Chapter 4

Creation of Knowledge-based System

4.1 Background of Use of Knowledge-Based System in Selection

Knowledge based system, also called expert systems , are computer programs that simulate the reasoning of human expert in a given field of knowledge. Expert system is driven by means of heuristics or rules of thumb, to approach and extract information from a large knowledge base. According to Mahmoud, M.F., (1997, [1]), expert system typically consists of three main components:

- knowledge base
- inference engine
- user interface

These component are related as shown as a block diagram in Fig.4.1

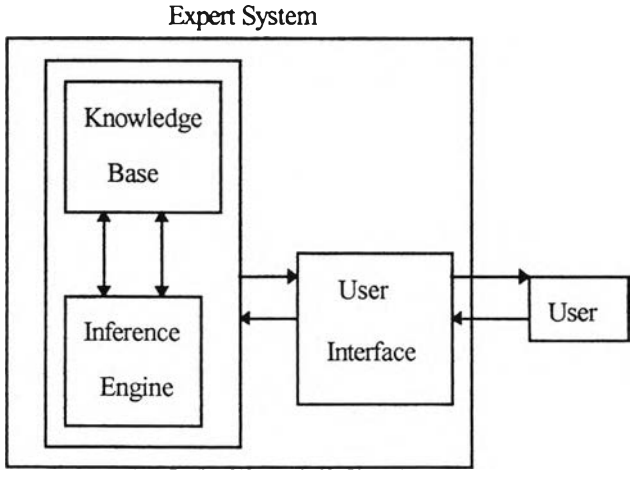

Figure 4.1. Block Diagram of An Expert System: D.V. Pigford, and Baur, G.[2]

Part 1: The knowledge base comprises of the facts and rules (or other representation) that the system posses a particular problem domain.

Part 2: The interference engine fulfill the ways of deciding how and when facts and rules are to be applied to make decisions(solve the problems).

Part 3: The user interface performs the communication between a user wishing to solve a problems. and expert system. By means of user interface, expert system may be command-driven, menu-driven, or icon-oriented.

Knowledge-based systems can be used in various application in industry including the areas of materials selection. An important advantage of expert systems is their ability to capture valuable expertise. In addition, they also provide recommendations and are able to search large database for appropriate solution. In the aspect of materials selection, expert system have been developed to help design engineers in solving materials.

4.2 Introduction to MATSEL-VPEX

A prototype knowledge-based system to assist material selection for plastic injection mold manufacturing, MATSEL-VPEX has been constructed by using VP-Expert version 3.1, which is the education version launched by Wordtech Systems in 1989. This prototype, MATSEL-VPEX , will offer you consultation in form of either text mode or graphic interface. User must have an EGA or VGA display and a Microsoft-compatible mouse installed to use this demonstration rule base properly. User can easily modify the rule base in order to meet his or her expectation.

As stated earlier, MATSEL-VPEX:- MATerials Selection- VP Expert created by means of the VP-Expert release 3.1. This Knowledge-based system demonstrates the

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4.3.1 Selection of System development Tool

The knowledge-based system is actually a software program that runs on a computer (supercomputer, mainframe, minicomputer, and microcomputer). As mentioned before, in this study, MATSEL-VPEX is a prototype knowledge-based system created by mean of VP-Expert version 3.1 as the system development tool or system shell. MATSEL-VPEX to assist materials selection constructed is able to operate only on personal computer. More details on computer specification that can be used to run MATSEL-VPEX have been provided in appendix B

After the system development tool is selected. Next, the two facets in the definition of MATSEL VPEX that are useful for knowledge-acquisition activities mentioned later are defined as follows:

- defining the system's user
- defining the source of expertise

The more details of the two facets in the definition of MATSEL VPEX will be discussed later.

4.3.2 Identifying the System's User

Understanding exactly who will use a prototype MATSEL VPEX is an integral part of defining what the system will do. In fact, the users are no limited to people who interact directly with the system.. The user can mean everyone who will use the results or outputs generated by this system. In practice, the definition of knowledge-based system's task can not be separately from the identify of the system's user

Because of the limitation of time of this study, however, the scope of this research has focused on the core or cavity of plastics injection mold with its physical properties such as mechanical and thermal properties: Therefore, the system's intended

user who has to deal with the results or output of this systems must be able to interactive with the MATSEL VPEX. Therefore, people with technical background especially in mold manufacturing field and plastics characteristics are identified as the group of users recommended to use this consultation program.

4.3.3 Identifying the Source of Expertise

This facet in the definition of the MATSEL VPEX system is also crucial for knowledge engineering activities. Without the source of expertise, the development of the knowledge-based system is not possible. Before starting task in developing system, the source of expertise involving in the task should be examined. In this study, the source of expertise comes from 2 sources : written related literature and human experts.

4.3.3.1 Identifying written related literature

In this study, the knowledge of materials for injection making had been derived from metal materials handbook, injection mold making handbook, plastic molding engineering handbook, manuals mold making materials render. However, some document provide same information of injection mold making materials. Therefore, some of information are omitted to keep in Appendix A.

4.3.3.2 Identify the expert

Identifying the expert is one of challenges in building knowledge-based system, because it mean the success of the system construction. This also significantly affects the knowledge acquisition- leading other people to describe how they do, what they do. To identify the expert in injection mold making field, qualification of expert who has both the knowledge and the available time to provide all the requisite knowledge in MATSEL system construction, are working consecutive experience in material mold making and education background. The lower education background are compromise with longer working experience in the field.

Table 4.3.3.1. Table of Expert Qualification

Educational Background	Bachelor degree of higher	lower Bachelor degree
Working Continued experience	8 Year minimum	12 year minimum
Test interview score	70 %	70%

Although a person pass both qualification: working continued experience with desired level of education background, it is not necessary that he or she is expert. The test by using dialog interview will help to assure whether he or she is expert or not. The example of the test interview question is shown in Appendix C.

4.3.4 Knowledge Acquisition for MATSEL-VPEX Development

Knowledge acquisition is one of the important part in building MATSEL-VPEX knowledge-based systems. Knowledge acquisition encompasses obtaining all information that the knowledge engineers need to build an knowledge-based systems. Thus, the purpose of knowledge engineering is to obtain the knowledge.

Actually, knowledge engineering activities set up to build a knowledge -based system. can not be isolated step in the system's development. Rather, it played a important role in each step. Knowledge acquisition, which is use to gather and validate information for MATSEL VPEX system, plays an important role in knowledge engineering as well. Thus, the process of knowledge acquisition in constructing should be defined.

In this study, the processes of knowledge acquisition to gather and validate information for building MATSEL VPEX consist of 2 stages progressing from initial inquiry to detailed investigation. More details of each is below:

MATSEL knowledge base constructed contains the knowledge of materials for injection mold making. Materials for injection mold making are classified by using physical properties of metal into 2 main group: Ferrous and non ferrous metals. The structure of two main groups are illustrates in the figure 5.

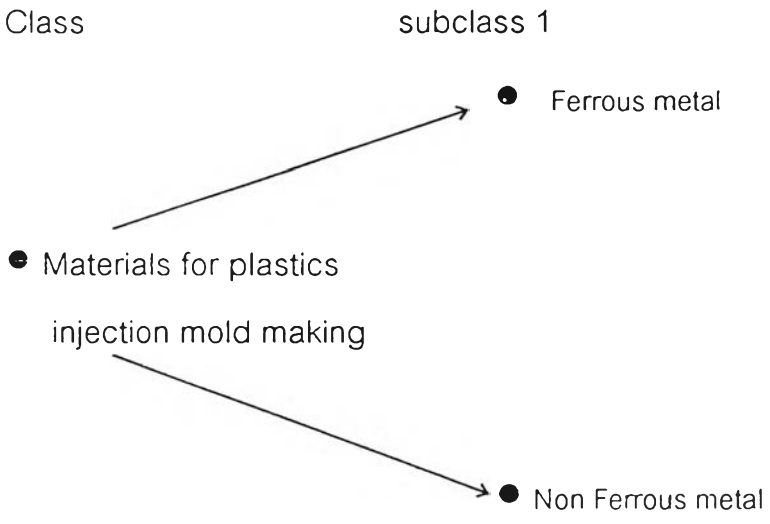

Figure 4.4.1 Structural knowledge base of Materials in class level.

Both group of ferrous metals and of non ferrous metals can be divided from subclass1 , subclass 2 into knowledge base of object level.

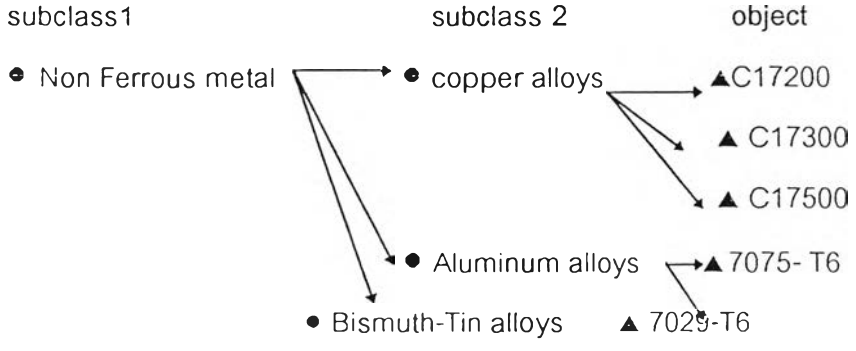

Figure 4.4.1-1 Structural knowledge base of Materials in sub class level and object level

4.3.4.1 Initial Inquiry Stage

Initial inquiry process is the preparatory stage. Information obtained in this stage is broad and overview of what the knowledge-based system does, how it will be used, and how it will be developed.

4.3.4.2 Detailed investigation

Detailed investigation is the discovery stage to focus on narrow and deep focus, with emphasis on details. The information gathered in this stage offers the knowledge engineers a comprehensive understanding of how the experts perform their tasks and duplicate the same process in the knowledge-based system.

4.4 Architecture of MATSEL-VPEX

A knowledge-based system, MATSEL-VPEX, to assist materials selection for plastics injection mold manufacturing can be organizing into 4 portions as follows:

1) Knowledge Base
2) Rule Base
3) Inference Mechanism
4) User Interface (text mode and graphic user interface)

4.4.1 Knowledge Base Development

The knowledge base comprises of the facts and rules (or other representation) that the system posses a particular problem domain. VP-Expert program as an expert - system shell, provides a frame work on which MATSEL VPEX can be developed. Although VP-expert version 3.1 has supplied the program that interpret and applied the knowledge, the knowledge base, which contains knowledge relevant to a particular task must be developed.

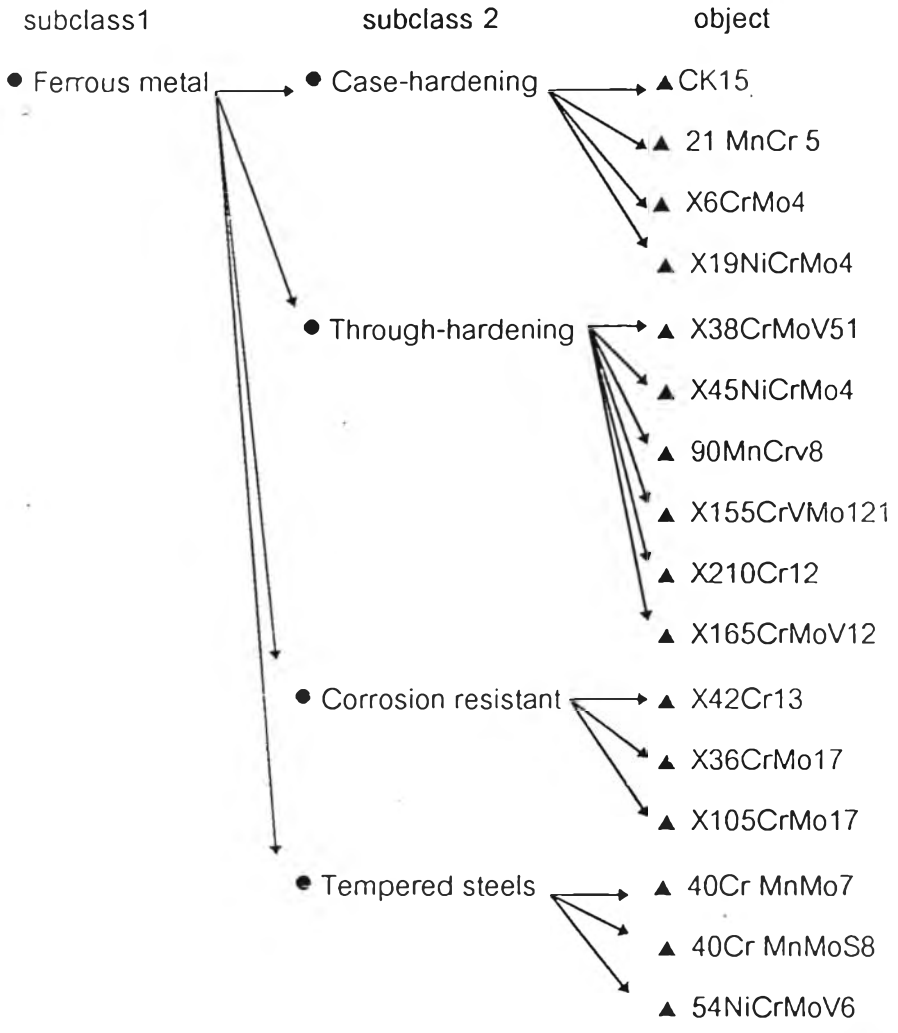

Figure 4.4.1-2 knowledge base of Materials in sub class level and object level (Cont')

In general, with the objective of achieving high functionality, different requirement are desired on the mold making materials. Material Selection must be able to be achieve the following general requirements for quality of injection mold:

@High wear resistance

@High corrosion resistance

@Good dimensional stability

@Good thermal conductivity

To achieve those different requirements stated above, knowledge base in object level has contained the knowledge base of properties so that an existing shell, VP-Expert shell developed to interprets and applied to acquire knowledge to select suitable materials for making injection molds.

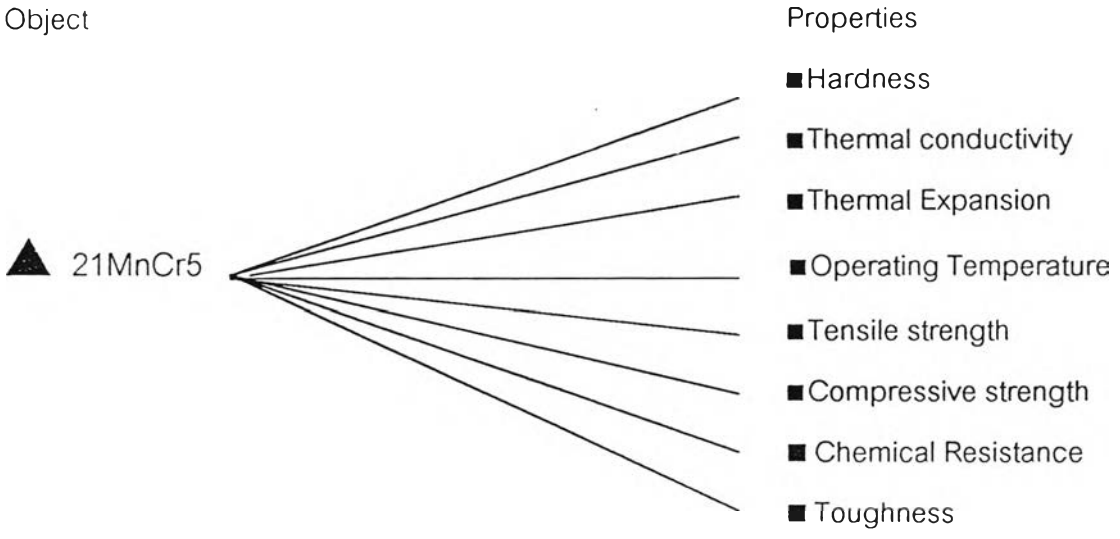

Figure 4.4.1-3 knowledge base of Materials in object level and properties (Cont')

According to the scope of research , the system's user must identify the final desired properties of injection mold that is the output result of engineering design, before the materials selection process will start. Therefore, properties knowledge in each object can be considered as the core of MATSEL's knowledge base. The properties knowledge is not be confused with the database. This module is created as a base to be translated into rule and strategies of knowledge-based system.

Depending on the problem scenario, the different system contains the different knowledge to solve the specific problem. Properties knowledge can be classified into groups as follows:

A. Mechanical properties knowledge

B. Thermal properties knowledge

C. Other properties knowledge

A-0. Mechanical properties knowledge of injection mold making materials consists of properties of tensile strength , hardness, toughness, and compressive strength.

A-1 Identifying tensile strength for mold materials in MATSEL

- Low tensile strength	≥ 440	MPa
- Medium tensile strength	450 - 750	MPa
- High tensile strength	750 -1100	MPa
- Very high tensile strength	≤ 1200	MPa

A-2 Identifying hardness for mold materials in MATSEL

- Low surface hardness	> 56	Rockwell C
- Medium surface hardness	56-60	Rockwell C
- High surface hardness	< 60	Rockwell C

B. Thermal properties knowledge of injection mold making materials consists of properties of thermal conductivity, thermal expansion and molding operating temperature.

B-1 Identifying thermal conductivity for mold materials in MATSEL

- Low thermal conductivity	≥ 600	BTU/hr F
- Medium thermal conductivity	600-900	BTU/hr F
- High thermal conductivity	≤ 1000	BTU/hr F

C. Other properties knowledge of injection mold making materials consists of wear resistance, corrosion resistance.

C-1 Identifying wear resistance for mold materials in MATSEL

- Low wear resistance for mold materials	Low
- Medium wear resistance for mold materials	Medium
- High wear resistance for mold materials	High
- Highly wear resistance for mold materials	Highly

C-2 Identifying corrosion resistance for mold materials in MATSEL

- Low corrosion resistance	Low
- Medium corrosion resistance	Medium
- High corrosion resistance	High

4.4.2 Rule Base

For MATSEL VPEX, knowledge can be represented through problem solving rule created on VP-Expert program. The IF-THEN rule format facilitate development of the rule in the knowledge base and in turn creates an impressive knowledge-base quickly. Rule Base embedded in MATSEL -VPEX can be illustrated in the following topic:

◆ Rule of mold-making-materials selections by means of the major type of materials

Rule of materials selections by selecting the main type of materials is in the shallow level of knowledge.. This rule of MATSEL is based on the standard classification of metal comprising with ferrous and non-ferrous metal materials.

Example of Rule of major materials :

IF METAL_MATERIAL is equal to FERROUS__METAL OR NON_FERROUS_METAL
THEN GDISPLAY
"MATSEL-VPEX displays list of materials in :"
GLOCATE 5, 16
GDISPLAY
"{METAL_MATERIAL} for injection mold making:" is confirmed.

◆ Rule of mold materials selections by using of subclass of materials

Rule of mold materials selections by using of subclass of materials is also in the shallow level of knowledge. This rule is in the subclass of the type of major materials. Non ferrous materials consists of copper alloys, aluminum alloys, Zinc alloys, and Bismuth-Tin alloys.

Example of Rule of major materials

IF Materials = Copper_alloys
THEN GLOCATE 16, 1
GDISPLAY "Information on Copper_alloys"

♦ Rule Base of User Interface

This rule of MATSEL- VPEX directly relates with communication channel between the knowledge-based system and the user.

Example of Rule of User Interface

IF Choices Response = "Yes" THEN

INTRODUCTION TO MATSEL-VPEX is confirmed to use.

4.4.3 Inference Mechanism

The inference mechanism is a technique that fulfill the ways of deciding how and when facts and rule are to be used to making decision or solving the specific problems. Thus, the inference engine is also known as the rule and fact interpreter due to its operation which behaves similarly to a software interpreter.

The inference mechanism, rule interpreter, examines the rule in a specified sequence looking for matches to the initial and current conditions given in the database. As the execution of the rule continues, the rule will reference one another to form an inference chain. For MATSEL system, two methods used by the inference engine to search for answers are forward and backward chaining. Forward chaining start with definitions and derives as many conclusion as possible. The rule in forward chaining are of " IF condition THEN Conclusion" . Backward reasoning or chaining, in contrast, The rule in backward reasoning are the form of " conclusion IF condition."

4.4.3.1 Mechanism for Ranking of Selected Mold Materials

MATSEL mechanism for sorting of the compromise result of selected mold materials utilized Alternative Inference Mechanism (AIM). AIM was developed by Hopgood [15] for polymer selection. AIM is the important portion of MATSEL system to sort materials on the basic of each material' score for selecting compromise solution.

In this study, Alternative Inference Mechanism (AIM) implemented in MATSEL-VPEX is in the equation as follows:

Total score for mold material i = $\prod$ { [(weight(j) - mid_point_1) x (action (i,j) - mid_point_2)] + Scale_var}

Scale_var = Minimum value to assure that total weight is positive

weight (j) = weighing score's user for property j

action (i,j) = action value to material I for property j

mid_point_1 = average value of weight (j)

mid_point_2 = average value of action (i,j)

4.4.3.2 MATSEL-VPEX Algorithm for Injection Mold Materials Selection

MATSEL-VPEX algorithm is used as the representation of this system model to illustrates how MATSEL system is able to help the system's user to select mold materials for injection mold making. Algorithm for Selection processes in MATSEL-VPEX is based on two level of knowledge: the deep-reasoning level and the shallow reasoning approach. MATSEL-VPEX algorithm is illustrated in the form of flow chart diagram as depicted in Figure 4.4.3.2

4.4.4 User Interface (text mode and graphic user interface)

The final element of MATSEL-VPEX architecture is the user interface. In general, the user interfaces serves as a communication between the user and the system. User interface is a software engine that allows the user to communicate with the MATSEL system. With the use of VP-Expert tool, the user is allowed to enter the initial consultation with MATSEL-VPEX system.

MATSEL-VPEX has the part of user interface concerned with screen design, text, color, graphics, printer output and input or output device such as light menu box, and graphic meter with interactive scale. MATSEL-VPEX is implemented the portion of user

interface by using VP-Expert 's user interface in form of both only text mode and graphic mode.

Figure 4.4.3.2 MATSEL-VPEX Algorithm for injection mold material