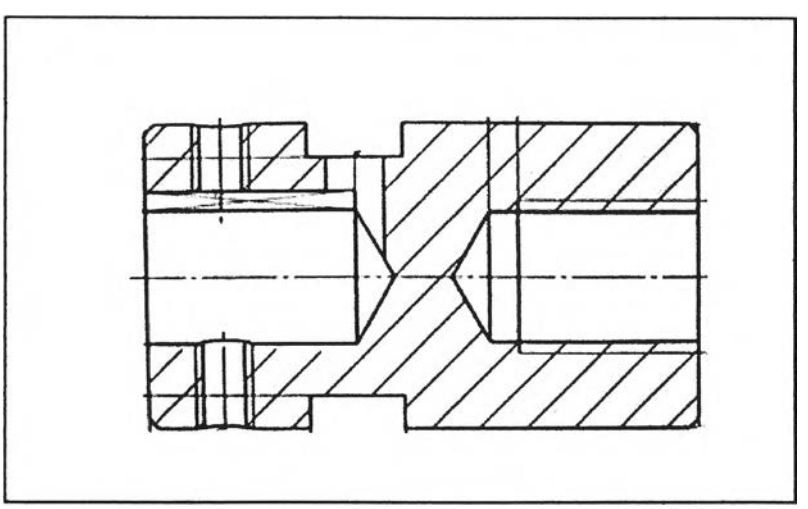

Figure 3.12: Drawing of connector

Example 3: When code 1-1-101-405-Cla-0001 is found

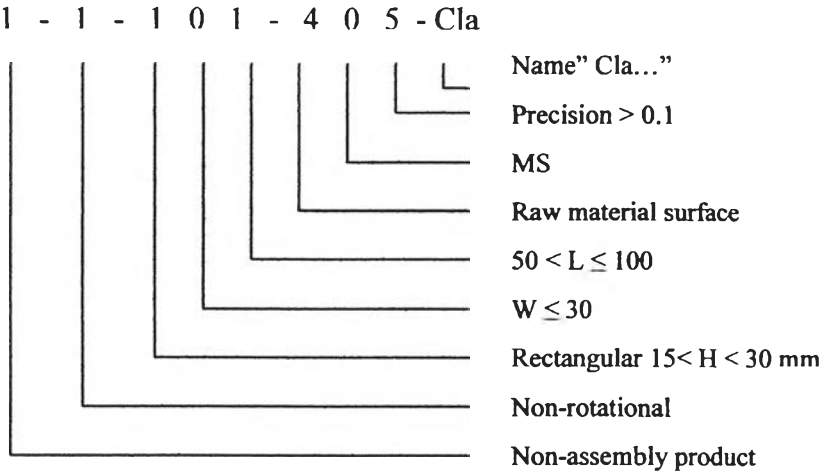

Figure 3.13: Code for clamping plate

From the code, employee will pay attention to small slim rectangular part made of MS. If more than one product were found, he will be able to get the target part by checking product name and size. We can compare above information with actual drawing shown in the following figure.

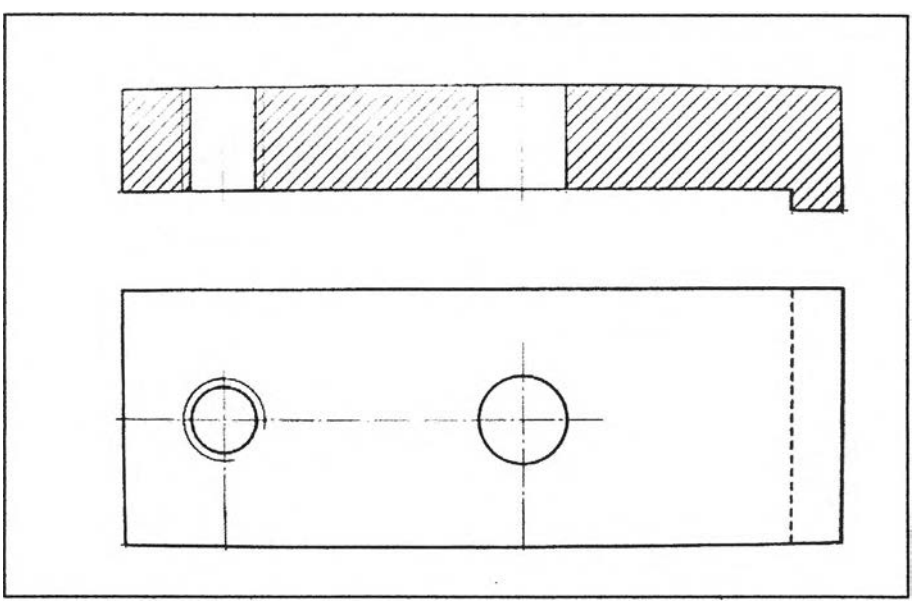

Figure 3.14: Drawing of clamping plate

Example 4: When code 1-1-637-405-Usu-0001 is found

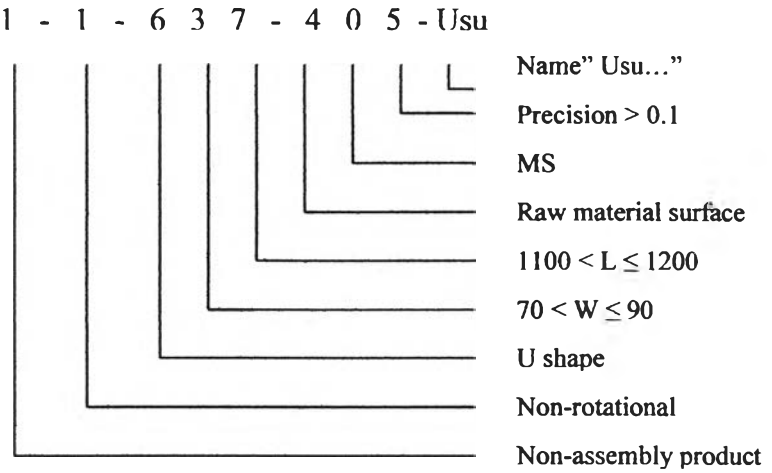

Figure 3.15: Code for U support

From the code, employee will pay attention to product having U shape, 1100-1200 long. If more than one product were found, he will be able to get the target part by checking product name and size. We can compare above information with actual drawing shown in the following figure.

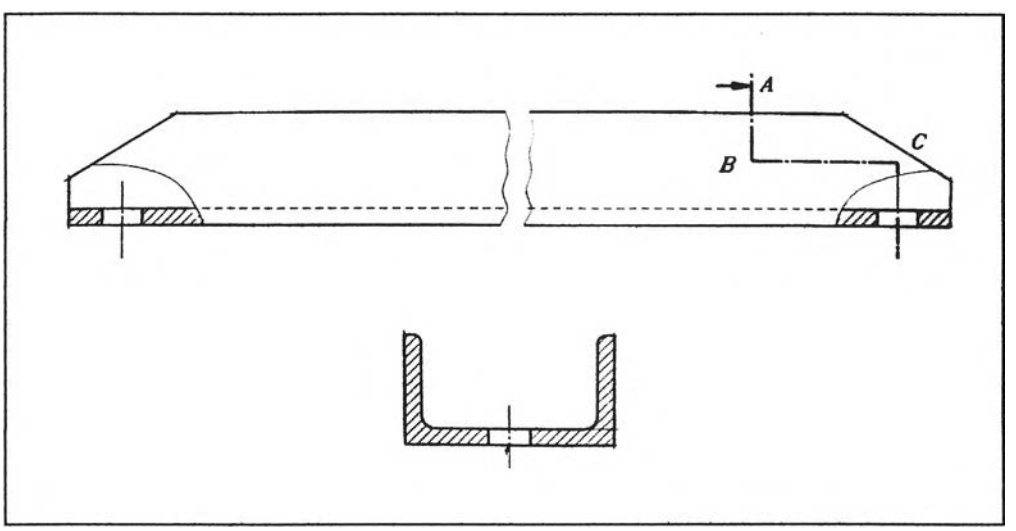

Figure 3.16: Drawing of U support

Example 5: When code 1-1-096-405-Sid-0001 is found

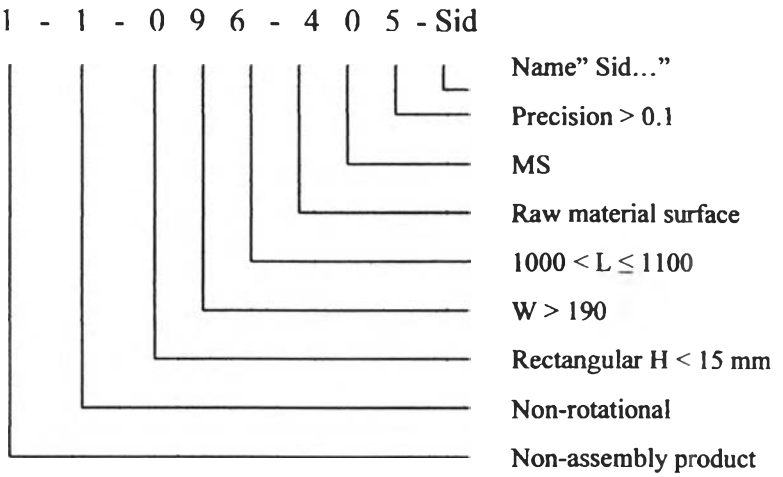

Figure 3.17: Code for Side plate B

From the code, employee will pay attention to thin large plate having more than 190mm width, and 1000-1100mm length. If more than one product were found, he will be able to get the target part by checking product name and size. We can compare above information with actual drawing shown in the following figure.

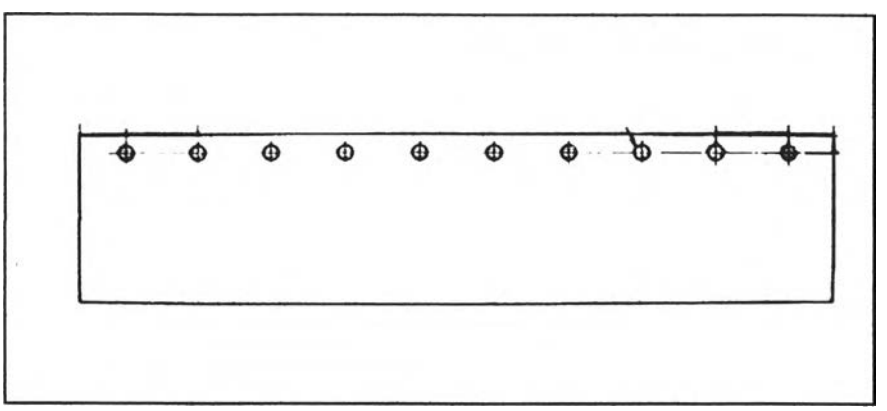

Figure 3.18: Drawing of Side plate B

Example 6: This example will show how to classify and code "Punch Cutter 202 SPOE" shown in figure 3.19.

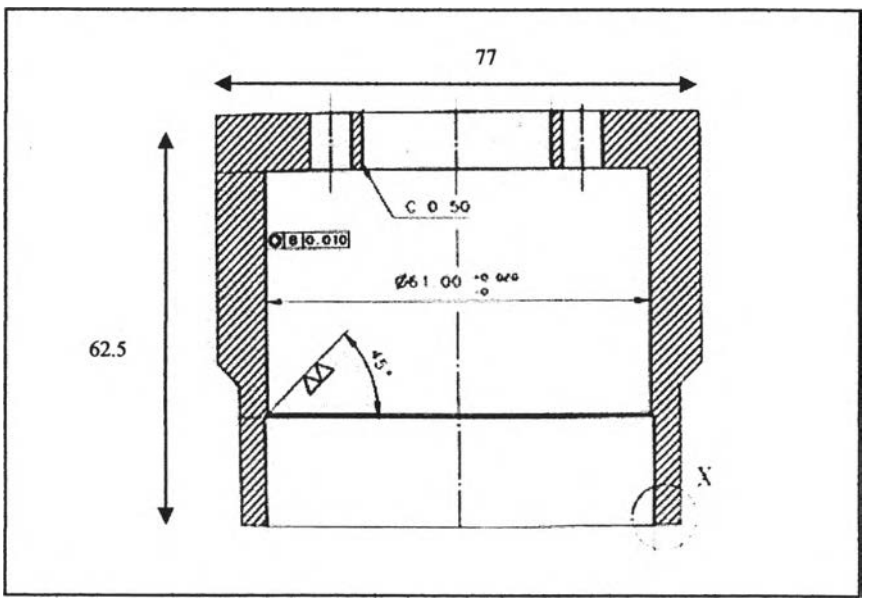

Figure 3.19: Drawing of Punch Cutter 202 SPOE

From the drawing, product attributes can be concluded as follows:

Digit No.	Attributes		Code result
1	Product type	Non-assembly product	1
2	Overall shape	Rotational shape	0
3	External shape	One side step, slope, and smooth end	2
4	Diameter	77	3
5	Length	62.5	4
6	Surface finish	Grinding surface	1
7	Material	Skd11	3
8	Precision	0.001-0.005mm	0
	Product name	Punch Cutter 202 SPOE	Pun

Table 3.22: Attribute of Punch Cutter 202 SPOE

Therefore, code of Punch Cutter 202 SPOE is **1-0-234-130-Pun**

Example 7: This example will show how to classify and code "Cover for ball mill" shown in figure 3.20.

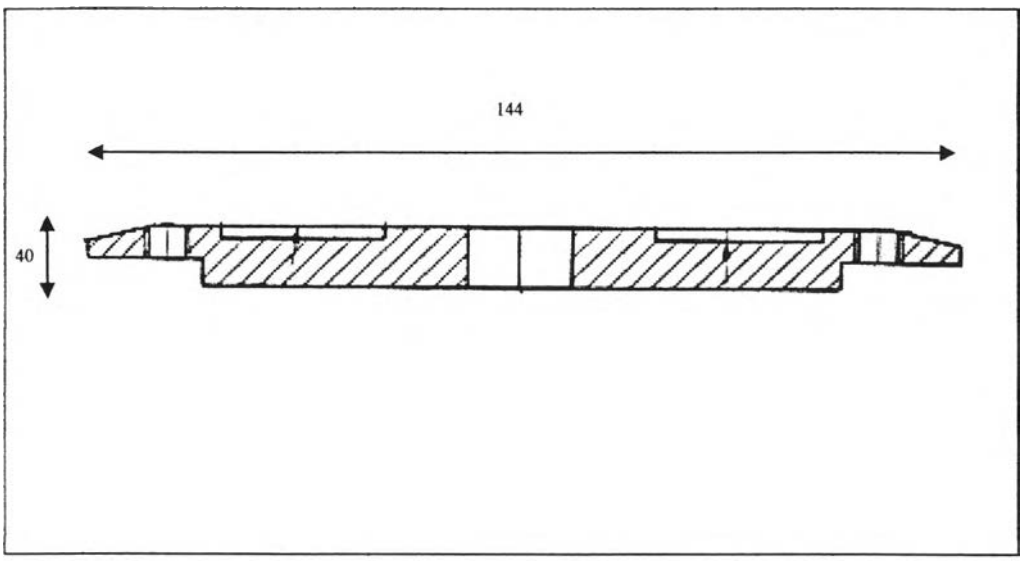

Figure 3.20: Drawing of Cover for ball mill

From the drawing, product attributes can be concluded as follows:

Digit No.	Attributes		Code result
1	Product type	Non-assembly product	1
2	Overall shape	Rotational shape	0
3	External shape	both sides step, slope, and slope end	7
4	Diameter	144	6
5	Length	10	0
6	Surface finish	Coating (Chromium)	2
7	Material	Ms	0
8	Precision	Not identified	5
	Product name	Cover for ball mill	Cov

Table 3.23: Attribute of Cover for ball mill

Therefore, code of Cover for ball mill is **1-0-760-205-Cov**

Example 8: This example will show how to classify and code "Clamping screw" shown in figure 3.21.

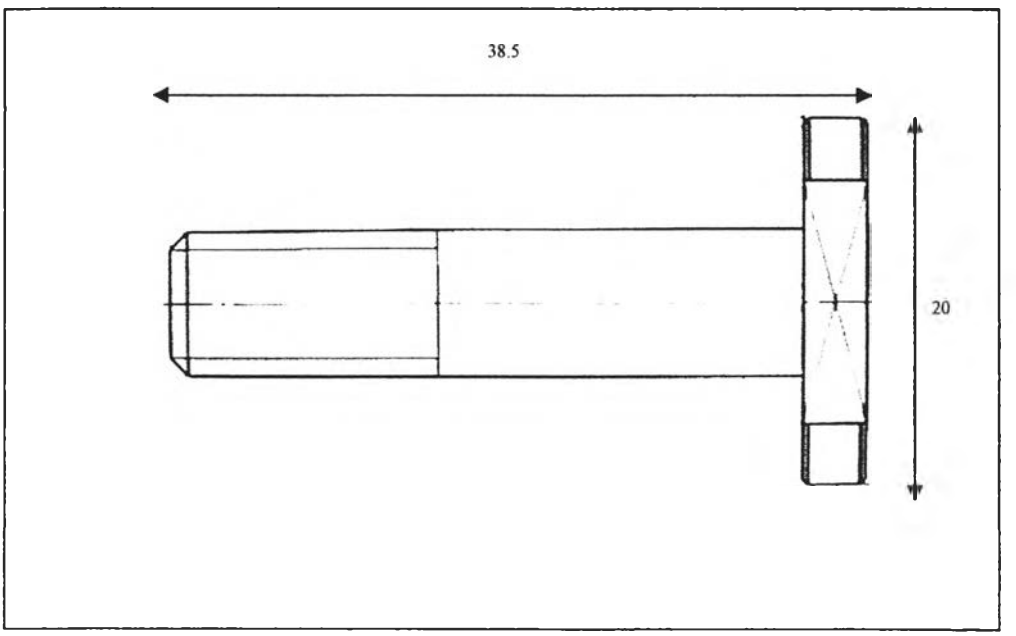

Figure 3.21: Drawing of Clamping screw

From the drawing, product attributes can be concluded as follows:

Digit No.	Attributes		Code result
1	Product type	Non-assembly product	1
2	Overall shape	Rotational shape	0
3	External shape	one side step, smooth	1
4	Diameter	20	1
5	Length	38.5	2
6	Surface finish	Coating (Chromium)	2
7	Material	Ms	0
8	Precision	Not identified	5
	Product name	Cover for ball mill	Cla

Table 3.24: Attribute of Clamping screw

Therefore, code of Clamping screw is **1-0-112-205-Cla**

Example 9: This example will show how to classify and code "Lower Blade No.L2 211x109" shown in figure 3.22.

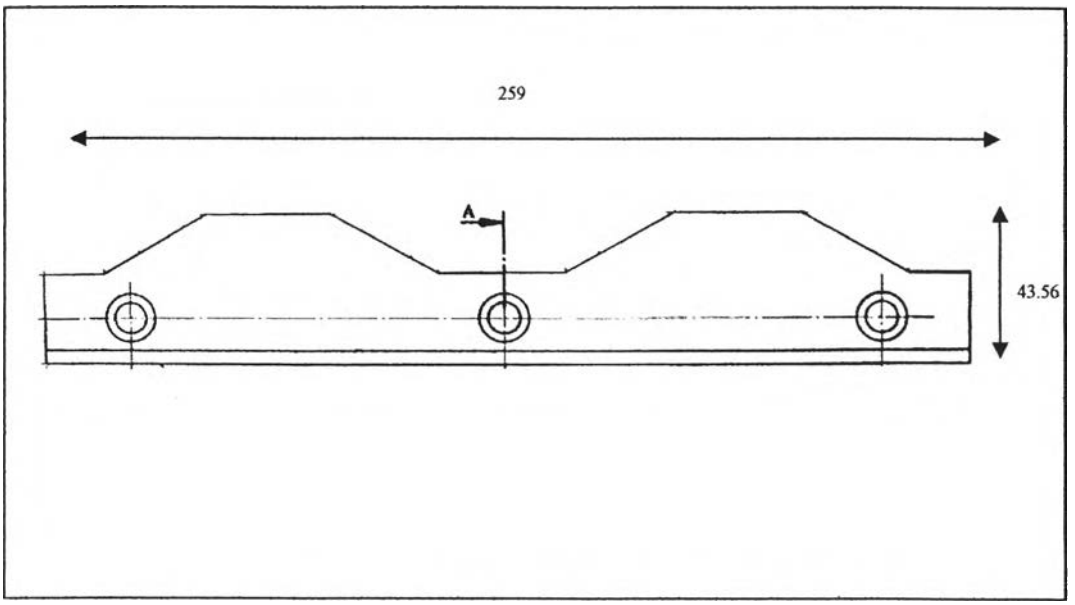

Figure 3.22: Drawing of Lower Blade No.L2 211x109

From the drawing, product attributes can be concluded as follows:

Digit No.	Attributes		Code result
1	Product type	Non-assembly product	1
2	Overall shape	Non-rotational shape	1
3	External shape	Rectangular 19mm height	1
4	Width	43.56	1
5	Length	259	3
6	Surface finish	Grinding surface	1
7	Material	SKD11	3
8	Precision	0.025-0.01	2
	Product name	Lower Blade No.L2 211x109	Low

Table 3.25: Attribute of Lower Blade No.L2 211x109

Therefore, code of Lower Blade No.L2 211x109 is **1-1-113-132-Low**

Example 10: This example will show how to classify and code "Square bar" shown in figure 3.23.

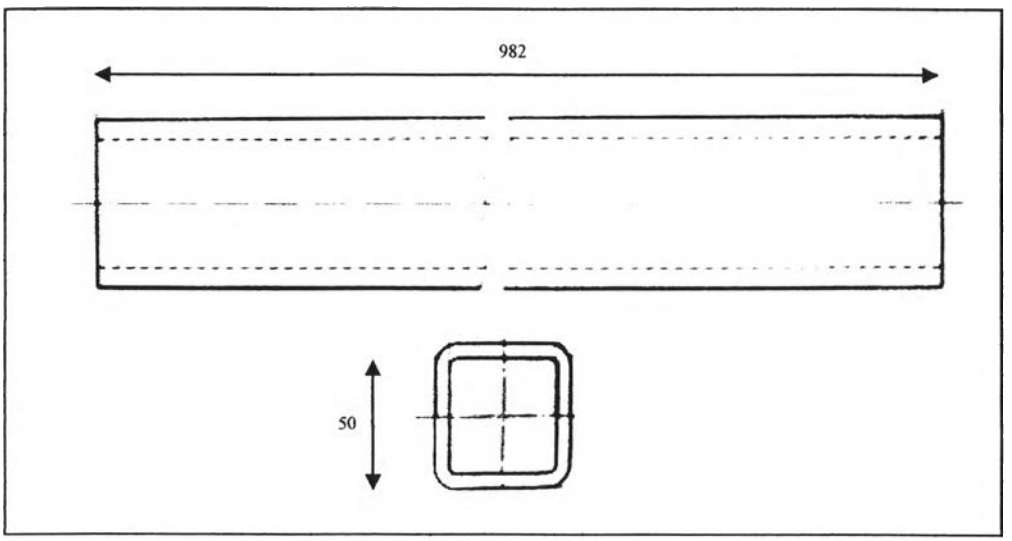

Figure 3.23: Drawing of Square bar

From the drawing, product attributes can be concluded as follows:

Digit No.	Attributes		Code result
1	Product type	Non-assembly product	1
2	Overall shape	Non-rotational shape	1
3	External shape	O Shape	4
4	Width	50	1
5	Length	982	5
6	Surface finish	Not identified	4
7	Material	Ms	0
8	Precision	Not identified	5
	Product name	Square bar	Sqa

Table 3.26: Attribute of Square bar

Therefore, code of Square bar is **1-1-415-405-Sqa**

3.3.14 Additional Coding system

Additional code is a group of code used to provide manufacturing information of product to production department. Although design attributes are suitable for the current users who involved in purchasing action, they may not provide enough manufacturing information to other users who involved in production planning activity. This means that though amount of products were classified into many small groups, they still be contained of products having different production time. The difference of production time usually occurs because manufacturing attributes that can significantly increase production time such as number of holes, number of thread, internal shape were not involved in the code. Therefore, the additional code will be developed based on them. The structure of additional code is shown as follows:

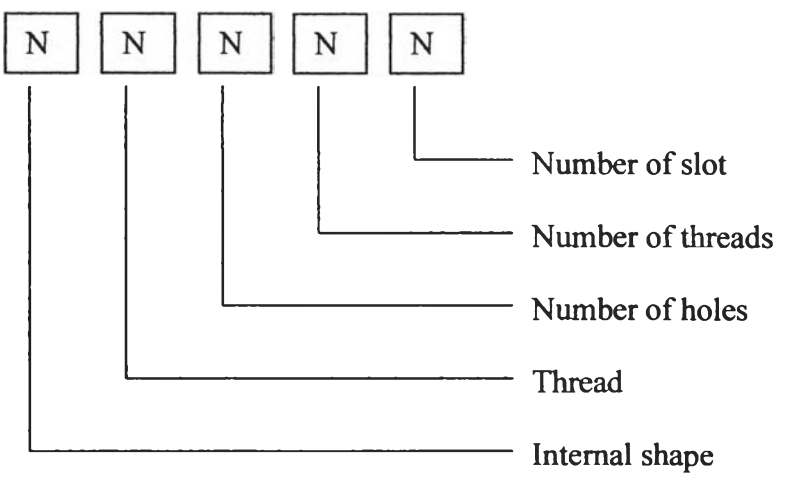

Figure 3.24: Structure of additional code

Internal shape

Like external shape, internal shape of rotational product can be shown in figure 3.25. However, since most of non-rotational products are used in machine structure, they have simple shape, which the external shape and size are already enough to be used to classify them. Only a few of them have complex shape, which cannot be classify as rectangular or structure shape such as oval shape and cutter shape. Therefore special product types will be used to classify internal shape of non-rotational product shown in figure 3.25.

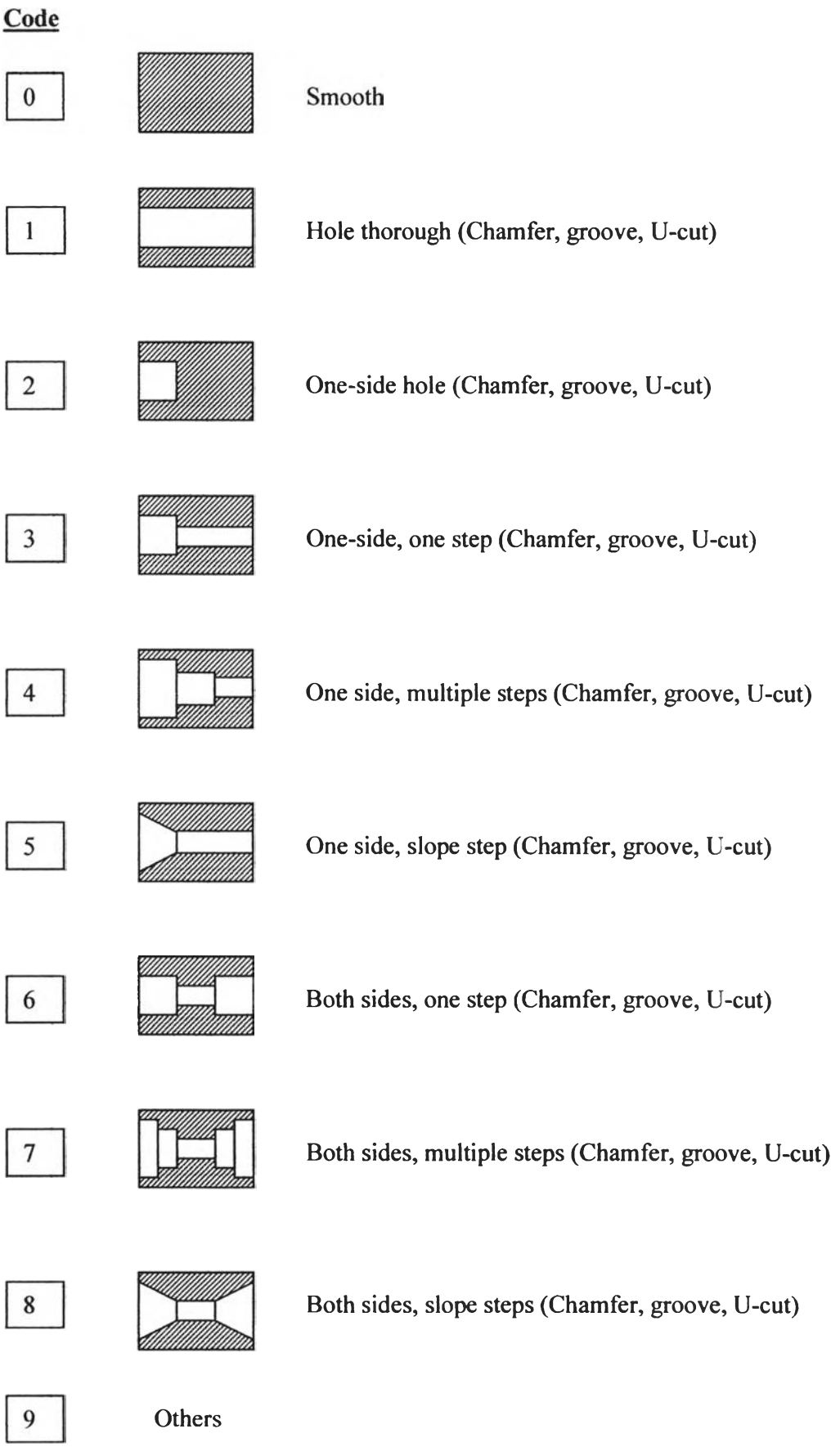

Figure 3.25: Classification by internal shape for rotational product

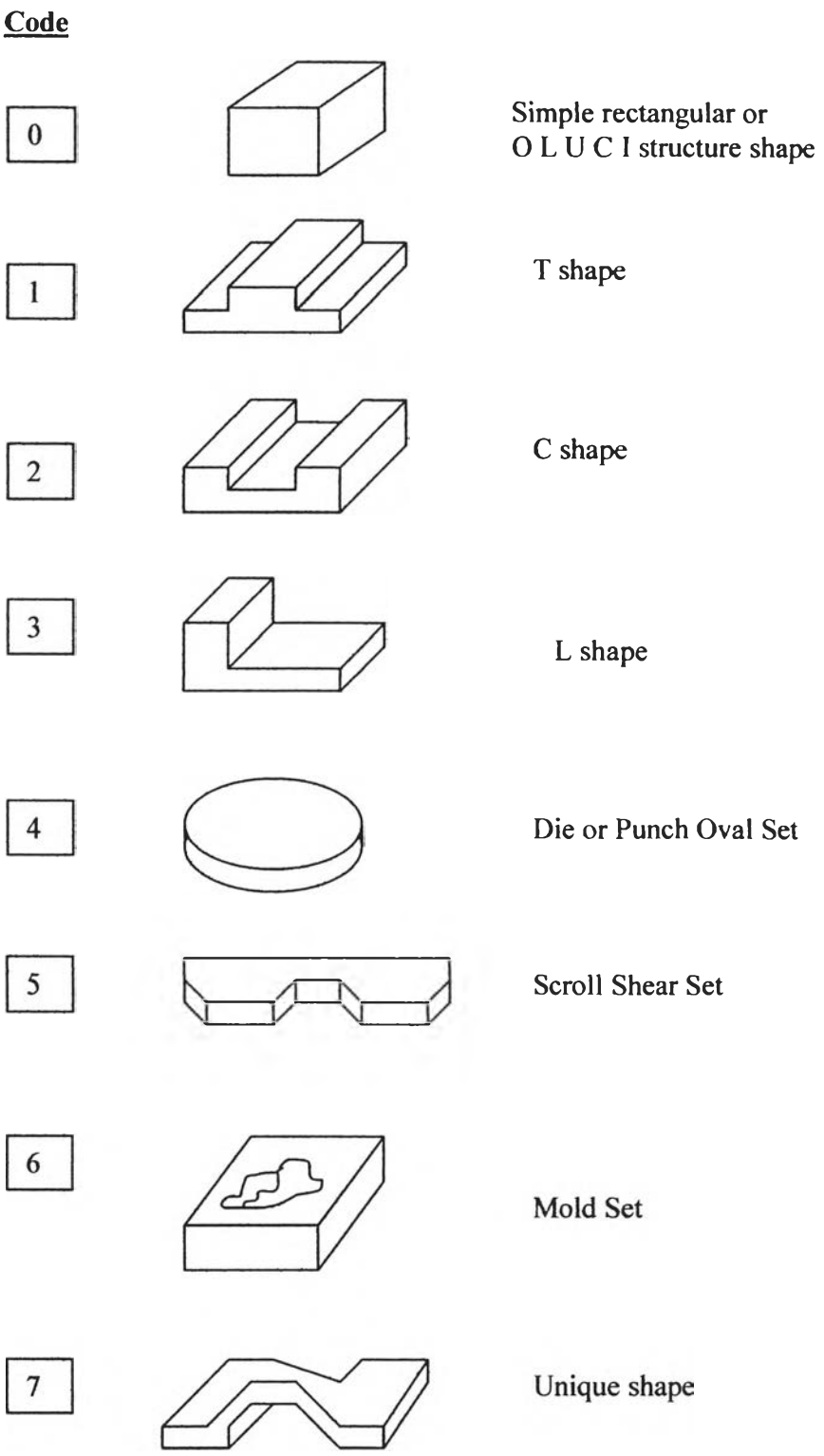

Figure 3.27: Classification by additional shape for non-rotational product

Threads

Thread attribute is derived from the external and internal shape. Since the last step of external or internal shape can be thread or smooth, which significantly affects the production time, rotational products having smooth or thread shape have to be separated from each other. The detail of thread is shown as follows:

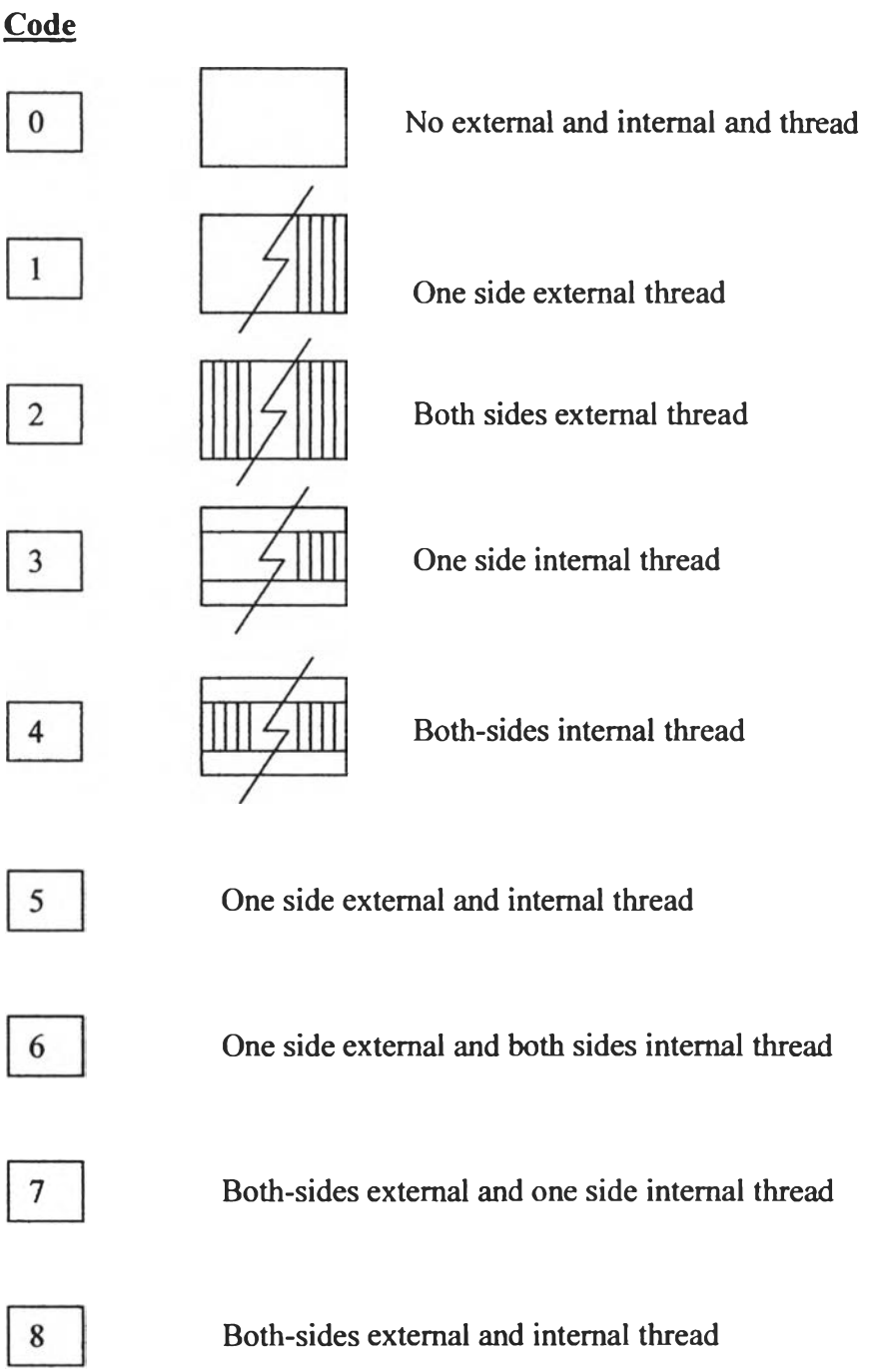

Figure 3.28: Classification by threads

Number of hole, thread, and slot

The number of hole, thread, or slot significantly affects the manufacturing time of a product. Therefore, it will be used to classify products having similar shape but having different number of hole, thread, or slot.

Code	Number of hole (thread) (slot)
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7-10
8	11-20
9	>20

Table 3.27: Classification by number of holes, thread, and slot

3.4 Database system development

To have the most appropriate system for the company, it is basically to know who the users are first. According to the production process of the case company, product data kept in WOS is normally required by two departments, accounting and production department. However, since significant data such as costs, prices, and profits shown in the WOS are required to be kept secretly, the production department is not permitted to get WOS directly. They have to request it from the accounting department. Therefore, the accounting employee becomes a current user and administrator at the same time. However, the director has explained that if the new system could hide all those secret data, he might allow the production department to access the system. As a result, the production employees may turn into the future users.

Once classification and coding system was developed, database system will be focused on. To improve ability to search, keep, maintain, and manage data in Work Order Sheet, The case company should implement computer program and database management system. According to the objective of the study, database management part is a target result expected by the case company. WOS should be recorded and maintained by computer system because it provides more safety and convenience. When user can manage data systematically, significant data used for estimating product standard time can be collected easily.

However, to establish computer system used for managing database system, it is better to include classification and coding system. User will be able to classify and code product and also record WOS simultaneously. Consequently, the computer program will be separated into two sections, which are classification and coding system, and WOS database management.

3.5 Program development

In general, a lot of instant software used to manage database in IT market could be bought. Anyway, since this software was created for using with many types of firm, users have to adapt many options before implement it in their company. Additionally, expenditure for copyright is high. The more abilities software has the more expenses firm pay. Thus, develop new own program allows the case company to have system that satisfy the requirements, and also to reduce copyright cost.

To design data management program firm has to summarize features that the program should have first. According to the objectives of the study, three main issues will be classification and coding, WOS database management, and security function.

3.5.1 Classification and coding system

There are two ways for applying classification and coding system generated in the previous section. The administrator may classify parts manually or use the program. To classify manually, the company may face with human errors and long time consumption. Therefore, letting the program generate and record by itself can reduce

these problems. Classification and coding section should be separated into three parts: Code installation, product classification and coding, and general management.

Code installation

This is the first part that administrator has to concern when details of each digit are identified. All details of each digit will be installed into this part. Obviously this part should be used only at the first time because changing code detail will affect all existing product codes. However, user can add or edit code detail when new details or inappropriate details are occurred. For example, user can add new figure with its meaning in the sixth digit of non-assembly product code, when a new type of surface is identified.

Product classification and coding

All products will be determined their class and code in this part. Administrator has to insert attributes of product, product name, drawing number, drawing name, and drawer's name. Then product will be classed and code will be generated. Other data such as customer, supplier, and raw material will not be inserted in this part since it is temporary data. In case of assembly product, component will be also selected. Generally, drawing in WOS is used to be a guide for inserting these attributes.

General management

Administrator is allowed to manage all data of product. Ability to search, edit, and delete is available in this part. Users can search the existing product code by product name, drawing name, drawing number, or drawer name.

3.5.2 WOS database management

The program has to able to manage all significant data used for determining standard time in WOS. Users should view, edit, add, or delete WOS easily and quickly. Generally, WOS database section should be separated into three parts: Data installation, product classification and coding, and general management.

Data installation

The program has to allow administrator to record significant data concerned in WOS. The data contains information of customer, supplier, worker, machine, raw material, hardening, and manufacturing operation. This data can allows user to find information of them promptly.

Product classification and coding

User may have to select the most suitable attribute from the list provided by the program and the program then classifies product and generates code automatically. According to product data management theory, Bill of Material is a total list of all components or materials required to manufacture product. It illustrates structure of these components to user. Since the case company is dealing with assembly product, it is one of the most important functions that program should have. The program should allow user to specify and display the summary structure of all components of an assembly product.

Standard time determination

According to Barnes(1980) [30], to determine standard time of worker, 4 methods are generally used.

1. Direct time study: This method determines standard time by using stopwatch or video camera directly.

2. Predetermined motion-time systems: This method determines standard time by applying standard calculation tables developed by many authors such as Motion time analysis (MTA), Methods time motion-time study (MTM), Dimensional motion time (DMT), and others.

3. Work sampling: This method using work sampling of statistical method

4. Standard time data and formula: This method uses historical data and some formulas to determine standard time.

However, with the scope of the study, this thesis will not put emphasis on standard time determination but it will use historical data of products to be the base data. Therefore, when the case company wants to find the actual standard time of product in the future, these data will be used beneficially. Consequently, once manufacturing data of a product is recorded in the database system, the system will use it to determine and conclude the approximate production time, which are average, the longest, and the shortest manufacturing time.

General management

As well as general management of classification and coding part, this part permits user to record, search, delete, and edit any data of WOS. The data is consisted of

-WOS number	-Product code	-Product name	-Drawing number
-Quantity	-Customer name	-Raw material	-Manufacturing time
-Workers	-Hardness	-Examiner	-Deliverer
-Order date	-Due date	-Delivery date	-Raw material cost
-Manufacturing cost		-Other costs	-Total cost

Since recording data from documents to computer database is a repeat work for employees, it is necessary to provide convenience for them. To provide convenience, the program should offer combo box or others, when general data like customer name, raw material use, or workers is going to be recorded.

3.5.3 Security function

As previously explained, although the account department is an only current user and administrator, there will be more users such as production department in the future. The increase of users will decrease ability and security of the system if users are allowed to edit or delete data in the system. In case of ability, if the company has only one computer to install database system, it may not enough for all users. When the company installs new computers, the database system has to be installed for all of them. Therefore, the application used to construct database system has to concern SQL server system. In case of security, the company will face problems occurred from data lost. Consequently, the system must provide simple security system such

as password. Users having no password will be able to search some information only. The ability to edit, add, or delete is unavailable.

3.6 Conclusions

In accordance with Bedworth (1991) [4], factors that should be kept in mind when selecting a system are *objective, robustness, expandability, differentiation, automation, efficiency, cost, and simplicity.* Since objective of installing the system will vary depending on user. This mean it is derived from user's requirement. The above developed coding system completely generated from administrator and user of the case company, thus it is a system that obviously direct to the objective. The important factors that the developed system provides are flexibility, cost, and simplicity. Detail of each digit can be changed in the future if user found inappropriate thing. It provides simplicity to all users since code structure and digit detail can be identified easily. The simplicity therefore causes the low cost consumption, which is one of the most important requirements of user. About robustness, the developed system is capable of handing all parts now being sold or planned to be sold. Code structure also involves looking at planned group technology applications and part attributes that might be needed. However, since the objective of the system currently depends on one who is not engineering or manufacturing, code detail then does not support engineering and manufacturing objective entirely.

For conclusion, the developed coding system obviously provides both advantage and disadvantage. The most important advantage of the system is that it completely offers the current requirements of the case company. The significant disadvantage is that it may not provide critically benefits in the future, when group technology or other system that need more suitable coding system is required. To accomplish the objective of the study, the company has to implement classification and coding theory and database management theory. Moreover, to provide more convenience, computer program that can combine both systems together should be established. Therefore the next chapter will present the structure of the program structure.