UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EXPERT SYSTEM OF MAINTENANCE PROBLEMS FOR SQUARE FOILING MACHINE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotics and Automation) (Hons.)

by

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TAJUK: **Expert System on Maintenance Problems for Square Foiling Machine**

SESI PENGAJIAN: 2014/2015 Semester 2

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DECLARATION

I hereby, declared this report entitled Expert System of Maintenance Problems for Square Foiling Machine is the results of my own research except as cited in references.

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Date : 1-7-2015

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) (Hons.). The member of the supervisory is as follow:

.....

(Project Supervisor)

ABSTRAK

Projek ini adalah tentang membina sistem pakar yang bertajuk Sistem Pakar Penyelenggaraan Masalah untuk Mesin Kedap Bersaiz Empat Segi Sama. Mesin ini telah dicipta oleh Teknologi Boryung yang dibeli oleh Nulatex Sdn Bhd. Mesin ini digunakan untuk pakej kondom lateks berkualiti. Boryung Teknologi telah memberi arahan operasi yang mengandungi senarai semak kecacatan. Senarai semak kecacatan mengandungi masalah penyelenggaraan terhadap Mesin Kedap Bersaiz Empat Segi Sama. Maklumat ini digunakan untuk membina sistem pakar. Pertama, maklumat ditukarkan kepada JIKA-MAKA kaedah dan melaksanakan menggunakan kaedah rantaian kehadapan. Kemudian, maklumat telah diprogramkan menggunakan Python Bahasa Pengaturcaraan dengan aplikasi muka grafik. Sistem yang lengkap dinilai keberkesanannya dengan menggunakan satu set soal selidik. Walau bagaimanapun, ini adalah sistem tertutup yang memerlukan penambahbaikan untuk melaksanakan kepada mesin. Sebagai contoh, sistem perlu mengemaskini masalah penyelenggaraan untuk menjadi lebih cekap dan berkesan. Hasil daripada kajian ini amat berguna yang akan dilaksanakan dalam industri untuk mengurangkan masa kerosakan dan kos. Sistem ini akan digunakan dalam ramalan prestasi mesin.

ABSTRACT

This project is about developing an expert system that titled Expert System of Maintenance Problems for Square Foiling Machine. This type of machine was invented by Boryung Technology that purchased by Nulatex Sdn Bhd. The machine was used to package quality latex condoms. Boryung Technology had been provided an operating instruction that includes a defect checklist. The defect checklists contain maintenance problems of Square Foiling Machine. This information used to build the expert system. First, the information transcribed into IF-THEN rule and executed the rules using Forward Chaining method. Then, the rules programmed using Python Programming Language with Graphical User Interface application. A complete system evaluated its effectiveness using a set of questionnaire. However, this is offline system that required further improvement to implement to the machine. For example, the system need update its maintenance problems to be more efficient and effective. The result from this research is useful to be implemented in industry to reduce breakdown time and cost. The system will be used in machine performance forecasting.

DEDICATION

Very special love and appreciation for my lovely parent and family for being an internal spirit and gives continual support that effect much in developing this project. Great appreciation to my supervisor for encouraging and invaluable guidance. Thanks to Nulatex Sdn. Bhd. for permission to the project regarding to Square Foiling Machine.

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I acknowledge my sincere obligation and gratitude to my family for their love and sacrifice throughout my life. I am thankful for their sacrifice, patience, and understanding that were inevitable to make this work possible. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve my dreams.

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LIST OF ABRREVIATIONS, SYMBOLS AND NOMENCLATURES

AI	-	Artificial Intelligence
BASIC	-	Beginner's All-purpose Symbolic Instruction Code
BRT	-	Boryung Technology
C	-	C Programming
C++	-	C++ Programming
C#	-	C# Programming
CMMS	-	Computerized Maintenance Management System
FMEA	-	Failure Modes and Effects Analysis
FORTRAN	-	Formula Translating System
GUI	-	Graphical User Interface
Haskell	-	Haskell Programming
Java	-	Java Programming
LAN	-	Local area network
Lisp	-	Lisp Programming
MATLAB	-	Matrix Laboratory Programming
ML	-	Meta Language Programming
OCmal	-	Objective Caml Programming
PDCA	-	Plan, Do, Check, Act
Perl	-	Perl Programming
Prolog	-	Prolog Programming

CHAPTER 1

INTRODUCTION

This chapter is about introducing the background of this project that is related to a disposable medical device manufacturing company, Nulatex Sdn. Bhd. located in Kluang, Johor, Malaysia. This chapter is describing the problem statement, objective and scope of this project. This project is focusing on the maintenance of the Square Foiling Machine (SFM). The information in defect checklist that provided by Boryung Technology will be used to build up an expert system. In addition, a gantt chart that shows the planned activities throughout two semesters in session 2014/2015 is attached.

1.1 Background

Maintenance refers to the concern of controlling the condition of equipment. Maintenance is necessary to preserve equipment, machines, and the work environment safe and secure. Lack of maintenance can require a situation become dangerous to someone or its surroundings, accidents, and health worries.

There are five classifications of most machinery maintenance problem (Bloch & Geitner, 2004).

i. Preventive / Periodic:
   There is a maintenance schedule that planned to carry out to the machine. This action is necessary to prevent or avoid any problem and keep them in good condition.

ii. Predictive / Condition Based:

Monitor the machine condition to predict proper operation and improper operation or problems. The worker will control & surveillance, inspection (on/off-line), overhaul & repair and replacement and any action that need to be taken towards the machine.

Breakdown / Demand Based:

Resolving problems that appeared, a decision must be brought to replace with new single.

iii. Bad Actor Management:

A problem caused by humans in direct or indirect actions. For instance, problems occur during inspection & failure analysis, weak spot identification, modification in operating procedures, maintenance, and design process.

iv. Organizational Concern:

It is about the interest of management and technician to the machine condition for some other use.

All the information related to the maintenance should be kept properly for future purpose. Same problems may occur and needed the same solution. Thus, the information, experience, and justification must be stored in a base so that it used as a problem solver.

There is a defect checklist in the instruction operated manual provided by Boryung technology. This a defect checklist shows the problem, its causes and remedy of SFM maintenance problems (Boryung Technology, 2013).

Maintenance problems are related to the SFM. This machine is a sealing machine that will foil every single of condoms. The sealing process is a process that some heat is supplied to mold to enclose a product to keep the hygiene product in clean and safe condition. It will prevent the content from coming out or other foreign particle moving into the product.

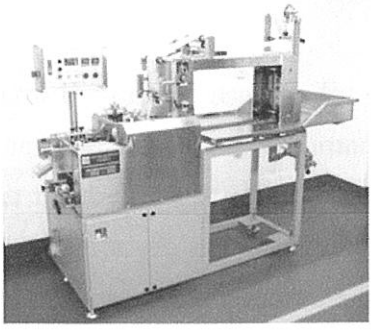


Figure 1.1: Square Foiling Machine (Boryung Technology, 2013)

This machine is used for foiling purpose and the model type is BRT-5000SA. It was invented by Boryung Technology (BRT) Company. BRT-5000SA is designed to seal condoms in a square shape by manual loading with four side seals. The packaging material should be plastic. It was to prevent the stain on the foils. Therefore, the silicone oils will keep in the foil with the condoms (Boryung Technology, 2013).

Table 1.1: Specifications of Square Foiling Machine (Boryung Technology, 2013)

No	Specifications	Details
1	Model no.	BRT-5000SA
2	Dimension	2200L x 1000W x 1650H mm
3	Power supply	240V. Single-Phase
4	Package size	55 x 57 mm
5	Production rate	About 70 to 100 pcs per minutes
6	Electric power consumption	2~3.0 Kwh
7	Automatic Grade	Semi-automated

This machine consists of several important parts. There are loads parts, oil insertion, heating the part, perforated and trimmed cutter. Loading part is a space provided for operators to place clean and rolled condoms on that specific fixture provided. Oil insertion is a component of silicone pump to pump the silicone oil on that condom. Furthermore, for the heating part is the primary part of this machine. There is a heated mold used for the sealing process. While for the perforated and trimmed cutter used to cut the foiled condoms in square form.

1.2 Machine operation

A batch of condom that have been tested using a dry electronic testing machine, passed and got confirmation from the quality department will be sealed and foil based on type and customer requirement. Start the machine by press green button. Temperature switch will be set to the optimum and accurate temperature and reserved for some minute to obtain an exact temperature.

The operator will place the condoms into the special fixtures called hopper feeder manually. Once put the condom on that particular fixture that also a special conveyor that functions to place the condom on the foil. The conveyor is rotated vertically.

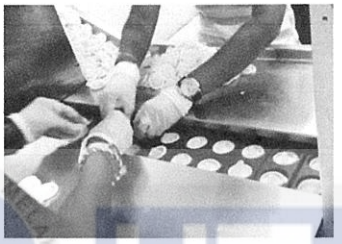


Figure 1.2: The rolled condoms on the special fixtures (Mohamad, 2014)

The condom will be along the bottom foil. Afterward that, there will be a drop of silicone oil that used to lubricate and keep the condom in good condition. A type of silicone used depends on the job order to be unflavoured or flavoured. There are many type flavours are available like vanilla, strawberry, tutti-fruity, lemon, orange, banana, cherry and green apple.

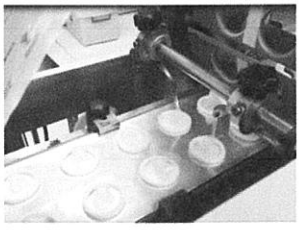


Figure 1.3: Silicone oil being pump on the condom (Mohamad, 2014)

There will be upper foil that flow together with the bottom foil. They will undergo a heating process to ensure the foil stick together at an absolute temperature. A mold will be heated so that the foil melt and stick together.

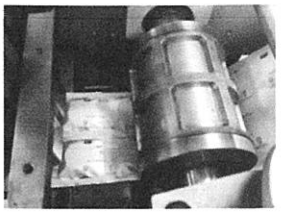


Figure 1.4: Heated mold (Mohamad, 2014)

The completion of foiling and sealing process the condoms need to perforate and trimmed to separate them each.

Figure 1.5: Perforated and trimmed equipment (Mohamad, 2014)

This machine is operated manually without programmed with specific software. The adjusted button will ensure this machine work smoothly and run according to the spec. There are buttons to control the temperature, speed and the flow according to the silicone oil pumping so that the movement of condom will be simultaneous to silicone oil pumping.

1.3 Problem Statement

Maintenance of a machine is a concept that maintains the machine performances in good condition. Maintenance is the necessary, a basic support of machines includes tasks such as lubricating, adjusting, and replacing parts of the SFM. From the defect checklist, there are seven maintenance problems provided in operating instructions. Man must know solutions or remedies to solve maintenance problems so that

breakdown time can be reduced. The expert system will use information provided that consists of symptoms complete with the causes and remedies. Therefore, the expert system will detect the maintenance problems based on certain causes and provide the remedies automatically if implemented to the SFM. Thus, breakdown time will reduce because all the causes of the maintenance problems complete with the remedies.

1.4 Objectives

The objectives of this project are to:

i. Identify maintenance problem related to SFM,
ii. Suggest a solution for maintenance of SFM using an expert system,
iii. Develop an expert system for the maintenance problem of SFM, and
iv. Evaluate the effectiveness of an expert system towards the maintenance problem.

1.5 Scope

This project is to develop an expert system of maintenance problems for BRT-5000SA SFM. This machine was used to foil pharmaceutical product which are male latex condoms. The system will use preliminary information in operating instructions from Broyung Technology that contain defect checklist. There are seven symptoms of maintenance problem. Every symptom has its causes and its causes have own remedies. An expert system is an intelligent computer program that simulates any practical or theory knowledge in any domain of human. Maintenance problems related to the will be utilized to build up an expert system. The expert system will be developed by using the Python Programming Language with Graphical User Interface, GUI. However, the expert system will be not implemented to the SFM due to some limitations. The expert system is an offline system that stands alone without connecting to the machine.

1.6 Gantt chart

The project started in September 2014 for PSM1 and expected to complete by June 2015 for PSM2. The gantt chart below will act as a guide in developing an expert system for the maintenance problem of SFM.

Activities	Month (2014/2015)									
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Introduction to PSM										
Writing Chapter 1: Introduction										
Writing Chapter 2: Literature Review										
Writing Chapter 3: Methodology										
Writing Chapter 4: Result and Discussion										
Writing Chapter 5: Conclusions and Recommendations										
Submission Report And Presentation										

Figure 1.6: Gant Chart for 2014/2015 session for PSM1 and PSM2

1.7 Concluding Remarks

This chapter was described maintenance problems that concern of controlling the condition of equipment. This chapter also briefed the background of SFM and machine's operation. Other than that, this chapter includes the problem statement, four objectives of this project and scopes of the project. There is a gantt chart that used as a guide in completing this research project.

CHAPTER 2

LITRETURE REVIEW

This chapter presents some research works that has been done previously by researchers in the area related to the maintenance problem of machine management and expert system. The gathered information will be used in developing an expert system for the maintenance problem of the SFM.

2.1 Maintenance Management

Maintenance management is essential either for currently used or in the future. Therefore, all the related information must be gathered and recorded to provide an acceptable process reliability level, acceptable risk level, in an efficient and cost effective manner. Some advantages of keeping the history of the maintenance problem and solutions are (Lyon, 2014):

i. Inspection and Compliance

   All the information that has been recorded will be used for inspection and compliance. The information gathered is used for developing a more reliable system to help manage the maintenance problem. It is to ensure the problem can be solved without waste of time and energy. It is used to track the performance of equipment and demonstrate that the equipment meets standards and certifications.

ii. Budgeting and Capital Expenditures

The recorded information helps management with planning annual budgets for produces reliable maintenance and repair data. Therefore, any related budget planning will increase efficiency and can reduce costs with precise budget planning. The solver will give an exact value because the cause of the problem determined.

iii. Replacing Equipment

The root causes of the trouble will be found easily by having a history of the maintenance problem. The equipment change not due to try and error analysis to redusce breakdown time and cost. Conversely, maintenance is indeed less expensive than replacing the entire machine.

iv. Labor

The tasks could resolve any maintenance problem if the history recorded. It will be the guideline to tackle the problem. The operators become more productive and skilled. It will shorten the lead time that waits for the technician come to work out the troubles. The production rate is less interrupted than using manual history record.

v. Transcends People

Work can be transferred to the next team or individual when the staff changes without any problem because the maintenance history recorded. The recorded detailed information can be applied to represent the data and performance to upper management.

2.2 Problems Solving Technique

Appeared problem must analyze to seek the cause that contributes the problem. It is must be detailed so that the effective problem solving can be seen. Several problem solving tools need to carry out to list out all relevant information. There several methods used to illustrate the problem of maintenance that is:

a) Plan, Do, Check, Act (PDCA)

This step clearly defines the problem and able to generate possible causes of particular problem, further step is carried out experimental test or action plan

and finally complete implementation plan to solve and monitor the reasons for the problem (Wealleans, 2001).

b) 5-Why Analysis

To detect the root of the cause of any problem, try to question the point with five times of "Why" questions then the problem can be treated and rectified. (English, 2011).

c) Ishikawa's Diagram

The analysis method is a cause and effect diagram. It is also known as an Ishikawa or "fishbone" diagram. The graphic method used to track the possible reasons for a particular effect by define, identify and eliminate known or potential problems from a certain system, design, process, or services. Several advantages of Ishikawa's Diagram are (Fryman, 2002):

i. It helps to understand the causes that contribute to an effect.

ii. It graphically displays the relationship between the causes of the effect and to each other.

iii. It helps to identify areas for improvement

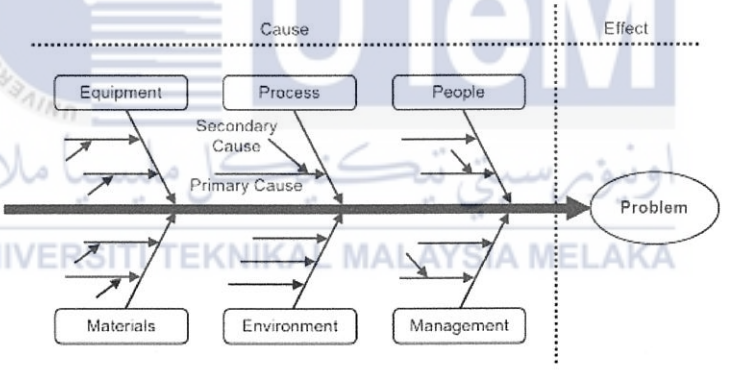


Figure 2.1: Example of Ishikawa or "fishbone" diagram (Ericson & II, 2011)

d) Failure Modes and Effects Analysis (FMEA)

Failure Modes and Effects Analysis used to determine and predict the potential failure of certain process or problems. It will be used to plan actions to prevent the failures. The related process will be recorded for documented purpose. This process applies to a new process or product. It will be an a modification of a certain process in the new environment. While the existing situation will be applied to a new surroundings (Arthur, 2001).

2.3 Development of Maintenance Management

In the beginning, maintenance is managed by using a checklist to record and as a guide to solving a maintenance problem. As the world has developed into the technology globalisation world, a computerized system has been developed, for example, Computerized Maintenance Management System (CMMS). This system will monitor the machine condition with aided by a computer. Through the days, the technology becomes more reliable in maintenance management. Thus, the expert system has been brought out with the help of expert person and expert knowledge. Example expert system that has been used in the world is fuzzy expert system.

i. Checklist

The checklist is the famous ways in maintenance management. It is easy for human that in charge solving the problems related to the machine. Everything associated with the maintenance will be recorded in a document. From that record, a table can be built to see the cause and problems occur throughout the process. That table will require the type of problems, cause and explanation of the problems and remedy solution to the problems.

ii. Computerized Maintenance Management System (CMMS)

As technologies become more reliable in the management of maintenance, there is a system used to help maintenance workers perform their jobs more efficiently and to help management make informed decisions. It is Computerized Maintenance Management System (CMMS). A CMMS software package maintains a computer database of information about an organization's maintenance operation. The CMMS packages able to produce status reports and documents that provide giving details or summaries of maintenance activities (Bagadia, 2006).

Several advantages of CMMS can work for a generation, prioritization, and tracking by equipment or component. Historical tracking of all work orders generated which become sortable by equipment, date, person responding and others. Also, it can track of scheduled and unscheduled maintenance activities other than just storing of maintenance procedures as well as all warranty information by component. The technical documentation or procedures by component also stored for further application (Cato & Mobley, 2002).

However, there are also some disadvantages of CMMS, which is related to the implementer. Suitable and properly selected of a CMMS vendor crucial for the matching system and service of a particular system. In addition, Inadequate training of the administrative staff on the input, function and maintenance of CMMS will affect the effectiveness of CMMS (Cato & Mobley, 2002).

iii. Expert System

Other than using Computerized Maintenance Management System, the expert system has been evolving in many sectors. An expert system is an intelligent system. It is a system using human experts that emulate the decision-making ability. One of the expert systems that have been used is fuzzy expert system. A fuzzy expert system is an expert system that uses a collection of fuzzy membership functions and rules, instead of Boolean logic, to reason about data. While neural networks are an excellent tool for modeling unknown systems and solving optimizing problems, fuzzy systems provide an alternative approach to representing problems and processing information. While there are many computational algorithms developed to process numerical data, the fuzzy system provides an alternative way to manipulate information, not just data (Grosan & Abraham, 2011).

2.4 Expert System

Giarratano and Riley (1998) found that Professor Edward Feigenbaum of Standard University has defined an expert system as "an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solutions" (Fageinbaum 82).

The expert system is a system using human experts that emulate the decision-making ability. The term emulates refers to the act of the system on the real thing in some situation more than a simulation (Giarratano, 1998).

An expert system is a branch of artificial intelligent that makes extensive use of specialized knowledge to solve problems at the level of the human expert. A human

expert is some who has expertise in a certain field. The expert has knowledge and skill in handling the problem efficiently. Expert systems are about simulating human reasoning the problem domain, rather than simulating the field itself. They perform reasoning over representations of human knowledge. They have corresponding distinct modules referred to as the inference engine and the knowledge base. The problems tend to be solved using heuristics or approximate methods or probabilistic methods which, unlike algorithmic solutions, are not guaranteed to result in a correct or optimal solution. They usually have to provide explanations and justifications of their solutions or recommendations to convince the user that their reasoning is correct (Giarratano, 1998).

An expert system usually has high performance. The system must be capable of responding at a level competency equal to or better than that of an expert in the field. Thus, the quality of the advice given must very high. In addition, the system performs in a reasonable amount of time comparable to or better than the time required by an expert to reach a decision. Furthermore, the expert system must be reliable and not prone to crashes, or it will not be used. The most important about the expert system is it is understandable. The system could explain the steps of its reasoning while executing (Giarratano, 1998).

The basic concept is knowledge-based expert system. The basic of an expert system is knowledge. Human expertise will transfer the knowledge and related information to the system to be analyzed. The systems that consist of two components will respond to the certain situation. The two components are a knowledge base and inference engine. The knowledge base contains the knowledge with which the inference engine draws the conclusions (Giarratano, 1998).

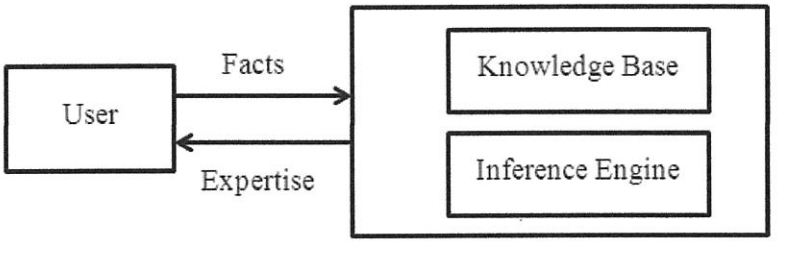


Figure 2.2: Basic concept of an Expert System (Giarratano, 1998)

In developing the expert system, the knowledge engineer must communicate with the human expert. It is because; they must exchange their knowledge and skills to solve any problems that related. This stage is analogous to a system designer in conventional programming discussing the system requirements with a client whom the program will be constructed. The knowledge engineer then codes the knowledge explicitly in the knowledge base. The experts then evaluate the experts system and give some comment and justifications to the knowledge engineer. This process continues till the system's performance is judged and evaluated by the expert to be satisfactory. The expression knowledge-based system is the application of knowledge-based technology that used to create an expert system (Giarratano, 1998).

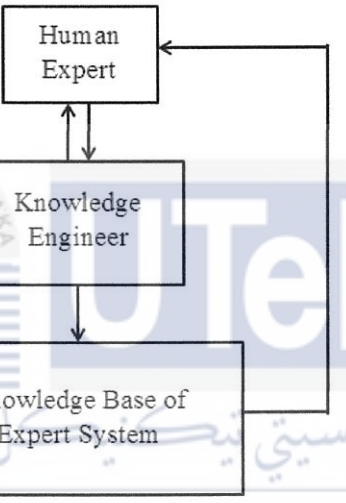


Figure 2.3: Development of an Expert System (Giarratano, 1998)

2.4.1 Rule-based Expert System

The rule-based expert system is most prevalent system. It is much different from the other because it is a modular nature. It is easy to encapsulate knowledge and expand the expert system by incremental development. In addition, it is easy to build explanation facilities with rules because the antecedents of the rule specify exactly what is necessary to activate the rules. Rules act as a knowledge representation technique. Knowledge is a theoretical or practical understanding of a subject or a

domain. Knowledge is also the sum of what is currently known and apparently knowledge is power. Those who possess knowledge are called experts. Most experts are capable of expressing their knowledge in the form of rules for problem solving. Any rules consist of two parts, for example, the basic syntax consist of (Giarratano, 1998):

IF <antecedent> THEN <consequent>

IF <antecedent> AND <antecedent > THEN <consequent>

IF <antecedent> OR <antecedent > THEN <consequent>

2.4.2 Structure of Rule-based Expert System

In a rule-based expert system, the knowledge base contain the domain knowledge base contains the domain knowledge needed to solve problems coded in the form of rules. Usually, the expert system consists of several components like in the Figure 2.3. The components are (Giarratano, 1998):

i. User interface: Mechanisms that allow the user and expert system communicate between themselves.
ii. Explanation facility: Explains the reasoning of the system to the user for a better explanation.
iii. Working memory: a Global database of facts used by the rules.
iv. Inference engine: Make inferences by deciding which rules are satisfied by facts or objects, prioritizes the satisfied rules and executes the rule with the highest priority.
v. Agenda: Prioritized list of rules created by the inference engine, whose patterns are satisfied by facts or objects in working memory.
vi. Knowledge acquisition facility: Automatic ways to the user to enter knowledge in the system other than having the knowledge engineer explicitly code the knowledge.

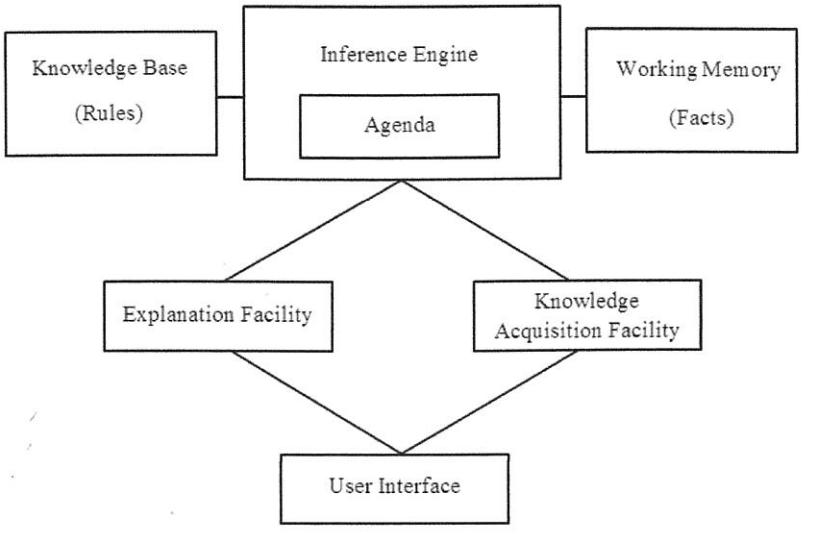


Figure 2.4: Structure of Rule-based Expert System (Giarratano, 1998)

2.5 Inference Techniques

An inference technique is a method to stimulate the antecedent and consequent event. The method helps to draw a conclusion or to derive any starting point for some problem or consequents. There are two types of technique known as (Negnevitsky, 2011):

i. Forward chaining

Starting from an antecedent it will be a series of consequent. This type of technique repeatedly occurs that performing the corresponding actions based on the knowledge base. Forward chaining method will look for the IF part of the rule first. It will select a path based upon meeting all the IF requirements. The process continues till reach the conclusion or limits but, things will not be so straight forward. It may a combination of many rules applicable at a certain stage.

Example:

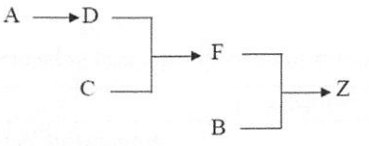


Figure 2.5: Forward chain with combination rule (Negnevitsky, 2011)

ii. Backward chaining

It is the reverse method in finding the antecedent from any consequent by looking at the working memory. Its start from the conclusion to identifies the IF condition either accepts or discards. This method works reversely from the goal to the starting facts. This method is more reliable since the search is to achieve the objective.

Example:

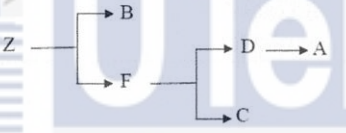


Figure 2.6: Backward chain technique (Negnevitsky, 2011)

2.6 Real Implementation

Artificial intelligence frameworks are focus concerned with representing and manipulating knowledge. A lot of human activities forcefully causes expand the advancement of an expert system. These include identifying the problem domain, finding the expertise and selecting the development tool (Akerkar, 2005).

Nowadays, many type programming language available used by programmers. Programmers write instructions or coding in either directly understandable by computers machine or need other intermediate translators. Scientist used to

categorize the many programming language and the different philosophies that represent in Table 2.1.

Table 2.1: Computer programming languages grouped by category (Fath, 2014)

No.	Category	Examples
1	Low-level and high-level languages	
	Low-level	Assembly, BASIC, FORTRAN
	Mid-level	C
	High-level	C++, Java, Perl
2	Procedural and object-oriented	
	Procedural	BASIC, FORTRAN, Pascal, C
	Object-oriented	C++, Java, Python
3	Compiled and interpreted languages	
	Compiled	Assembly, BASIC, C/C++, FORTRAN
	Interpreted	Perl, MATLAB
	Hybrid	Java, Python, Net
4	Imperative and Declarative languages	
	Imperative	BASIC, C/C++, Java, FORTRAN
	Functional	LISP, Scheme, ML, OCaml, Haskell
	Logical	Prolog

Based on some research, expert system have been developed extensively in any field either in engineering itself or others, for example; expert system been used in medical, agriculture, management and electric and electronic field.

The first example of the application of an expert system is it has been developed in the medical field, for example, Expert System for Detecting Mental Disorder with Forward Chaining Method. This expert system used in the medical field in term of detecting the mental disorder. Co-assistants performed this expert system testing. Patients about 100 peoples were checked randomly who came to The Outpatient Clinic, Dr. Cipto Mangunkusumo National Referral Hospital. The test was performed by the experts directly and indirectly by the patients' medical record that means co-assistants did not know the patient's diagnosis and history before. The accuracy value of this system is 96%, which is calculated by comparing expert system's result with the true value in the detection system with the number of tested patients diagnosed by psychiatrists. This expert system was built by gaining the expert's knowledge as

its knowledge and by using MINI ICD-10 as the instrument. The database used was MySQL while programming language used was PHP (Windriyani, Kom, & Sihwi, 2008).

PHP is a server-side scripting language designed for web development and also used as a general-purpose programming language. PHP code can be mixed with HTML code, used in combination with various templating engines and web frameworks. PHP code is usually processed by a PHP interpreter, which is usually implemented as a web server's native module or a Common Gateway Interface (CGI) executable. PHP can be used in 3 ways (Tatroe, MacIntyre, & Lerdorf, 2013):

i. Server side scripting
ii. Command line scripting
iii. Client-side GUI Scripting

Another example that the expert system been implemented in the medical field is about the genetic algorithm. Titled of the paper is Genetic Algorithm Implementation Using Python. This paper wrote by Won Jae Lee and Hak-Young Kee. They are from Electronic and Telecommunication Research Institute. This paper is about genetic information that is a probabilistic search algorithm based on the mechanics of natural selection and natural genetics. A genetic algorithm is started with a population that represented by a chromosome. The population size is preserved throughout each generation. The fitness of each chromosome is evaluated, and the next generation are probabilistically selected according to their fitness values. Some of the selected chromosomes randomly mate and produce offspring. When producing offspring, crossover and mutation occurs. Chromosomes with high fitness values have a high probability of being selected than those of the old generation. The process will be repeated until the end condition is satisfied. The programming wrote using Python represented by a list or a string (Lee & Kim, 2005).

Python is a high-level programming language and widely used in general-purpose. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines compared to others. Python can support multiple programming paradigms, including the object-oriented, imperative

and functional programming or procedural styles. It features a dynamic type system and automatic memory management. It is also has a large and comprehensive standard library (Lambert, 2011).

Some other advantages of using Python are:

a. It has simple and conventional syntax. It is closed to pseudocodes algorithm. For this reason, less time to learn the syntax of a programming language but more time to learn about solving problems.
b. It has safe semantics and scales well. Any expression or statement that not suitable for the definition will be an error. But with the scale, it is easy to write a program. Python also includes the advanced features and object-oriented software development.
c. Highly interactive and general purpose. With the presence of interpreter's prompt any statement or expression can be used for the experimental purpose. It is a comfortably and flexible programming language either for beginners or expert.

The expert system also used in the electrical field. One example that involve in this field was proved with this journal that is Development Implementation of A Power System Fault Diagnosis Experts System. It will describe a fault diagnosis expert system installed at the Toholcu Electric Power Company. This system aims for improved practicability by using time-tagged data from circuit breakers, protective relays, and automatic reclosing relays also to the input data used in earlier systems. In addition, this system also uses data from fault detection systems that locate fault points within electric stations. This system uses an AI-specific back-end processor to perform inferencing rapidly. Furthermore, this fault diagnosis expert system is interfaced and integrated with a restorative operations expert system, an intelligent alarm processing system, a protective relay setting, and management system. Authors have been developed this power system fault diagnosis domain shell to ease system development and used the protective relay operation simulation function of a protective relay setting and management system for system verification. The main features of this system are careful selection of the inferencing input data, rapid inferencing, integration of the expert system with other systems in a practical

structure, and the adoption of a domain shell. The knowledge processing that runs on the AIP is written in LISP, and other functions that run on the EMS computer are written in C (Minakawa et al., 1995).

C is a high-level and general purpose programming language that is ideal for developing permanent software programmed into a read-only memory or portable applications. C belongs to the structured, procedural paradigms of languages. It is proven, flexible and powerful and may be used for a variety of different applications. Even though this type of programming language is a high-level language, C and assembly language share many of the same attributes (Janssen, 2014).

Several C programming language features are:

a. C programming has fixed number of keywords, including a set of control primitives, such as for, do-while, while, if and switch.
b. Multiple logical and mathematical operators that include the bit manipulators.
c. Multiple assignments may be applied in a single statement.
d. Function return values may be ignored if unneeded and sometimes are not always required.
e. Typing is static, and all data has a type but may be implicitly converted. The basic form of modularity, as files may be separately compiled and linked. Control of function and object visibility to other files. It is via extern and static attributes.

Lisp is the most widely known general-purpose Lisp dialects are Common Lisp and Scheme. Lisp was created as a practical mathematical notation for computer programs, influenced by the notation of Alonzo Church's lambda calculus but nowadays, it has become the favoured programming language for artificial intelligence research. Lisp is a pioneer of many ideas in computer science, including tree data structures, automatic storage management, dynamic typing, conditionals, higher-order functions, recursion, and the self-hosting compiler.

It is different for ShellAg: Expert System Shell for Agricultural Crops. It is proved that the expert system can be used in agriculture field. An Expert System Shell is an interface for strengthening, refining and maintaining the knowledge–base of an

expert system by directly interacting with it. This journal was developed DEX, which an expert system shell for decision support by a specialized expert system for interactive construction of the knowledge base, evaluation of options and explanation/analysis of the results. The expert system shell is a complete development environment for developing and maintaining Knowledge-Based Applications and Expert Systems. It provides a step-by-step methodology for a knowledge engineer that allows the domain experts themselves to be directly involved. (Islam, 2013).

2.7 Concluding Remarks

In summary, this chapter explained about maintenance management. Moreover, it stated about problem solving technique which is PDCA, 5-W Analysis, Ishikawa's Bone and FMEA. Development of maintenance management starts with manually like manual report and checklist. After that, information technology begins to discover and CMMS produced. This chapter also described the expert system, the Rule-based expert system and the structure of the rules. There are two inference techniques which are forward chaining and backward chaining. This chapter also provides the real implementation of the expert system. For example is the expert system have been used in the medical field in detecting genetic algorithm implementation.

CHAPTER 3

METHODOLOGY

This chapter describes the methodology that will be used in developing an expert system of maintenance for SFM. Other methods will be used for this research project is collecting data from books and internet.

3.1 Overall project methodology

Figure 3.1 shows the full methods used in developing the expert system. In order completing the projects, the projects start with collecting preliminary data. The data was in an operating instruction manual that is defect checklist of maintenance problems for SFM. Then, the information transcribed into rules using basic syntax IF THEN rules. Next, the rules will be executed using forward chaining methods. The rules that had been developed will be used in programming to create the system. The programming language will be used Python. The system must be in GUI and the .py file will be converted into an .exe file so that the system could be run in another computer that is not installed with Python.

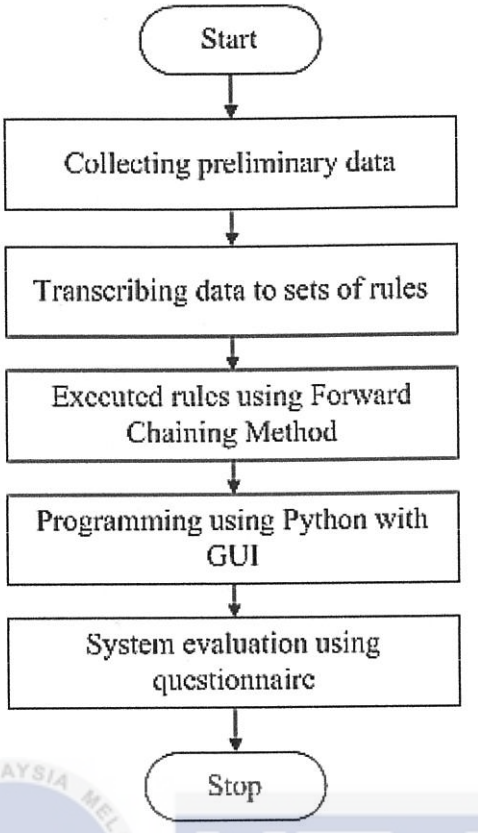


Figure 3.1: Overall methodology used in develop the expert system

3.2 Identification of the maintenance problem related to SFM

Maintenance has been recognized by Boryung Technology Company since they are the inventor of this SFM. An operating instruction manual that contain defect checklist table was built based on maintenance problems that have been occurred in (Refer Appendix A).

Table 3.1: Checklist defect (Boryung Technology, 2013)

No	Symptom	Cause	Remedy
1	Main switch is switch on and entire electric part is not function.	Electric input line is defect.	Check electric input line.
		Fuse is defect.	Check fuse and replace when defect.
2	Motor does not start.	One or two of foil is run out but limit switch is working.	Replace new foils.
		Cable connections are loose.	Tighten cable connections
		Motor is problem.	Replace motor when problem.
3	Set point for heating controller cannot be reached in spite of longer time.	Temperature sensors are defect.	Replace temperature sensor when defect.
		Heating cartridge is defect.	Replace heating cartridge.
		Wire connections of heating have been confused.	Check wire connections and correct the connections.
4	Heater does not work.	Fuses are defect.	Check fuses and replace when defect.
		Heating cartridge is defect.	Check heating cartridge and replace when defect.
		Controller is defect.	Check controller and replace.
5	Indicating temperature is unstable.	Carbon brush is defect.	Replace the carbon brush.
		Carbon brush does not contact properly.	Give more pressure for better contacting.
		Temperature controller is defect.	Replace the temperature controller.
6	Open sealing or air leaking of package	Pressure between two sealing moulds is not enough.	Check flowers of sealing mould.
		Temperature for sealing is low.	Check temperature and adjust it.
		Condom is not located in the center of the cavity.	Check the condom shape. It must be in round shaped.
		Lubricant is stained on the sealing area of foil.	Adjust amount of lubricant and check lubricant pump position.
		Tensions for each foil are not same.	Adjust tensions by weight of friction belt for foils.
7	Double sealing	Condom is slipped from original position when condom is entering for sealing.	Loosen tension of foils and adjust to enter the under foil should be kept flat.
		Condom is not located in the center of the cavity.	Adjust amount of lubricant and check lubricant pump position.

3.3 Solution for maintenance of SFM using an expert system

Based on Table 3.1, there are seven symptoms of maintenance problems that determined by the company. Each symptom has the cause that contributes to those particular problems. After discussion with the knowledge person and expert person, the remedy or the solution that solve the problem gather and build a defect checklist table. The table used as a guide to solving the problem.

Moreover, each component in the table is represented by using a symbol. It symbol will be used in coding the program using an expert system. Table 3.2, Table 3.3 and Table 3.4 show the cause, symptom and remedy that represent by some character. For the clear flow refer to the Figure 3.2 which is Forward Chaining Inference Technique. The technique will be used because more direct and simple in determine any problem to the solution remedy.

Table 3.2: Naming of symptom

No.	Symbol	Symptom
1	I	Main switch is on and entire electric part not alive.
2	II	Motor does not start.
3	III	The set point for heating controller cannot be reached in spite of a longer time.
4	IV	Heater does not work.
5	V	Indicating temperature is unstable.
6	VI	Open sealing or air leaking of package
7	VII	Double sealing

Table 3.3: Naming of cause

No.	Symbol	Cause
1	A(1)	Electric input line defect
2	A(2)	Fuse is defect.
3	B(1)	One or two of foil is finished, and limit switch is working.
4	B(2)	Cable connections are loose.
5	B(3)	Motor is problem
6	C(1)	Temperature sensors are defect.
7	C(2)	Heating cartridge is defected
8	C(3)	Wire connections of heating have been confused.
9	D(1)	Fuses are defect.
10	D(2)	Heating cartridge is defect.
11	D(3)	Controller is defected
12	E(1)	Carbon brush is defected
13	E(2)	Carbon brush does not contact properly.
14	E(3)	Temperature controller is defect.
15	F(1)	Pressure between two sealing moulds is not enough.
16	F(2)	Temperature for sealing is low.
17	F(3)	Condom is not located in the center of the cavity.
18	F(4)	Lubricant is stained in the sealing area of foil.
19	F(5)	Tensions for each foil are not same.
20	G(1)	Condom is slipped from original position when condom is entering for sealing.
21	G(2)	Condom is not located in the center of the cavity.

Table 3.4: Classifications of remedy

No.	Symbol	Remedy
1	a1	Check electric input line.
2	a2	Check the fuse and replace when defect.
3	b1	Replace new foils.
4	b2	Tighten cable connections.
5	b3	Replace the motor when problem.
6	c1	Replace temperature sensor when defect.
7	c2	Replace heating cartridge.
8	c3	Check wire connections and correct the connections.
9	d1	Check fuses and replace when defect.
10	d2	Check heating cartridge and replace when defect.
11	d3	Check the controller and replace.
12	e1	Replace the carbon brush.
13	e2	Give more pressure for better contacting.
14	e3	Replace the temperature controller
15	f1	Check flowers of sealing mould.
16	f2	Check the temperature and adjust it.
17	f3	Check the condom shape. It must be in round shaped.
18	f4	Adjust amount of lubricant and check lubricant pump position.
19	f5	Adjust tensions by weight of the friction belt for foils.
20	g1	Loosen the tension of foils and adjust to enter the under foil should be kept flat.
21	g2	Check the condom shape. It must be in round shaped.

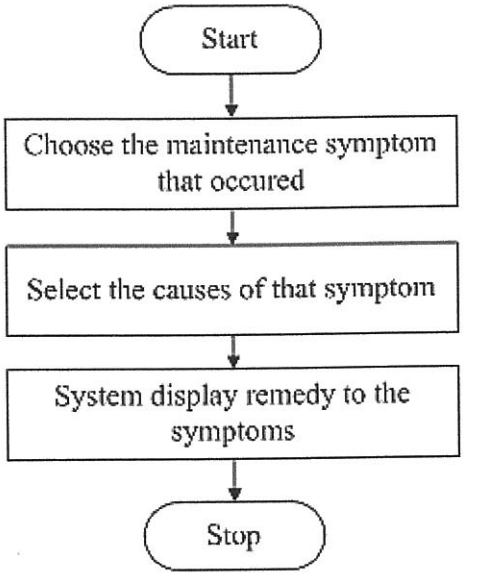


Figure 3.2: General flow of an expert system

The expert system will start with input from the user to select the type of problem that occurred. Then, the second input is about the cause of the problem. After the input is gathers, the system will analyze and display the remedy to the problems. The system will stop after print the solution.

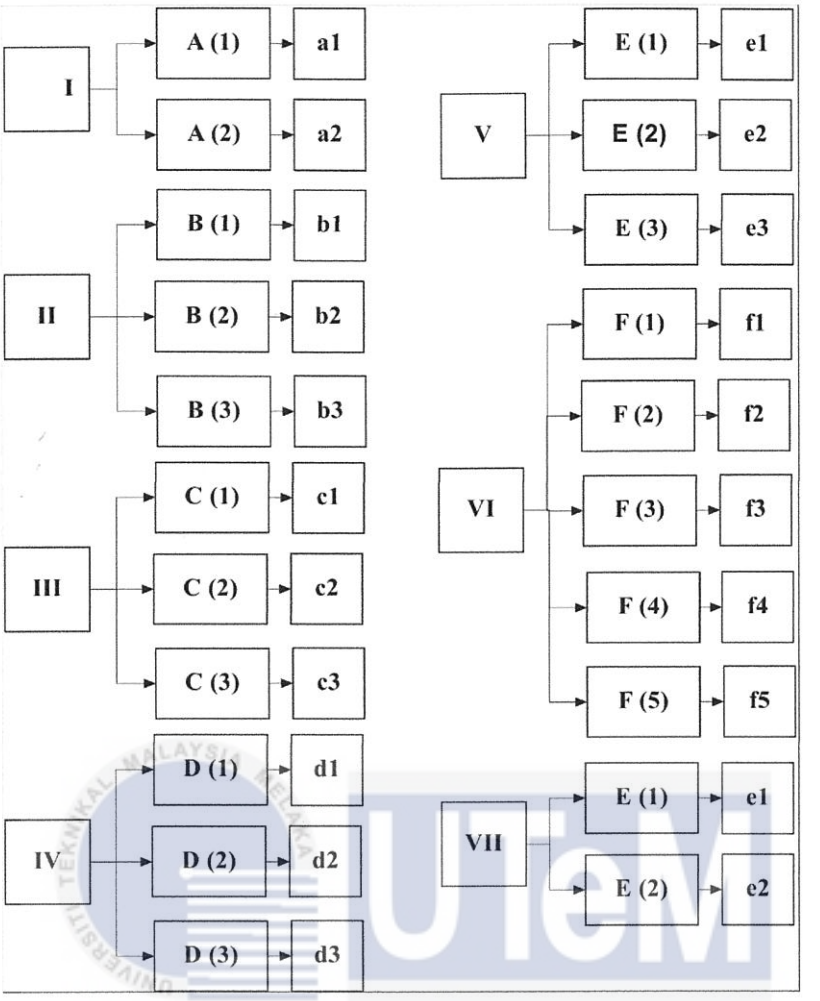


Figure 3.3: Forward chaining inference technique

3.4 Development of an expert system for the maintenance problem of SFM

An expert system is a system using human experts that emulate the decision-making ability. The information will be gathered from expert person and knowledge expert. This expert system is about the maintenance problem of SFM that will use Python programming language.

Based on Table 3.1, the forward chaining inference technique showed the combination of antecedent and consequent event. The following equations define the

rules for the expert system of the maintenance problem for SFM. For example, the expression for Rule 0 is corresponding to expression rule 4.0 in Chapter 4.

i. Rule 0 (Initiation)

IF Rule 1:
  THEN I
elif Rule 2:
  THEN II
elif Rule 3:
  THEN III
elif Rule 4:
  THEN IV
elif Rule 5:
  THEN V
elif Rule 6:
  THEN VI
elif Rule 7:
  THEN VII (Rule 0)

ii. Rule 1

IF < I ∩ A(1) > THEN < a1 > (Rule 1.a)

IF < I ∩ A(2) > THEN < a2 > (Rule 1.b)

iii. Rule 2

IF < II ∩ B(1) > THEN < b1 > (Rule 2.a)

IF < II ∩ B(2) > THEN < b2 > (Rule 2.b)

IF < II ∩ B(3) > THEN < b3 > (Rule 2.c)

iv. Rule 3

IF < III ∩ C(1) > THEN < c1 > (Rule 3.a)

IF < III ∩ C(2) > THEN < c2 > (Rule 3.b)

IF < III ∩ C(3) > THEN < c3 > (Rule 3.c)

v. Rule 4

IF < IV ∩ D(1) > THEN < d1 > (Rule 4.a)

IF < IV ∩ D(1) > THEN < d2 > (Rule 4.b)

IF < IV ∩ D(1) > THEN < d3 > (Rule 4.c)

vi. Rule 5

IF < V ∩ E(1) > THEN < e1 > (Rule 5.a)

IF < V ∩ E(2) > THEN < e2 > (Rule 5.b)

IF < V ∩ E(3) > THEN < e3 > (Rule 5.c)

vii. Rule 6

IF < VI ∩ F(1) > THEN < f1 > (Rule 6.a)

IF < VI ∩ F(2) > THEN < f2 > (Rule 6.b)

IF < VI ∩ F(3) > THEN < f3 > (Rule 6.c)

IF < VI ∩ F(4) > THEN < f4 > (Rule 6.d)

IF < VI ∩ F(5) > THEN < f5 > (Rule 6.e)

ix. Rule 7

IF < VII ∩ G(1) > THEN < g1 > (Rule 7.a)

IF < VII ∩ F(3) > THEN < f3 > (Rule 7.b)

From the rule 3.4 it can be explained through the programmatic flowchart. The function of the flowchart is to represent full description about it. It is easier to understand and interesting. The flowchart will help in building complete coding in an expert system that will use Python.

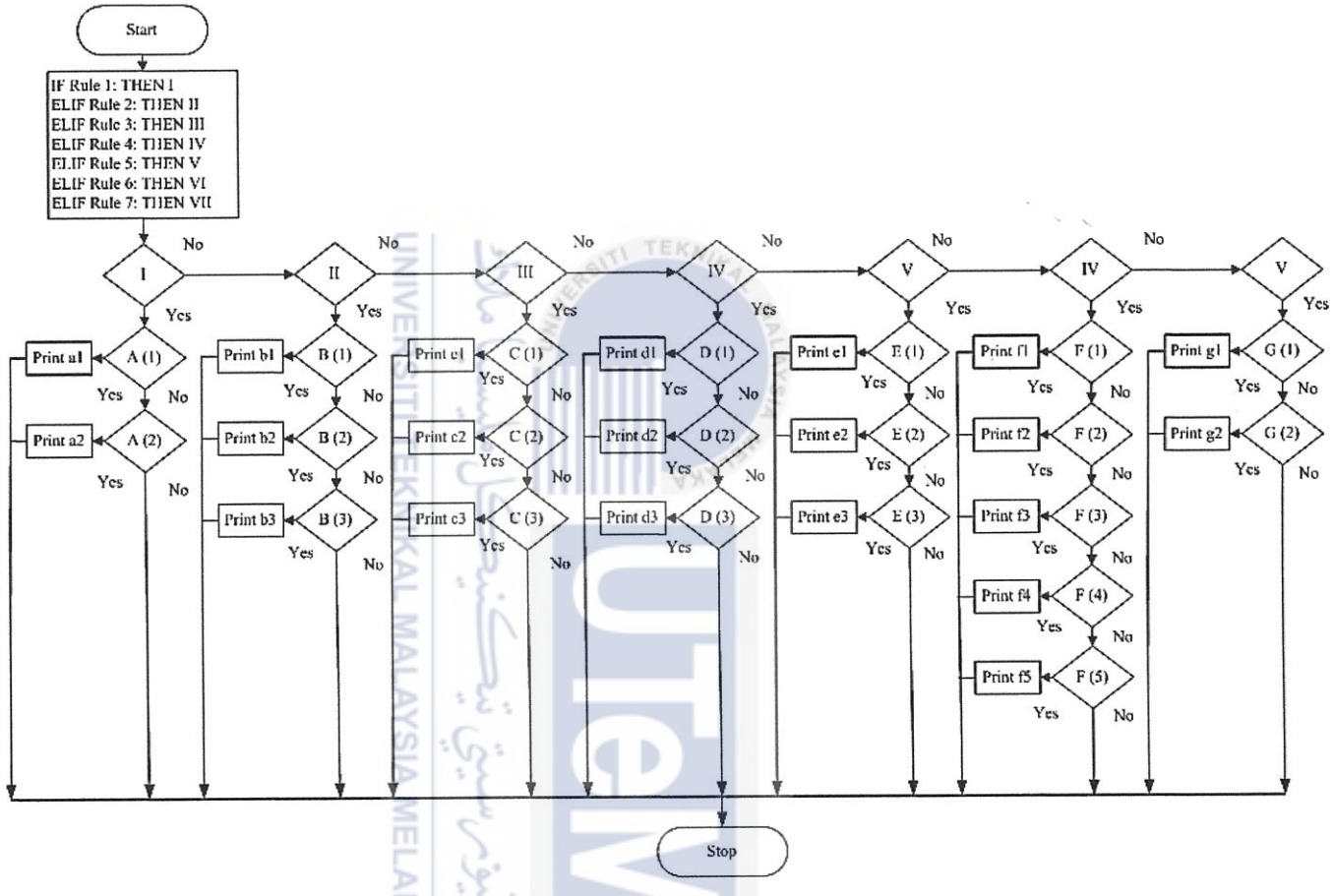


Figure 3.4: General programming flowchart

3.5 Evaluation of the effectiveness of an expert system towards the maintenance problem

In order to evaluate the effectiveness of the expert system, a set of the questionnaire will be distributed to the respondent. Respondents must try the system first before answering the questions. There is aided with user's manual to use the system and defect checklist provided for user check the complimentary information to the expert system based on the defect checklist. Refer to Appendix D. It is because there is a part that respondents must evaluate the effectiveness of the system.

3.5.1 Questionnaire

In order to evaluate the effectiveness of the expert system, a questionnaire will be distributed to respondents. The target respondents are students and staff from two different technical backgrounds that are engineering and information technology (IT) background. It is because, a student from this background have theory knowledge about maintenance problems and expert system while staff have experienced in handling machine problems. The numbers of the respondent are 20 persons. Theirs feedback will be valuable in determining the effectiveness of the expert system. (Refer Appendix B).

3.5.2 Python Programming

The expert system will be developed by using Python programming language. Python is a widely used for general-purpose, and it is high-level programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code. The language provides constructs intended to enable clear programs on both a small and large scale. Python supports multiple programming paradigms, including object-oriented, imperative and functional programming or procedural styles. It features a dynamic

type system and automatic memory management and has a large and comprehensive standard library. The basic Python Programming rules and function refer to Appendix C. Full programming coding refer to Appendix F.

For this project, 'if Selection Structure' much more suitable because the presence of selection option. The problem stated have the own solution; the option is based on certain condition and situation. It performs a specified action only when the condition is true. There are two options for selection structure. There are (Deitel, 2002):

i. if / else

This type of structure suitable when needs to specify that a different action is to be performed when a condition is true from an action when a condition is false. It can be written in Python as:

```
if expression:
        statement
else:
        statement
```

ii. if / elif / else

The if / elif / else statement control conditional code execution. It is more straightforward and easy to write the program without too much indention. The general format of a conditional statement is as follow:

```
if expression:
        statements
elif expression:
        statements
elif expression:
        statements
...
else:
        statements
```

3.6 Concluding Remarks

This chapter described the methods will use to create the expert system using information provided by Boryung Technology. First, the preliminary data collected from the instructions operating manual. The data then transcribed to a set of rules using Forward Chaining. The rules will be programmed using Python. There is a flowchart act as guide to write the coding using Python. A complete set of programming will be evaluated by 20 respondents for its effectiveness.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents the result of the developed expert system. The system programmed using Python Programming language with the Graphical User Interface, GUI. An installer builds so that the system can be used with different laptop or computer with window. To evaluate the system, a number of sets of a questionnaire distributed to the respondent. A few graph builds to show the important of the expert system and its effectiveness.

4.1 Maintenance problems of SFM

Preliminary data was provided by Maintenance problem of SFM was provided by Broyung Technology. There are seven problems that related to the machine. The information was gathered from expert knowledge and expert skill person. This information was provided with causes to the problems and remedy for the problems. There are seven symptoms that provided with several causes. Each cause have an own remedy. Based on this defect checklist, a forward chaining technique was used to create a few rules. The seven symptoms recognize by Boryung Technology is:

i. Main switch is switch on and entire electric part not function

   This symptom may cause by electric input line is defect or fuse is defected. Therefore, to solve the problem user need to check the electric input line if the electric input line defect. Ensure the input line in good condition. While if the switch on and entire electric part are still not function, check the fuse. Replace the fuse if the fuse defects.

ii. Motor does not start

This symptom cause by three factors first is one or two of foil is run out but limit switch is working. Second, cable connections are loose. Third is the motor is a problem. The user needs to replace with new foils since the foil run out. When the cable connections are loose, please tight the cable connection so that the motor can run. If the motor totally problem and defect, the motor need to be replaced.

iii. Set point for heating controller cannot be reached in spite of longer time

This symptom can be caused by temperature sensors are a defect, heating cartridge is defect and wire connections of heating have been confused. If the problem caused by the temperature sensor defect, the user need to replace with new one. Same goes to the heating cartridge if problem and defect change the heating cartridge. Wire connections of heating been confused means the wire connection is wrong. Therefore, check the connection and ensure the right connections.

iv. Heater does not work

This symptom may cause by fuse are a defect. User needs to replace if the condition of fuse is not satisfied. Other that, this symptom could be caused by the heating cartridge is a defect. Therefore, the user needs to replace the heating cartridge so that the heater will normally work . Furthermore, the controller is defect can be the reason. Go check the controller and replace when needed.

v. Indicating temperature is unstable

There are three reasons that contribute to this symptom. First is carbon brush is defected. When the carbon brush is defected, replace the carbon brush with a good condition carbon brush. Second is carbon brush does not contact properly. This cause can be solved by giving more pressure for better contacting. Third is a temperature controller defect, and then the controller must be changed to ensure the temperature stable.

vi. Open sealing or air leaking of package

Open sealing or air leaking can be caused by pressure between two sealing molds is not suitable. The user needs to check the flowers of sealing the mold. The unsatisfied condition of sealing mold can cause air leaking. In addition, the temperature for sealing is low. Check the temperature, adjust

and ensure the temperature is suitable follow the standard operating procedure. Moreover, the condom is not located in the center of the cavity. The condom must be in round shape and located at the center of the foil. Besides that, the symptom can be caused by its lubricant stained on the sealing area of foil. Check the lubricant pump position and the amount of lubricant must be optimum so that there is no stained oil in packaging. Lastly, one of the reasons is the tensions for each foil is not same. Check the foils tensions, adjust the tensions by weight of friction belt for foils.

vii. Double sealing

The condom is slipped from the original position when a condom is entering for sealing can be the reason of double sealing. Therefore, loosen the tension of foils and adjust the foil, so that keep in flat position. Next, the condom is not located in the center of the cavity. The condom must be in round shape and located at the center of the foil.

4.2 Forward Chaining Method approach to Expert System

All the information is converted into rules. Rules are a statement that contain one or several antecedent and one or several consequents. After the IF part, called the antecedent (premise or condition) while the THEN part called the consequent (conclusion or action). The basic syntax is:

IF < antecedent > AND < antecedent >

THEN < consequent >

Below are the rules that used to build an expert system:

i. Rule 0 (Initiation)

If *Rule 1*:
Then < *Main switch is on and entire electric part not alive* >
elif *Rule 2*:
Then < *Motor does not start* >
elif *Rule 3*:
Then < *The set point for heating controller cannot be reached in spite of a longer time* >
elif *Rule 4*:
Then < *Heater does not work* >
elif *Rule 5*:
Then < *Indicating temperature is unstable* >
elif *Rule 6*:
Then < *Open sealing or air leaking of package* >
elif *Rule 7*:
Then < *Double sealing* > (4.0)

ii. Rule 1

IF < *Main switch is on and entire electric part not alive AND electric input line is defect* > THEN < *Check electric input line* > (4.1)

IF < *Main switch is on and entire electric part not alive AND fuse is defect* > THEN < *Check fuse and replace when defect* > (4.2)

iii. Rule 2

IF < *Motor does not start AND one or two of foil is finished and limit switch is working* > THEN < *Replace new foils* > (4.3)

IF < *Motor does not start AND cable connections are loose* > THEN < *Tighten cable connections* > (4.4)

IF < *Motor does not start AND Motor is problem* > THEN < *Replace motor when problem* > (4.5)

iv. Rule 3

IF < *The set point for heating controller cannot be reached in spite of a longer time AND temperature sensors are defected* > THEN < *Replace temperature sensor when defect* > (4.6)

IF < *The set point for heating controller cannot be reached in spite of a longer time AND heating cartridge is defected* > THEN < *Replace heating cartridge*> (4.7)

IF < *The set point for heating controller cannot be reached in spite of a longer time AND wire connections of heating have been confused* > THEN < *Check wire connections and correct the connections* > (4.8)

v. Rule 4

IF < *Heater does not work AND fuses are defected* > THEN < *Check fuses and replace when defect* > (4.9)

IF < *Heater does not work AND heating cartridge is defected* > THEN < *Check heating cartridge and replace when defect* > (4.10)

IF < *Heater does not work AND controller is defect* > THEN < *Check controller and replace* > (411)

vi. Rule 5

IF < *Indicating temperature is unstable AND carbon brush is defect* > THEN < *Replace the carbon brush* > (4.12)

IF < *Indicating temperature is unstable AND carbon brush does not contact properly* > THEN < *Give more pressure for better contacting* > (4.13)

IF < *Indicating temperature is unstable AND temperature controller is defect* > THEN < *Replace the temperature controller* > (4.14)

vii. Rule 6

IF < *Open sealing or air leaking of package AND pressure between two sealing moulds is not enough* > THEN < *Check flowers of sealing mould* > (4.15)

IF < *Open sealing or air leaking of package AND temperature for sealing is low* > THEN < *Check temperature and adjust it* > (4.16)

IF < *Open sealing or air leaking of package AND condom is not located in the center of the cavity* > THEN < *Check the condom shape. It must be in round shaped* > (B.17)

IF < *Open sealing or air leaking of package AND lubricant is stained in the sealing area of foil* > THEN < *Adjust amount of lubricant and check lubricant pump position* > (4.18)

IF < *Open sealing or air leaking of package AND tensions for each foil are not same* > THEN < *Adjust tensions by weight of the friction belt for foils* > (4.19)

ix. Rule 7

IF < *Double sealing AND condom is slipped from original position when condom is entering for sealing* > THEN < *Loosen tension of foils and adjust to enter the under foil should be kept flat* > (4.20)

IF < *Double sealing AND condom is not located in the center of the cavity* > THEN < *Check the condom shape. It must be in round shaped* > (4.21)

These twenty-one rules that related to SFM were transcribed into forward chaining like mentioned before in Table 3.1. This rule is the main references to build an expert system that also is a decision-support system. The function of this rules to guide the system to solve a maintenance problem that occurred. By following these rules, the maintenance expert system will be more natural knowledge representation in a uniform structure.

4.3 Python Programming for Expert System

A programming was written based on the rules and the forward chaining. Python Programming was used to be the language of the program. It is because Python is a high-level programming language. It has been used for many general purposes. Its design is more readability that others and allow expressing concepts in lesser lines. Other than that, Python able to supports a number of programming paradigms include object-oriented, imperative and functional programming or procedural styles. For the full set of programming refer to Appendix F.

4.3.1 Basic structure

The basic structure used in the programming is 'if Selection Structure'. This structure used because there are options to be selected. For certain symptom, there are certain causes that contribute to the symptom. User needs to select the causes to have the remedy. It performs a specified action only when the condition is true.

The basic syntax of 'if Selection Structure' is:

```
if expression:
        statement
else:
        statement
```


For example, user selected Symptom I. Refer Figure 4.1. There would be two options of causes. First is electric input line is a defect and second is fuse is defected. When the user hit the check button A1, that defined for a first cause, the remedy that is please check electric input line will display in the info box and ensure the electric input line in good condition. While second cause that represent by check button B1 hit, the remedy for that cause will display which is Fuse is please check the fuse and ensure the fuse is a function and in good condition.

```
def update_text1(self1):
    likes = ""
    if self1.checkBoxA1.get():
        likes += "Cause 1: Electric input line is defect.\n"
        "Remedy : Please check electric input line. "
        "Ensure the electric input line in good condition. \n\n"
    else:
        likes += ""

    if self1.checkBoxB1.get():
        likes += "Cause 2: Fuse is defect.\n"
        "Remedy : Please check the fuse. "
        "Ensure the fuse is fucntion and  in good condition. \n\n"
    else:
        likes += ""
```

Figure 4.1: 'IF ELSE selection' structure

4.3.2 Python Imaging Library, PIL

PIL is a library adds support for opening, manipulating and saving many different image file formats. It has image processing capabilities to Python interpreter since this library supports many file formats and provides powerful image processing and graphics capabilities.

The core image library is designed for fast access to data stored in a few basic pixel formats. It should provide a solid foundation for a general image processing tool. The current release includes TkPhotoImage and BitmapImage interfaces, as well as a Windows DIB interface that can be used WinPython and other Windows-based toolkits. Many other GUI toolkits come with some kind of PIL support.

The PIL used in displaying the image in the expert system. The image was used in gif format. There are two type of displaying the image used in the programming. First the image was displayed using TkPhotoImage. The image is 'utem.gif' and 'nulatex.gif'. This image was placed at the main interface. Refer Figure 4.2.

```
imageFile = "utem.gif"
image1 = ImageTk.PhotoImage(Image.open(imageFile))
panel1 = Tk.Label(leftframe, image=image1,bg = "light blue")
panel1.pack(side='top')
panel1.image = image1

imageFile = "nulatex.gif"
image3 = ImageTk.PhotoImage(Image.open(imageFile))
panel3 = Tk.Label(leftframe, image=image3,bg = "light blue")
panel3.pack()
panel3.image = image3
```

Figure 4.2: Syntax for displaying image

The second image was displayed on a canvas. Figure 4.3 shows the basic syntax in displaying the image. The canvas is a rectangular space provided to show any image or any complex layout.

```
def show_image():
    canvas.delete("all")
    x = canvas.create_image(350, 250, image=tk_img1)
    canvas.configure(state="normal")
    canvas.itemconfigure(x)
def show_image2():
    canvas.delete("all")
    y = canvas.create_image(350, 250, image=tk_img2)
    canvas.configure(state="normal")
    canvas.itemconfigure(y)
def show_image3():
    canvas.delete("all")
    y = canvas.create_image(350, 900, image=tk_img3)
    canvas.configure(state="normal")
    canvas.itemconfigure(y)
```


Figure 4.3: Syntax for displaying image on a canvas

4.3.3 Tkinter, The Graphical User Interface Programming

The standard GUI library for Python is Tkinter. By using Tkinter, application of GUI can easily create and fast. Tkinter provides a powerful object-oriented interface to the Tk GUI toolkit. There are another useful examples to provide various control for example button, canvas, check button, entry, frame, label, list box, menu, menu button, message, radio button, scale, scrollbar, text, top-level, spin box, paned window, label frame and tkMessageBox. These examples are

known as Tkinter Widgets. These widgets ensure the GUI become more attractive and efficient. A good system must be simple and user-friendly. So that user will find it easy to use and attractive ("Python GUI Programming (Tkinter)," 2015)

This expert system used several number of Tkinter widgets that make the system become more functional and meet the objective. They are:

i. Check button

The Check button widget act as toggle buttons that display a number of options to a user. The user can select one or more options by clicking the button corresponding to each option. This check button is used to display causes of the symptom choose. Refer Figure 4.4 for the basic syntax. The user may choose one cause or multiple causes to the symptom.

```
self1.checkBoxA1 = BooleanVar()
Checkbutton(otherFrame,text = "Electric input line is defect.",
            font = "Verdana 10", variable = self1.checkBoxA1,
            command = self1.update_text1).grid(row = 3, column = 0, sticky = W)

self1.checkBoxB1 = BooleanVar()
Checkbutton(otherFrame,text = "Fuse is defect. ",
            font = "Verdana 10", variable = self1.checkBoxB1,
            command = self1.update_text1).grid(row = 4, column = 0, sticky = W)
```

Figure 4.4: Syntax of check button used for displaying the causes of the symptom

ii. Button

The Button widget is used to add buttons in a Python application. These buttons can be assign function to them. The function of the buttons may display text or images that convey the purpose of the buttons. Furthermore, the buttons also can assign to a function that called automatically when the button clicked. Many types of button used in the programming. There is a button to open a new window like in Figure. There is also a button for exiting the interface and button to back to the main interface. Figure 4.5 shows the basic syntax that use of the button.

```
Button(bottomframe, text="I",font = "Verdana 10",
       bd= 4, height=1, width=2,command=self.openFrame1).grid(row=4,column=2,sticky=E)
Button(bottomframe, text="II",font = "Verdana 10",
       bd= 4, height=1, width=2,command=self.openFrame2).grid(row=5,column=2,sticky=E)
Button(bottomframe, text="III",font = "Verdana 10",
       bd= 4, height=1, width=2,command=self.openFrame3).grid(row=6,column=2,sticky=E)
Button(bottomframe, text="IV",font = "Verdana 10",
       bd= 4, height=1, width=2,command=self.openFrame4).grid(row=7,column=2,sticky=E)
Button(bottomframe, text="V",font = "Verdana 10",
       bd= 4, height=1, width=2,command=self.openFrame5).grid(row=8,column=2,sticky=E)
Button(bottomframe, text="VI",font = "Verdana 10",
       bd= 4, height=1, width=2,command=self.openFrame6).grid(row=9,column=2,sticky=E)
Button(bottomframe, text="VII",font = "Verdana 10",
       bd= 4, height=1, width=2,command=self.openFrame7).grid(row=10,column=2,sticky=E)
Button(bottomframe, text="EXIT",font = "Verdana 10",
       bd= 4, height=1, width=5,command=self.onClose).grid(row=12,column=2,sticky=E)
```

Figure 4.5: Syntax of button used for open new window and quit an interface

iii. Canvas

Canvas is an area for displaying drawing picture or any other complex layouts. It may be a graphics, text, widgets or frames. These graphics will be placed on the specified area. This programming used canvas for displaying information in image form. There is details button that once clicked will show new interface that contain the canvas. That canvas will show a full image of SFM, its specification, and standard operating procedure. Refer Figure 4.6.

```
def show_image():
    canvas.delete("all")
    x = canvas.create_image(350, 250, image=tk_img1)
    canvas.configure(state="normal")
    canvas.itemconfigure(x)
def show_image2():
    canvas.delete("all")
    y = canvas.create_image(350, 250, image=tk_img2)
    canvas.configure(state="normal")
    canvas.itemconfigure(y)
def show_image3():
    canvas.delete("all")
    y = canvas.create_image(350, 900, image=tk_img3)
    canvas.configure(state="normal")
    canvas.itemconfigure(y)

canvas=Canvas(leftframe,bg='#FFFFFF',width=700,height=600,scrollregion=(0,0,800,1800)

vbar=Scrollbar(leftframe,orient=VERTICAL)
vbar.pack(side=RIGHT,fill=Y)
vbar.config(command=canvas.yview)
hbar=Scrollbar(leftframe,orient=HORIZONTAL)
hbar.pack(side=BOTTOM,fill=X)
hbar.config(command=canvas.xview)

canvas.config(xscrollcommand=hbar.set,yscrollcommand=vbar.set)
canvas.pack(side=LEFT,expand=True,fill=BOTH)
```

Figure 4.6: Syntax that used canvas in programming to display image

iv. Frame

The Frame widget used either for the process of grouping or organizing other widgets. So that the application of Tkinter is getting more friendly and interesting. It will act as container that separate their contains. Basically, the frame will in rectangular size to organize the layout and to provide padding of these widgets. A frame can also be used as a foundation class to implement complex widgets. The frame used in the program is to give partition left, upper and bottom frame. Coding like in Figure 4.7 shows the uses of the frame in this expert system.

```
left_right_pane = PanedWindow(self.root, orient=HORIZONTAL, relief='groove',borderwidth=2)
left_right_pane.grid(column=0, row=0, sticky=(W,S,E,N), columnspan=2)
left_right_pane.rowconfigure(0, weight=1)
left_right_pane.columnconfigure(0, weight=1)
left_right_pane.rowconfigure(1, weight=1)
left_right_pane.columnconfigure(1, weight=1)

leftframe = Tk.Frame(self.root, relief='groove',bg="light blue",borderwidth=2)
leftframe.grid(column=0, row=0, sticky=(N, W, E, S), rowspan=2)
leftframe.rowconfigure(0, weight=1)
leftframe.columnconfigure(0, weight=1)
left_right_pane.add(leftframe)

top_bottom_pane = PanedWindow(self.root, orient=VERTICAL, relief='groove', borderwidth=2)
top_bottom_pane.grid(column=1, row=0, rowspan=2, sticky=(N, W, E, S))
top_bottom_pane.rowconfigure(0, weight=1)
top_bottom_pane.columnconfigure(0, weight=1)
left_right_pane.add(top_bottom_pane)

upperframe = Tk.Frame(self.root, relief='groove', borderwidth=2)
upperframe.grid(column=1, row=0, sticky=(N, W, E, S))
upperframe.columnconfigure(1, weight=1)
upperframe.rowconfigure(0, weight=1)
top_bottom_pane.add(upperframe)
```

Figure 4.7: Syntax to write the frame partition for the main interface

v. Label

The Label widget used to display text either in a single line or multiple like in Figure 4.8. Sometimes its contain image. Most of this program used the label to display text that show information. For example, the label used to display the title at the upper frame in the main interface.

```
top = Label(upperframe, text=" \n Expert System of Maintenance Problem \n\n"
           "on Square Foiling Machine \n",bg= "light blue",font = "Verdana 11 bold")
top.grid(column=1, row=0,sticky=(W,S,E,N))
```

Figure 4.8: Syntax used for label in program

vi. Radiobutton

This widget used for multiple choice buttons. Users are offered with number of options. The users are allowed to choose only one option because each group of radio buttons associated to the same variable and each one of the buttons must symbolize a single value. Therefore, the value of choice is only one. The radio button that used are for details section. The coding uses of radio button like in Figure 4.9. It's give three choices either to select a full image of SFM or specifications or SOP.

```
RadioButton = Radiobutton(rightframe, text="Full Image",
                          font = "Verdana 10", bg="light blue",value="0", command=show_image)
RadioButton.pack(anchor = W)
RadioButton = Radiobutton(rightframe, text="Specifications",
                          font = "Verdana 10", bg="light blue",value="1", command=show_image2)
RadioButton.pack(anchor = W)
RadioButton = Radiobutton(rightframe, text="Standard Operating Procedure",
                          font = "Verdana 10", bg="light blue",value="2", command=show_image3)
RadioButton.pack(anchor = W)
```

Figure 4.9: Syntax used for radio button to show three options

vii. Scrollbar

The Scrollbar widget is used to add scrolling capability to various widgets, such as list boxes, text, and canvas. The scrollbar can be in vertical and horizontal form. This scrollbar used in the canvas that displaying an image of SFM or specifications or SOP. The coding of scrollbar refers to Figure 4.10.


```
vbar=Scrollbar(leftframe,orient=VERTICAL)
vbar.pack(side=RIGHT,fill=Y)
vbar.config(command=canvas.yview)
hbar=Scrollbar(leftframe,orient=HORIZONTAL)
hbar.pack(side=BOTTOM,fill=X)
hbar.config(command=canvas.xview)
```

Figure 4.10: Syntax of scrollbar in horizontal and vertical

4.4 Results

The expert system on maintenance problem of SFM completed when a set of programming run smoothly. As mentioned, the programming language is Python with 2.7.9 version. Creating the programming are using Tkinter and PIL to have a better GUI.

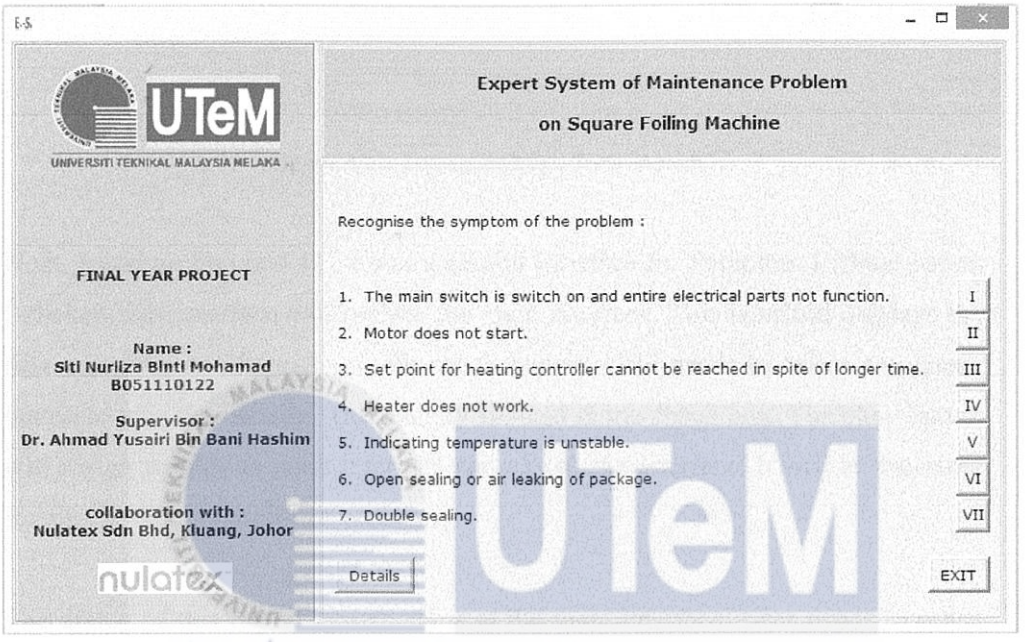


Figure 4.11: Main interface for the expert system

Figure 4.11 shows the main interface. The main interface consists of three frames which are left the frame, upper frame and bottom frame. The left frame shows personal information of universities, subject, student, supervisor and company. The upper frame just stated the title of the system which is 'Expert System of Maintenance Problem on SFM'. The most important frame is the bottom frame. The bottom frame displays the seven maintenance problems. There is a button that represents each of the maintenance problems. The button once clicked will be the open new interface and close the main interface. The details button will open information related to the SFM. This button also will close the main interface and open new interface to display the details information. There would be an exit button to close the system.

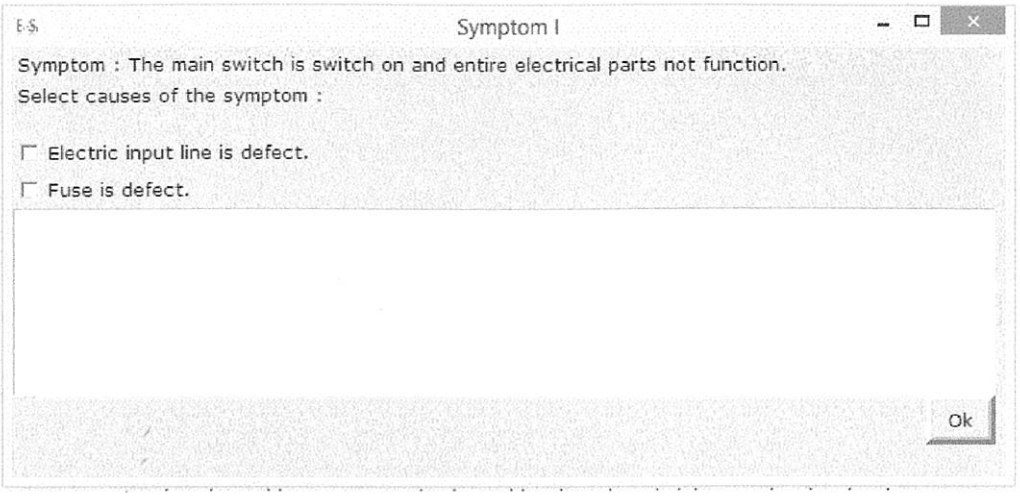
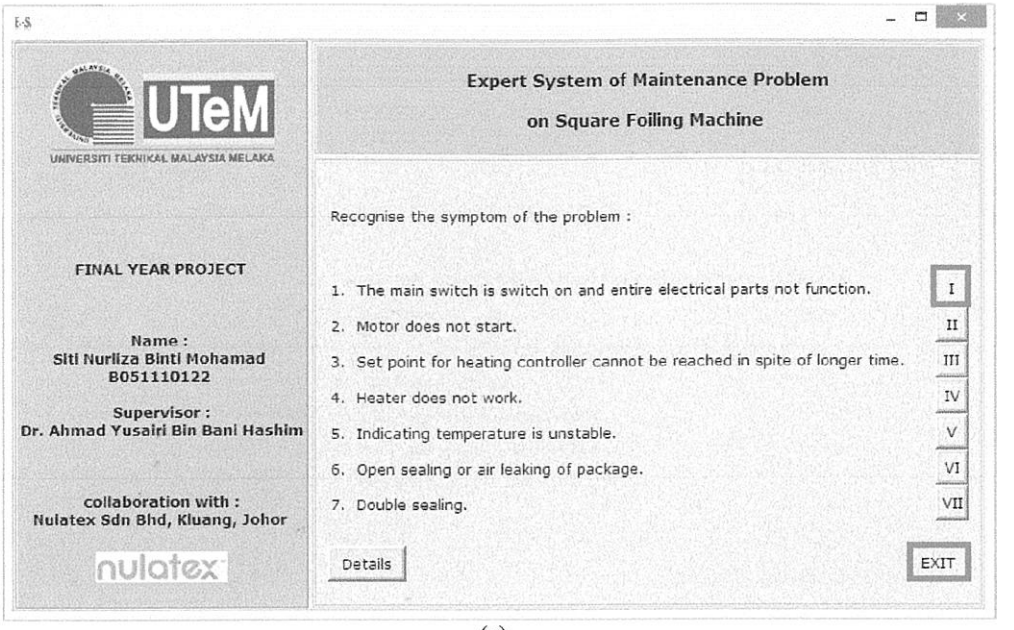


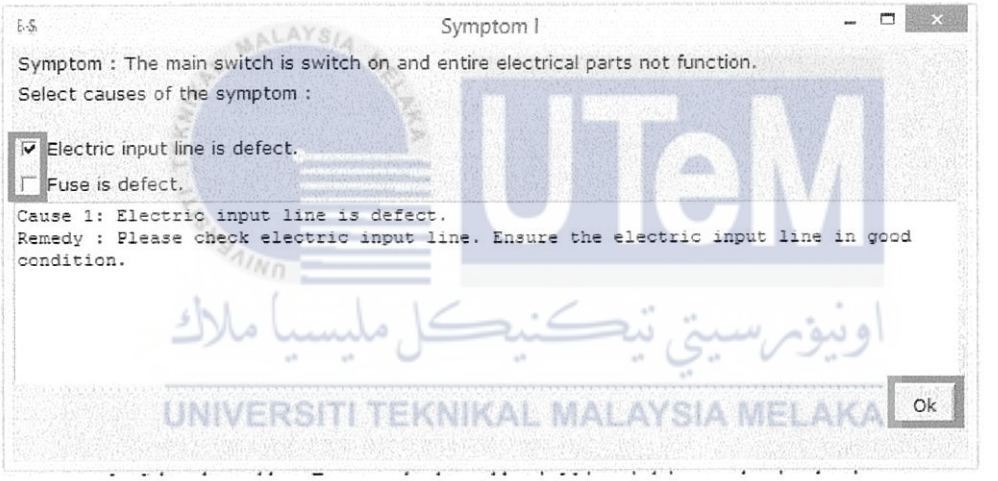
Figure 4.12: Second interface for Symptom I

Next, based on Figure 4.12, it was a second interface for Symptom I. Once button I clicked, this interface will replace the main interface. This interface displays the first symptom and its causes with check button. User needs to select any check button to gain the remedy. The remedy showed in the check box. The okay button will assign to back to main interface and closed the interface. It will be the same for another six maintenance problems.

The dialog of this expert system starts at the main interface. User needs to select the maintenance problem of the SFM by click one of the seven button display with capital Roman at the main interface. For example, user selected Symptom I. He clicked the button like in Figure 4.13 (a). Then, the second interface for Symptom I appeared replace the main interface. Next, the user was allowed select one or more check box of causes of the symptom to display remedy in the info box. Figure 4.13 (b) showed that the user selected first check box that is the cause to the symptom. The remedy showed was for the first cause of Symptom I. Then, the user may choose Ok button to back to the main interface. The user may repeat same dialog for other options. Finally, the user may click button exit to quit at the main interface.



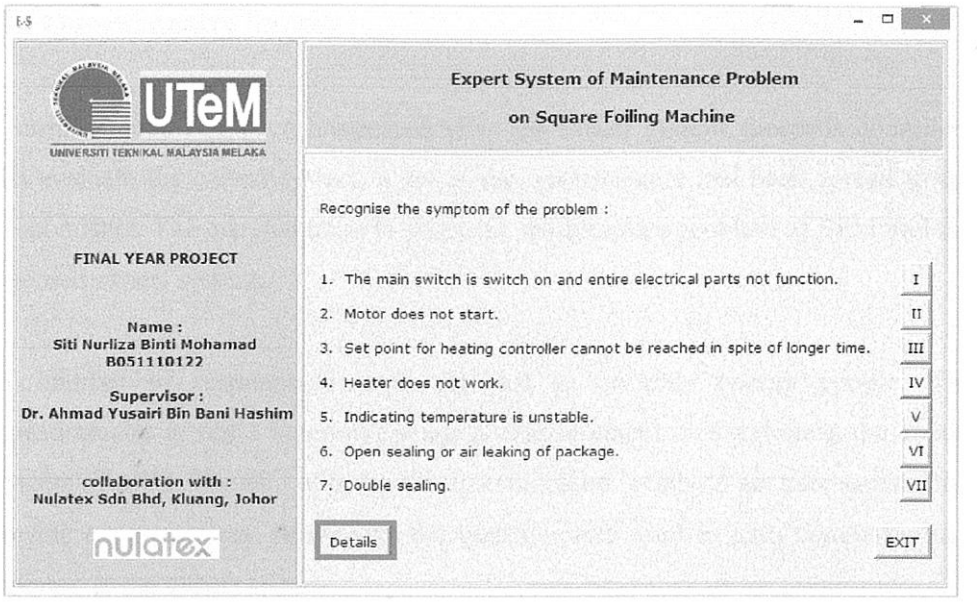
(a)



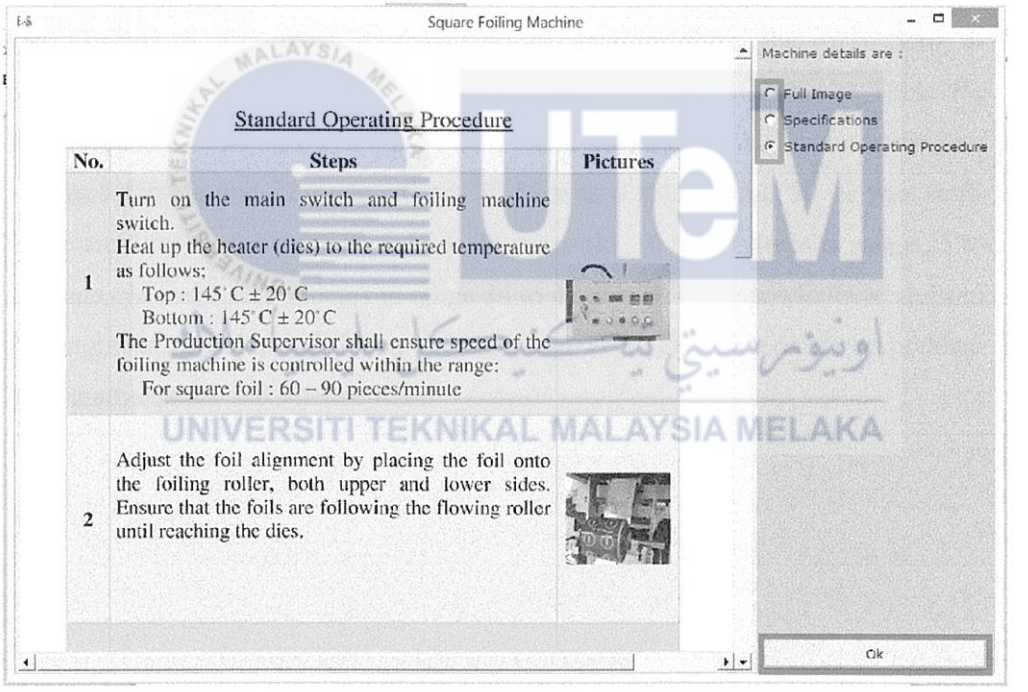
(b)

Figure 4.13: (a) (b) Dialog of the expert system in choosing the symptom of maintenance problems

In addition, the second dialog may user would like to know details about the machine. The user may click the Details button. The details button will close the main interface and new open interface that will show the details of the SFM. The details are a full image, specifications and Standard Operating Procedure, SOP. The Ok button will link back to the main interface. Refer to Figure 4.14 (a) and (b).



(a)



(b)

Figure 4.14: (a) (b) Details button of the expert system shows full image, specification and SOP

4.5 Questionnaire Survey

Questionnaires had been conducted after the expert system succeeds compiled. To evaluate the expert system, a set of the questionnaire had been spread to the respondents. The questionnaire is about the maintenance problem of SFM and the succeed expert system.

A number of respondents were set just to be only twenty people. The questionnaire is not a compulsory social measurement in developing the expert system of SFM. The aim of using this questionnaire is only to get user satisfaction to this expert system. Moreover, the questionnaire used to gain comments and opinion to the expert system.

The questionnaire consists of five small parts which are Part A, Part B, Part C and Part D. Part A was about demographic information about the respondent. It includes gender, occupation, age and technical background. Refer to Table for respondent's information. From the Table 4.1, it showed that the respondents were among 8 female and 12 male. About 50 % was a student and 50 % was staff. There are 4 respondents in range 16 to 24 years old, 10 respondents in range 25 to 33 years old and 6 respondents in range 34 to 42. About 18 respondents were from the engineering field, and 2 respondents from IT field. There is no respondent from mathematics and science field.

Table 4.1: Demographic information of respondents

Parameter	Total
Gender	
Male	8
Female	12
Occupation	
Student	10
Staff	10
Non-employee	-
Others	-
Age	
16 - 24	4
25 -33	10
34 – 42	6
>42	-
Technical background	
Engineering	18
Information technology	2

Part B asked the respondent about maintenance problem of the machine. There are 18 respondents known about maintenance while 2 respondents do not know about maintenance. The number of respondents who had experienced faced the maintenance problem is 80% and the 20% never experienced maintenance problem. There are 16 respondents had handled manual machine, 16 respondents handled the semi-automatic machine and 10 respondents handled the fully automatic machine. Type of methods used in maintenance problem management different each respondent. One respondent may have faced a different type of methods used in maintenance problem management. Therefore, they may select one or more type of method. Refer to Figure 4.15. The highest method used is writing a report and followed by checklist and CMMS.

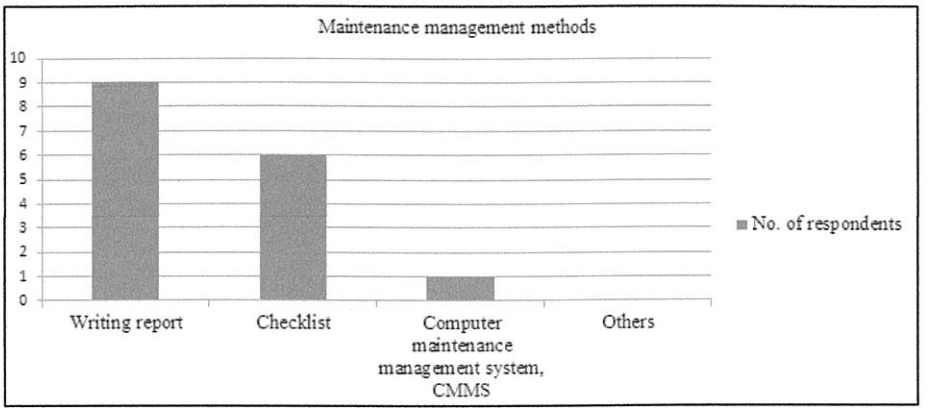


Figure 4.15: Type of methods used in maintenance problem management

Respondent are asked either type of methods used in maintenance management satisfied or not. If respondents answered the type of methods satisfied, they must proceed to Part C while the answer is not satisfied they must give opinion what is the lack of the maintenance management. There are 4 respondents was satisfied to the existing methods and 16 respondents were not satisfied. Lack of existing maintenance management has five options and the respondent who not satisfied to existing maintenance management may select one or more options. The five options are inefficient information storage, improper filing methods, lack of practicality, lack of data, philosophical differences. Refer Figure 4.16 to view highest number of lack of existing maintenance management.

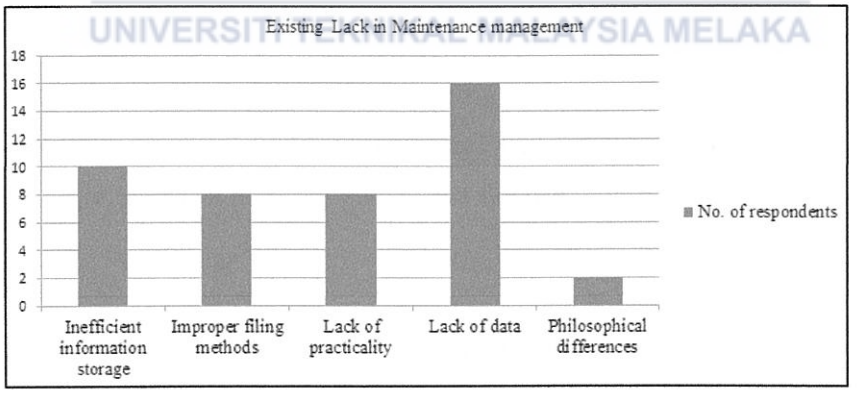


Figure 4.16: Lack of existing part in maintenance management

Part C was about the expert system. There are 12 respondents stated that had heard about the expert system while 8 respondents do not know about the expert

system. Respondents asked about the potential expert system in solving maintenance problem. 100% respondents assume that the expert system can help in solving maintenance problem. 90% respondents agreed that the expert system can be implementing to the SFM, but none of them agrees that the expert system can stand alone without operator, technician or engineer.

Lastly, Part D is evaluating the expert system. 100% of respondents said the expert system is user-friendly and easy to use. Moreover, all the respondents choose the expert system is effective and achieved the objectives. Some of them were left a few comments and some not. Examples of the comments are:

"If the user found a new case can he/she insert that into your system? So that the system will store and it can be used in future."

(Respondent 1)

"The expert system can be improved by including diagrams and also input means for the service personnel to make notes and records."

(Respondent 2)

"Automatic report generation. Include SOP to troubleshoot the suggested remedy."

(Respondent 3)

"Prepare SOP on how to use the expert system of maintenance problem on SFM. The system is limit to predefine problem. Language selected use for other operators/technician that does not understand English."

(Respondent 4)

"Expert system as reference for operator. So operator know how to troubleshoot or solve SFM when breakdown. Technician or maintenance person have their responsibility and job scope. They are already know very well and got full training. Expert system very useful for operator, just click and come out solution. So the production line can running as usual and can minimise breakdown time."

(Respondent 5)

"For future, try to add various of machines options. Nice work :). Add more scope for the machine problems."

(Respondent 6)

"Design kurang menarik. Penggunaan kurang details yang sempurna. System kurang cekap tanpa rekod dan report."

(Respondent 7)

Based on the selected comments, respondents give their opinions in order to improve the expert system. They suggest adding some features for example the expert system must able to record and report the maintenance problems that occurred. The information will used to upgrade the system knowledge to have large scope of maintenance problems. The expert system must have SOP to troubleshoot the detected maintenance problems. Additional figures and information can be added to the expert system to be more attractive and effective.

4.6 Concluding Remarks

As a summary for this chapter, it has been discussed rules used for maintenance problems for SFM. Other than that, it was discussed Tkinter and PIL features that used to build the GUI. The most important is about the result on the expert system that programmed using Python and GUI. Moreover, this chapter also provides comments from respondent towards the expert system on the system effectiveness.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This chapter will conclude the finding and development of the expert system on maintenance problem of SFM. It will sum up information from the beginning till the last of this project. Other than that, there would be recommendations about the project.

5.1 Conclusions

This project was about developing a system based on a selected data. The preliminary data was taken from Broyung Technology which is a Korean based company. The data was a defect checklist of maintenance problems of SFM. SFM is a semi-automatic machine used to packing pharmaceutical product that is condoms. It will seal off the condoms to ensure the quality of the products guaranteed. The defect checklist consists of symptoms of maintenance problems, its causes and its remedy. From this data, a set of rules build using Forward Chaining Technique to create an expert system. Then, the rules transcribed into codes and programmed using Python 2.7.9 with GUI application. The expert system succeeded when there was no error on the programming. Finally, the expert system was evaluated its effectiveness using a set questionnaire with trying the system together. Respondents stated that the expert system is user-friendly and effective to be implemented to the SFM.

By the way, this expert system is an offline system that not connected to the SFM because of some limitations. It should be implemented to the SFM with special

sensors installed together. So that, the system can functions automatically with the help of certain sensors and equipment in detecting the problems. The system will give solutions or remedies automatically to the user. The information of the maintenance problem must be updated to get an effective system.

5.2 Recommendations

Recommendation important for future work to ensure the system will be more effective and efficient. First of all, the information must be updated and more details about the maintenance problems. It is because, maintenance problem will not stick only to that seven symptoms mentioned before. The more symptoms and more details of symptoms will ensure the effectiveness and efficiency of the expert system.

Secondly, the system must upgrade to have record and report applications. Every single problem must be recorded and save. The expert system should able to generate maintenance report automatically. The information will use to update the expert system. Moreover, the information will be used to forecast the maintenance problems and its solution in term of the production plan, a component used etc.

Thirdly, as mentioned before this expert system is an offline system. Therefore, for further improvement the expert system must be implementing to SFM. Ensure the system will work automatically in providing the remedies. In addition, by having the automatically remedies, the system must provide the SOP in troubleshoot the problems. Multiple of figure can assist in solving the detected problems.

Last but not least, the system created must be more creative, attractive and effective. The expert system should allocate pictures or images together to assist understanding among user. The problem detected may easier to solve with help of pictures.

REFERENCES

Akerkar, R. (2005). *Introduction to Artificial Intelligence* (pp. 196–200). PHI Learning Pvt. Ltd.

Arthur, J. (2001). *Six Sigma Simplified: Quantum Improvement Made Easy* (p. 117). KnowWare International.

Bagadia, K. (2006). *Computerized Maintenance Management Systems Made Easy: How to Evaluate, Select, and Manage CMMS* (pp. 5–6). McGraw Hill Professional.

Bloch, H. P., & Geitner, F. K. (2004). *Machinery Component Maintenance and Repair* (Vol. 26, p. 5). Elsevier.

Boryung Technology. (2013). *Operating Instructions*. Seoul, Korea.

Cato, W. W., & Mobley, R. K. (2002). *Computer-managed Maintenance Systems: A Step-by-step Guide to Effective Management of Maintenance, Labor, and Inventory* (pp. 1–180). Butterworth-Heinemann.

Deitel, H. M. (2002). *Python: How to Program* (pp. 35–79). Prentice Hall.

English, P. F. (2011). *Safety Performance in a Lean Environment: A Guide to Building Safety into a Process* (Vol. 21, p. 32). CRC Press.

Ericson, C. A., & II. (2011). *Concise Encyclopedia of System Safety: Definition of Terms and Concepts* (p. 229). John Wiley & Sons.

Fath, B. D. (2014). Encyclopedia of Ecology (Vol. 3, p. 720). Newnes.

Fryman, M. A. (2002). *Quality and Process Improvement* (pp. 195–199). Cengage Learning.

Giarratano, J. C. (1998). *Expert Systems: Principles and Programming*. PWS Publishing Company.

Grosan, C., & Abraham, A. (2011). *Intelligent Systems: A Modern Approach* (p. 123). Springer Science & Business Media.

Islam, S. N. (2013). ShellAg: Expert System Shell for Agricultural Crops. *2013 International Conference on Cloud & Ubiquitous Computing & Emerging Technologies*, 83–86. doi:10.1109/CUBE.2013.24

Janssen, C. (2014). What is C Programming Language? Retrieved November 17, 2014, from http://www.techopedia.com/definition/24068/c-programming-language-c

Lambert, K. (2011). *Fundamentals of Python: First Programs* (p. 510). Cengage Learning.

Lee, W., & Kim, H. (2005). Genetic algorithm implementation in Python. *Fourth Annual ACIS International Conference on Computer and Information Science (ICIS'05)*, 8–11. doi:10.1109/ICIS.2005.69

Lyon, G. (2014). 5 Key Reasons To Keep Maintenance History. Retrieved November 09, 2014, from http://www.impomag.com/blogs/2014/09/5-key-reasons-keep-maintenance-history

Minakawa, T., Ichikawa, Y., Kunugi, M., Shimada, K., Wada, N., & Utsunomiya, M. (1995). Development and implementation of a power system fault diagnosis expert system. *IEEE Transactions on Power Systems*, *10*(2), 932–940. doi:10.1109/59.387936

Mohamad, S. N. (2014). *Industrial Training Report* (pp. 1–48).

Negnevitsky, M. (2011). *Artificial Intelligence: A Guide to Intelligent Systems* (p. 479). Addison Wesley/Pearson.

Python GUI Programming (Tkinter). (2015). Retrieved April 29, 2015, from http://www.tutorialspoint.com/python/python_gui_programming.htm

Tatroe, K., MacIntyre, P., & Lerdorf, R. (2013). *Programming PHP* (p. 540). "O'Reilly Media, Inc."

Wealleans, D. (2001). *The Organizational Measurement Manual* (pp. 122–123). Gower Publishing, Ltd.

Windriyani, P., Kom, S., & Sihwi, S. W. (2008). Expert System for Detecting Mental Disorder wWindriyani, P., Kom, S., & Sihwi, S. W. (2008). Expert System for Detecting Mental Disorder with Forward Chaining Method.ith Forward Chaining Method.

APPENDICES

APPENDIX A

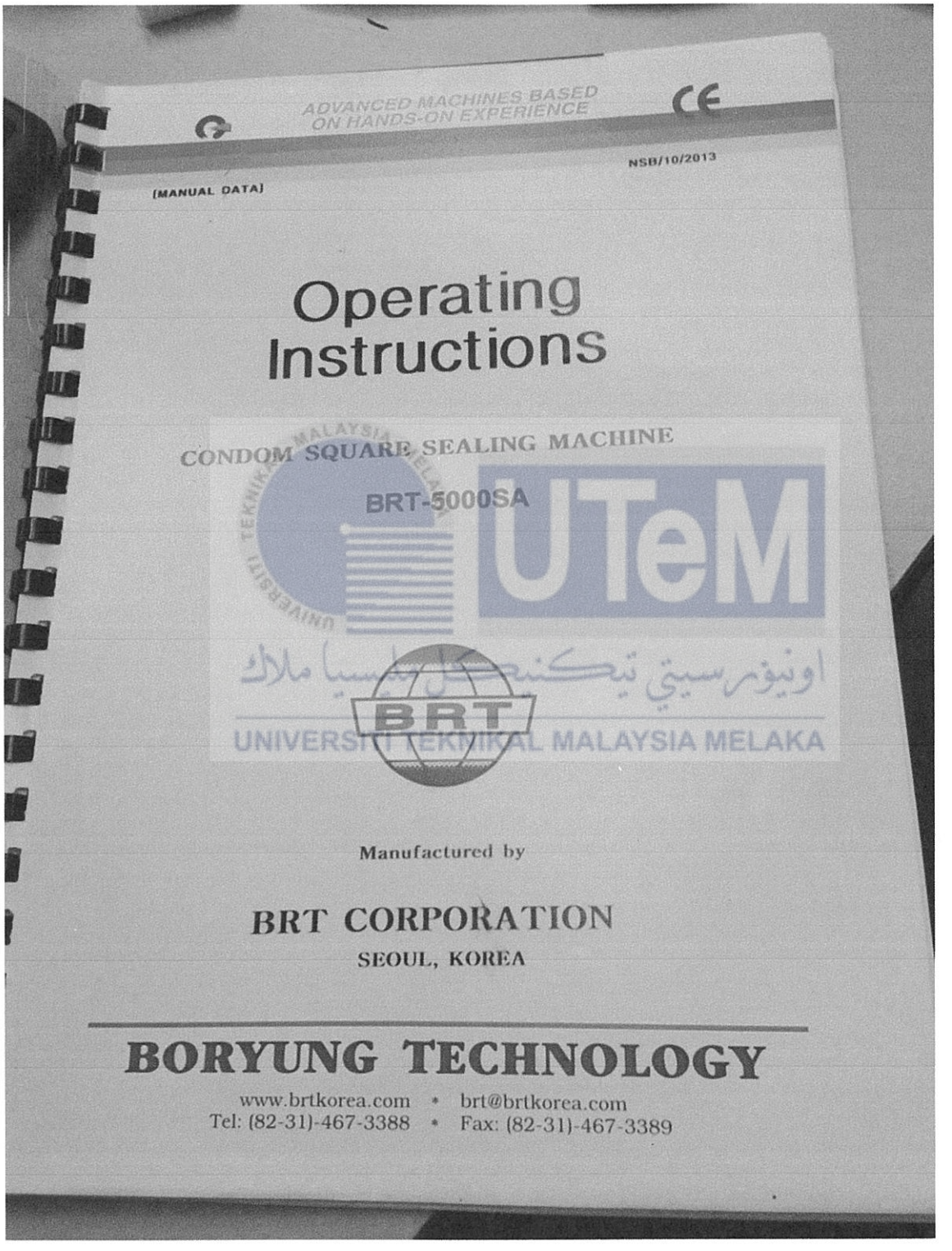


Figure A.1: Operating instructions for square foiling machine (Boryung Technology, 2013)

VII. DEFECTS CHECKLIST

SYMPTOM	CAUSE	REMEDY
- Main s/w is on and entire electric part not alive	- Electric input line is defect. - Fuse is defect.	- Check electric input line. - Check fuse and replace when defect.
- Motor dose not start.	- One or two of foil is finished and the limit s/w is working. - Cable connections are loose - Motor is problem.	- Replace new foils. - Tighten cable connections. - Replace motor when problem
- The set point for heating controller can not be reached in spite of longer time	- Temp. sensors are defect. - Heating cartridge is defect. - Wire connections of heating have been confused.	- Replace temp. sensor when defect. - Replace heating cartridge. - Check wire connections and correct the connections.
- Heater dose not work	- Fuses are defect. - Heating cartridge is defect. - Controller is defect.	- Check fuses and replace when defect. - Check heating cartridge and replace when defect. - Check controller and replace.
- Indicating temp. is unstable.	- Carbon brush is defect - Carbon brush does not contact properly. - Temp. controller is defect	- Replace the carbon brush. - Give more pressure for better contacting - Replace the temp. controller.
-Open sealing / air leak -ing of package	- Pressure between two sealing moulds is not enough - Temp. for sealing is low. - Condom is not located in the center of the cavity. - Lubricant is stained on the sealing area of foil. - Condom is slipped. - Tensions for each foil are not same.	- Check flowers of sealing mould, if not clear, refer VI-6 clause. - Check temperature and adjust it. - Refer to VI-5 clause of this manual. - Check the reason and settle the problem. - Refer to "DOUBLE SEALING". - Adjust tensions by weight of friction belt for foils.
- Double sealing	- Condom is slipped from original position when condom is entering for sealing. - Condom is not located in the center of cavity of sealing mould.	- Loosen tension of foils. - Adjust to enter the under foil should be kept flat. - Check condom shape, condom should be round shape. - Refer to VI-5 clause of this manual.

Figure A.2: Defect checklist of square foiling machine (Boryung Technology, 2013)

APPENDIX B

QUESTIONNAIRES

The purpose of this questionnaire is to evaluate the effectiveness of expert system for maintenance problem of square foiling machine from respondents. This project is about developed of an expert system using available information in defect checklist that provided by Boryung Technology to Nulatex Sdn. Bhd. The expert system was built by using Python programming language.

Instruction:
Please tick [/] your options. You are allowed to tick only one option.

Part A: Demographic information

Gender : Female ☐ Male ☐

Occupation : Student ☐
Employee ☐
Non-employee ☐

Age : 16 – 24 ☐
25 – 33 ☐
34 – 42 ☐
> 42 ☐

Technical Background: Mathematics ☐
Science ☐
Engineering ☐
Information Technology ☐
Others (please specify) : _____

Part B: Maintenance Management

1. Do you know what maintenance is about? Yes ☐ No ☐
2. Have you experienced faced the maintenance problem? Yes ☐ No ☐

3. What type of machine that you had handled before?
   - i) Manual machine ☐
   - ii) Semi-automatic machine ☐
   - iii) Fully automatic machine ☐

4. What type of methods used in maintenance problem management?
   - i) Writing report ☐
   - ii) Checklist ☐
   - iii) Computerized Maintenance Management System, CMMC ☐
   - iv) Others (please specify) : _____

5. Are you satisfied with the existing maintenance management? Yes ☐ No ☐
   (If yes, proceed to Part C)

6. Which part is lack in existing maintenance management?
   - i) Inefficient information storage ☐
   - ii) Improper filing methods ☐
   - iii) Lack of practicality ☐
   - iv) Lack of data ☐
   - v) Philosophical differences ☐

Part C: Implementation of Expert System

1. Have you heard about expert system? Yes ☐ No ☐

2. Expert system is a branch of artificial intelligent that makes extensive use of specialised knowledge to solve problems at the level of human expert. Do you think that expert system can help in solving maintenance problem?

   Yes ☐ No ☐

3. Do you think that the expert system can be implementing to the square foiling machine?

   Yes ☐ No ☐

4. Since the expert system is combination information from both knowledge person and expert person, technician or maintenance people does not require anymore. Do you agree?

   Yes ☐ No ☐

Part D: Evaluation of the expert system

(Please try the expert system with aided of manual script)

1. From your observation, did my system is user friendly? Yes ☐ No ☐

2. What do you think about the expert system for maintenance problem of square foiling machine, did the system effective and achieve the objective?

   Yes ☐ No ☐

3. Please comment for further improvement.

Thank you for your cooperation.

APPENDIX C

Basic Python Programming

The syntactic and lexical conventions of a Python program include line structure, grouping of a statement, reserved words, literals, operators, tokens and source of coding. Identifiers and reserves word used to identify variables, functions, classes, modules, and another object. Identifiers can include the letters; numbers and the underscore character (_), but must always start with nonnumeric character. Letters are currently confined to the character A-Z and a-z in the ISO-Latin character sets. Special symbol like such as $, % and @ are not allowed in identifiers (Beazley, 2009).

Table C.1: Escape sequence (Deitel, 2002)

No.	Escape sequence	Description
1	\ n	Newline. Move the screen cursor to the beginning of the next line.
2	\ t	Horizontal tab. Move the screen cursor to the next tab stop.
3	\ r	Carriage return. Move the screen cursor to the beginning of the current line. Do not advance to the line.
4	\ b	Backspace. Move the screen cursor back one space.
5	\ a	Alert. Sound the system bell.
6	\ \	Backlash. Print a backlash character.
7	\ ”	Double quote. Print a double quote character.
3	\ ’	Single quote. Print a single quote character.

Table C.2: Arithmetic operators (Deitel, 2002)

No.	Python operation	Arithmetic operator	Algebraic expression	Python expression
1	Addition	+	$f + 7$	$f + 7$
2	Subtraction	-	$p - c$	$p - c$
3	Multiplication	*	bm	Bm
4	Exponentiation	**/	x^y	x^y
5	Division	//	x / y	x / y
6	Modulus	%	$r \bmod s$	$r \bmod s$

Table C.3: Precedence of arithmetic operation (Deitel, 2002)

No.	Operators	Operations	Order of Evaluations (Precedence)
1	( )	Parentheses	Evaluated first. If the parentheses are nested, the expression in the innermost pair is evaluated first. If there are several pairs of parentheses on the same level that is not nested, they are evaluated left to right.
2	**	Exponentiation	Evaluated second. If there are several, they are evaluated right to left.
3	* / // %	Multiplication Division Modulus	Evaluated third. If there are several, they are evaluated left to right
4	+ -	Addition Subtraction	Evaluate last. If there several, they are evaluated left to right.

Table C.4: String-formatting characters (Deitel, 2002)

No.	Conversion Specifier Symbol	Meaning
1	C	Single character, for example, a string of length one or the integer representation of an ASCII character.
2	S	String or a valve to be converted to a string.
3	D	Signed decimal integer.
4	U	Unsigned decimal integer.
5	O	Unsigned octal integer.
6	X	Unsigned hexadecimal integer (with hexadecimal digit **a** through **£** in lower case letter).
7	X	Unsigned hexadecimal integer (with hexadecimal digit **A** through **F** in upper case letter).
8	F	Floating-point number.
9	e, E	Floating-point number (using scientific notation).
10	g, G	Floating-point number (using least-significant digits).

Table C.5: Equality and relational operators (Deitel, 2002)

No.	Standard algebraic equality operator or relational operator	Python equality or relational operator	Example of python condition	Meaning of python condition
1	Relational operators			
	>	>	**x > y**	**x** is greater than **y**
	<	<	**x < y**	**x** is less than **y**
	≥	> =	**x > = y**	**x** is greater than or equal to **y**
	≤	< =	**x < = y**	**x** is less than or equal to **y**
2	Equality operators			
	=	==	**x = = y**	**x** is equal to **y**
	≠	!=, < >	**x ! = y,** **x < > y**	**x** is not equal to **y**

Table C.6: Precedence and associativity of operators discussed (Deitel, 2002)

No.	Operators	Associativity	Type
1	( )	Left to right	parenthese
2	**	Right to left	exponential
3	* / // %	Left to right	multiplicative
4	+ -	Left to right	additive
5	< <= > >=	Left to right	relational
6	= = ! = < >	Left to right	equality

Table C.7: Python reserved identifiers or keywords (Beazley, 2009)

Python reserved words				
and	del	from	nonlocal	try
as	elif	global	not	while
assert	else	if	or	with
break	except	import	pass	yield
class	exec	in	print	
continue	finally	is	raise	
def	for	lambda	return	

APPENDIX D

EXPERT SYSTEM ON MAINTENANCE PROBLEM FOR SQUARE FOILING MACHINE

User's Manual

1. Go to the Expert System folder.
2. Double-click the expert_system application to initialize the interface.

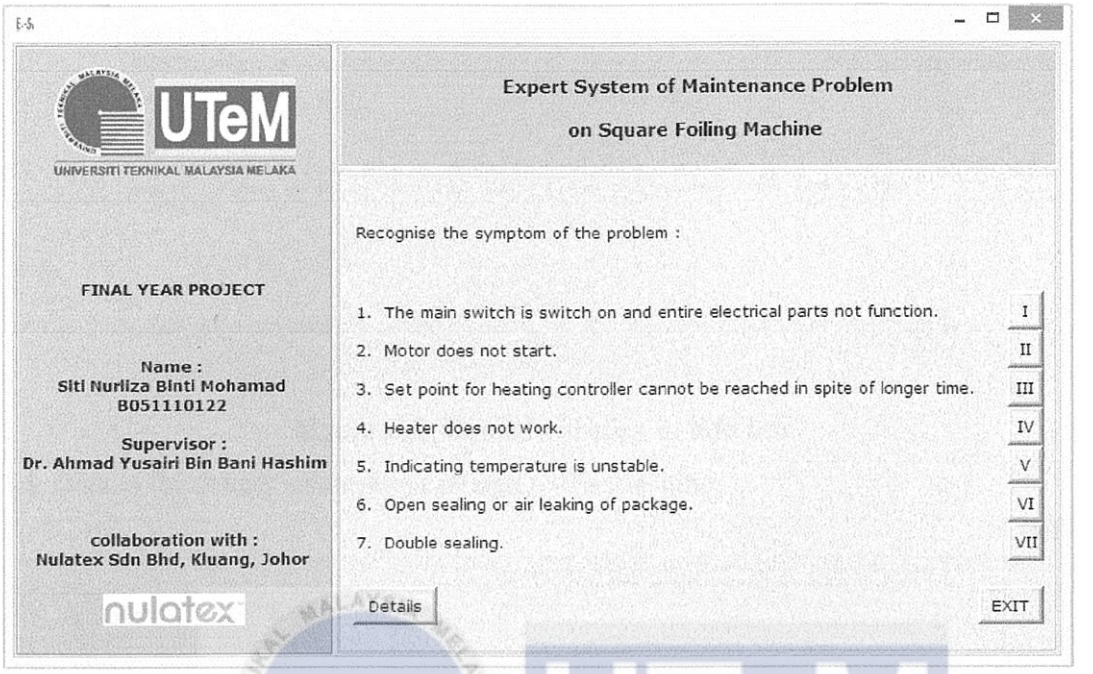


Figure D.1: Main interface of expert system

3. Select the problem. For example, the problem I is Main switch is on and entire electric part not alive.

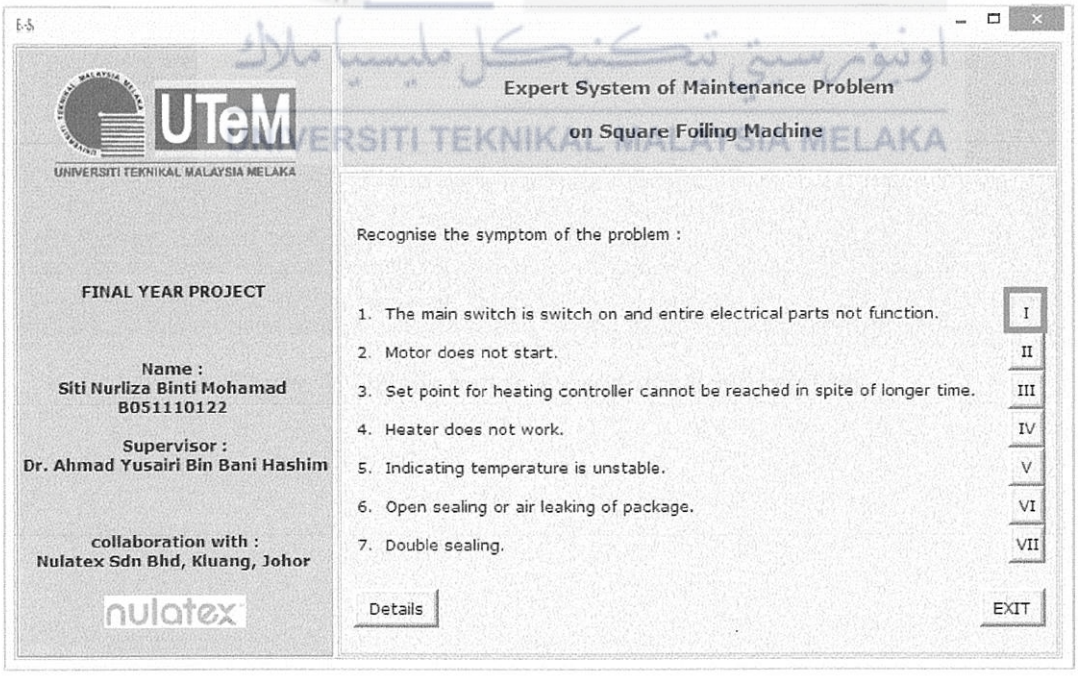


Figure D.2: Select one of the maintenance problems

4. Second interface for the problem appeared. Tick the causes and remedy will display in info box. Click button Ok to back to main interface.

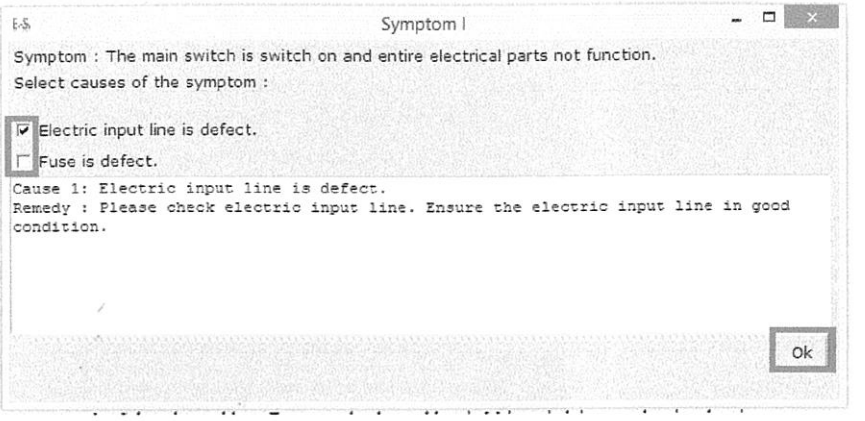


Figure D.3: Remedy display in info box

5. Click Details for details information related to the machine.

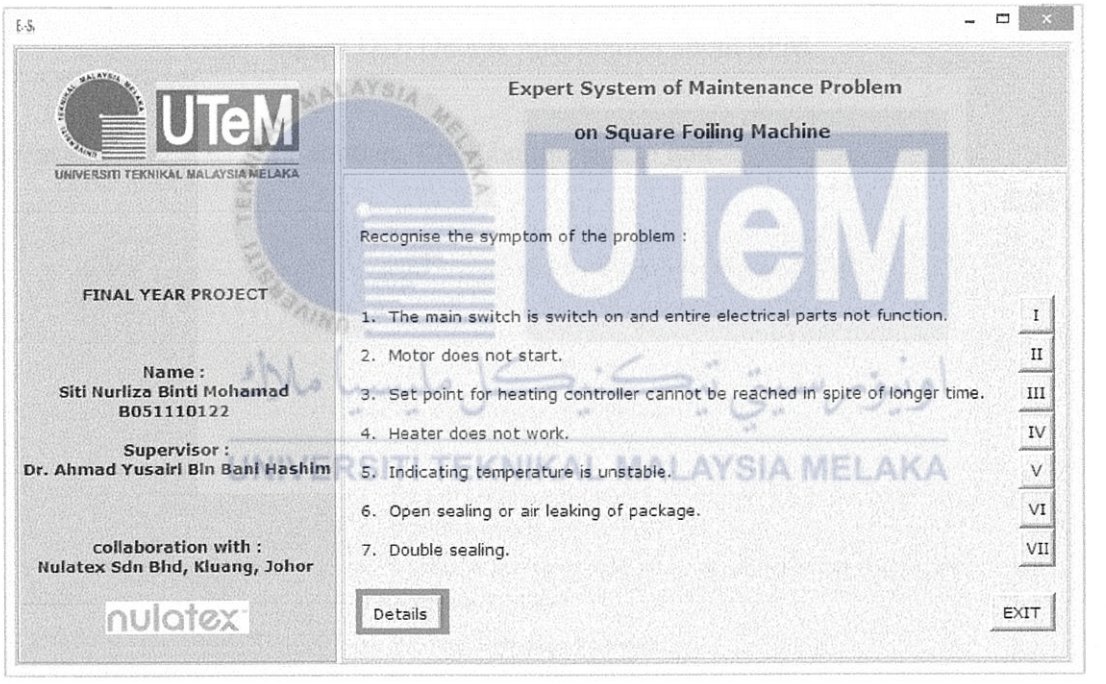


Figure 4: Details button for additional information

6. Details information. Select the radio button to show the information.

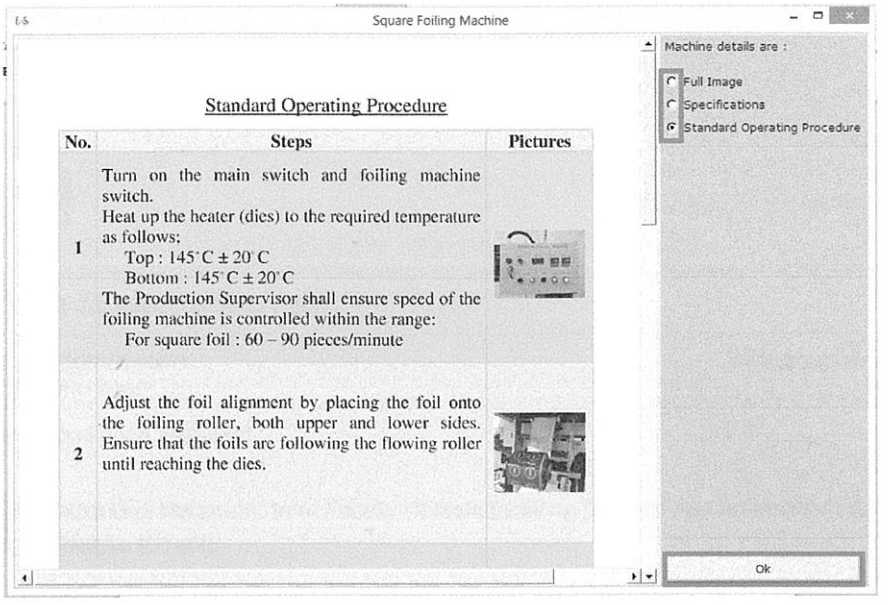


Figure D.5: Details information about SFM

7. Repeat step 3 to step 7 for another. Click button exit to quit.

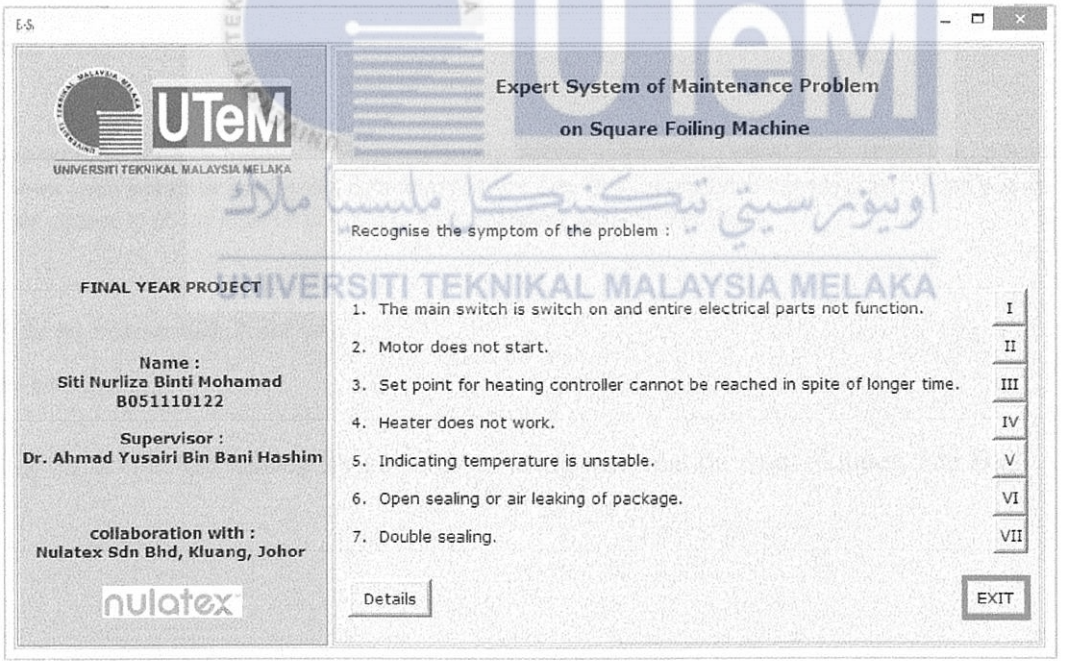


Figure D.6: Exit button to quit

APPENDIX E

Gmail by Google

Siti Nurliza <ctnliza@gmail.com>

Projek Sarjana Muda,PSM UTeM

Siti Nurliza <ctnliza@gmail.com> 24 September 2014 15:14
To: zue - <zue@nulatex.com>

Assalamualaikum and good afternoon.

My name is Siti Nurliza binti Mohamad, from Faculty Of Manufacturing (Robotic And Automation) at Universiti Teknikal Malaysia Melaka (UTeM).

I would like to have my Projek Sarjana Muda (PSM) related to Nulatex Sdn. Bhd.. My topic is 'Expert system of maintenance for square foiling machine'. From my discussion with my supervisor Dr Ahmad Yusairi bin Bani Hashim, he said that the topic just related to my industrial training report. I had undergone my industrial training on 23 June 2014 and end to 29 August 2014. Scope of my project is focusing on maintenance of square foiling machine. I don't need extra or detail information like I had told you last time. I just have to build an expert system related the maintenance problem only.

I am really sorry upon my mistake in giving explanation related to the topic. I would like to stress that I will not and never used private or confidential data from Nulatex Sdn. Bhd. or related to the company. I hope you will give me chance to do my PSM related to this great company, Nulatex Sdn. Bhd..

Sorry for the inconvenient. Thank you.

[Quoted text hidden]

Figure E.1: Email asking for permission using information from Nulatex Sdn Bhd

Gmail by Google

Siti Nurliza <ctnliza@gmail.com>

Projek Sarjana Muda,PSM UTeM

zue - <zue@nulatex.com> 29 September 2014 10:29
To: Siti Nurliza <ctnliza@gmail.com>

Dear Ms Liza,

Refer to your email regarding your project which is focusing on square foiling machine.

We agreed and you can proceed with your project but you have to make sure to keep confidential for certain things.

Thank you.
Zuhana
HR Department
Nulatex Sdn Bhd
[Quoted text hidden]

Figure E.2: Permission email using the information from Nulatex Sdn Bhd

Appendix F

```
from Tkinter import *
import Tkinter as Tk
from PIL import Image, ImageTk
################################################################################
class MyApp(object):
    """"""
    #----------------------------------------------------------------------
    def __init__(self, parent):
        """Constructor"""
        self.root = parent
        self.root.title("")
        self.root.iconbitmap('icon.ico')
        self.root.columnconfigure(0, weight=1)
        self.root.columnconfigure(1, weight=1)
        self.root.rowconfigure(0, weight=1)
        self.root.rowconfigure(1, weight=1)

        left_right_pane = PanedWindow(self.root, orient=HORIZONTAL, relief='groove',borderwidth=2)
        left_right_pane.grid(column=0, row=0, sticky=(W,S,E,N), columnspan=2)
        left_right_pane.rowconfigure(0, weight=1)
        left_right_pane.columnconfigure(0, weight=1)
        left_right_pane.rowconfigure(1, weight=1)
        left_right_pane.columnconfigure(1, weight=1)

        leftframe = Tk.Frame(self.root, relief='groove',bg="light blue",borderwidth=2)
        leftframe.grid(column=0, row=0, sticky=(N, W, E, S), rowspan=2)
        leftframe.rowconfigure(0, weight=1)
        leftframe.columnconfigure(0, weight=1)
        left_right_pane.add(leftframe)
```

```
top_bottom_pane = PanedWindow(self.root, orient=VERTICAL, relief='groove', borderwidth=2)
top_bottom_pane.grid(column=1, row=0, rowspan=2, sticky=(N, W, E, S))
top_bottom_pane.rowconfigure(0, weight=1)
top_bottom_pane.columnconfigure(0, weight=1)
left_right_pane.add(top_bottom_pane)

upperframe = Tk.Frame(self.root, relief='groove', borderwidth=2)
upperframe.grid(column=1, row=0, sticky=(N, W, E, S))
upperframe.columnconfigure(1, weight=1)
upperframe.rowconfigure(0, weight=1)
top_bottom_pane.add(upperframe)

bottomframe = Tk.Frame(top_bottom_pane, relief='groove', borderwidth=2)
bottomframe.grid(column=1, row=1, sticky=(N, W, E, S))
bottomframe.columnconfigure(1, weight=1)
bottomframe.rowconfigure(1, weight=1)
top_bottom_pane.add(bottomframe)

top = Label(upperframe, text=" \n Expert System of Maintenance Problem \n\n"
        "on Square Foiling Machine \n",bg= "light blue",font = "Verdana 11 bold")
top.grid(column=1, row=0,sticky=(W,S,E,N))

imageFile = "utem.gif"
image1 = ImageTk.PhotoImage(Image.open(imageFile))
panel1 = Tk.Label(leftframe, image=image1,bg = "light blue")
panel1.pack(side='top')
panel1.image = image1

Label(leftframe,
    text="\n\n\n\n\n"
    "FINAL YEAR PROJECT \n\n\n\n"
    "Name : \n"
    "Siti Nurliza Binti Mohamad \n"
```

```
        "B051110122 \n\n"
        "Supervisor :\n"
        "Dr. Ahmad Yusairi Bin Bani Hashim\n\n\n\n"
        "collaboration with :\n"
        "Nulatex Sdn Bhd, Kluang, Johor \n", bg = "light blue",font = "Verdana 10 bold").pack()

    imageFile = "nulatex.gif"
    image3 = ImageTk.PhotoImage(Image.open(imageFile))
    panel3 = Tk.Label(leftframe, image=image3,bg = "light blue")
    panel3.pack()
    panel3.image = image3
    Label(leftframe,
        text="",bg = "light blue").pack(side='bottom')

    bottom = Label(bottomframe, text="Recognise the symptom of the problem : ",font = "Verdana 10")
    bottom.grid(column=1, row=1, sticky=(W))
    Label(bottomframe,
        text="1. The main switch is switch on and entire electrical parts not function.",font = "Verdana
10").grid(row=4,column=1,sticky=W)
    Label(bottomframe,
        text="2. Motor does not start.",font = "Verdana 10").grid(row=5,column=1,sticky=W)
    Label(bottomframe,
        text="3. Set point for heating controller cannot be reached in spite of longer time.",font = "Verdana
10").grid(row=6,column=1,sticky=W)
    Label(bottomframe,
        text="4. Heater does not work.",font = "Verdana 10").grid(row=7,column=1,sticky=W)
    Label(bottomframe,
        text="5. Indicating temperature is unstable.",font = "Verdana 10").grid(row=8,column=1,sticky=W)
    Label(bottomframe,
        text="6. Open sealing or air leaking of package.",font = "Verdana
10").grid(row=9,column=1,sticky=W)
    Label(bottomframe,
        text="7. Double sealing.",font = "Verdana 10").grid(row=10,column=1,sticky=W)
    Label(bottomframe,
```

```
        text=" ").grid(row=11,column=3,sticky=W)

    Label(bottomframe,

        text=" ").grid(row=13,column=0,sticky=W)


    Button(bottomframe, text="I",font = "Verdana 10",bd= 4, height=1,
width=2,command=self.openFrame1).grid(row=4,column=2,sticky=E)

    Button(bottomframe, text="II",font = "Verdana 10",bd= 4, height=1,
width=2,command=self.openFrame2).grid(row=5,column=2,sticky=E)

    Button(bottomframe, text="III",font = "Verdana 10",bd= 4, height=1,
width=2,command=self.openFrame3).grid(row=6,column=2,sticky=E)

    Button(bottomframe, text="IV",font = "Verdana 10",bd= 4, height=1,
width=2,command=self.openFrame4).grid(row=7,column=2,sticky=E)

    Button(bottomframe, text="V",font = "Verdana 10",bd= 4, height=1,
width=2,command=self.openFrame5).grid(row=8,column=2,sticky=E)

    Button(bottomframe, text="VI",font = "Verdana 10",bd= 4, height=1,
width=2,command=self.openFrame6).grid(row=9,column=2,sticky=E)

    Button(bottomframe, text="VII",font = "Verdana 10",bd= 4, height=1,
width=2,command=self.openFrame7).grid(row=10,column=2,sticky=E)

    Button(bottomframe, text="EXIT",font = "Verdana 10",bd= 4, height=1,
width=5,command=self.onClose).grid(row=12,column=2,sticky=E)


    imageButton = Tk.Button(bottomframe, text='Details',font = "Verdana 10",bd= 4, height=1, width=7,
command=self.openFrame8)

    imageButton.grid(row=12,column=1,sticky=W)

#-----------------------------------------------------------------------

def openFrame1(self1):

    """"""

    self1.hide()

    otherFrame = Tk.Toplevel()

    otherFrame.iconbitmap('icon.ico')

    otherFrame.geometry("690x300")

    otherFrame.title("Symptom I")

    handler = lambda: self1.onCloseOtherFrame(otherFrame)


    Label(otherFrame,text = "Symptom : The main switch is switch on and entire electrical parts not
function.",font = "Verdana 10").grid(row=0, column=0, sticky=W)

    Label(otherFrame,text = "Select causes of the symptom :\n",font = "Verdana 10").grid(row=2,
column=0,sticky=W)
```

```
    self1.checkBoxA1 = BooleanVar()

    Checkbutton(otherFrame,text = "Electric input line is defect.",font = "Verdana 10", variable =
self1.checkBoxA1, command = self1.update_text1).grid(row = 3, column = 0, sticky = W)

    self1.checkBoxB1 = BooleanVar()

    Checkbutton(otherFrame,text = "Fuse is defect. ",font = "Verdana 10", variable = self1.checkBoxB1,
command = self1.update_text1).grid(row = 4, column = 0, sticky = W)


    self1.results_txt = Text(otherFrame, width=85, height = 8, wrap = WORD)

    self1.results_txt.grid(row = 5, column = 0, columnspan = 4, sticky = E+W)


    Tk.Button(otherFrame, text="Ok",font = "Verdana 10",bd= 5, height=1, width=4,
command=handler).grid(row=6,column=3,sticky=E)


  def update_text1(self1):

    likes = ""

    if self1.checkBoxA1.get():

      likes += "Cause 1: Electric input line is defect.\nRemedy : Please check electric input line. Ensure the
electric input line in good condition. \n\n"

    else:

      likes += ""


    if self1.checkBoxB1.get():

      likes += "Cause 2: Fuse is defect.\nRemedy : Please check the fuse. Ensure the fuse is fucntion and  in
good condition. \n\n"

    else:

      likes += ""


    self1.results_txt.delete(0.0, END)

    self1.results_txt.insert(0.0, likes)

  #---------------------------------------------------------------------

  def openFrame2(self2):

    """"""

    self2.hide()

    otherFrame = Tk.Toplevel()
```

```
otherFrame.iconbitmap('icon.ico')

otherFrame.geometry("690x370")

otherFrame.title("Symptom II")

handler = lambda: self2.onCloseOtherFrame(otherFrame)


Label(otherFrame,text = "Symptom : Motor does not start.\n",font = "Verdana 10").grid(sticky=W)

Label(otherFrame,text = "Select causes of the symptom :\n",font = "Verdana 10").grid(sticky=W)


self2.checkBoxA2 = BooleanVar()

Checkbutton(otherFrame,text = "One or two of foil is run out but limit switch is working.",font = "Verdana 10", variable = self2.checkBoxA2, command = self2.update_text2).grid(row = 4, column = 0, sticky = W)

self2.checkBoxB2 = BooleanVar()

Checkbutton(otherFrame,text = "Cable connections are loose. ",font = "Verdana 10", variable = self2.checkBoxB2, command = self2.update_text2).grid(row = 5, column = 0, sticky = W)

self2.checkBoxC2 = BooleanVar()

Checkbutton(otherFrame,text = "Motor is problem. ",font = "Verdana 10", variable = self2.checkBoxC2, command = self2.update_text2).grid(row = 6, column = 0, sticky = W)


self2.results_txt = Text(otherFrame, width=85, height = 11, wrap = WORD)

self2.results_txt.grid(row = 8, column = 0, columnspan = 4, sticky = E+W)


Tk.Button(otherFrame, text="Ok",font = "Verdana 10",bd= 5, height=1, width=4, command=handler).grid(row=10,column=3,sticky=E)


def update_text2(self2):

likes = ""

if self2.checkBoxA2.get():

    likes += "Causes 1: One or two of foil is run out but limit switch is working.\nRemedy : The foil must be replace with new one. Motor will not function if one or two foil damage. \n\n"

else:

    likes += ""


if self2.checkBoxB2.get():

    likes += "Causes 2: Cable connections are loose.\nRemedy : Check the cable connection. Ensure the cable connections tight enough. \n\n"
```

```
    else:
        likes += ""

    if self2.checkBoxC2.get():
        likes += "Causes 3: Motor is problem.\nRemedy  : Check the motor and replace if needed. \n\n"
    else:
        likes += ""

    self2.results_txt.delete(0.0, END)
    self2.results_txt.insert(0.0, likes)
#---------------------------------------------------------------------
def openFrame3(self3):
    """"""
    self3.hide()
    otherFrame = Tk.Toplevel()
    otherFrame.iconbitmap('icon.ico')
    otherFrame.geometry("690x360")
    otherFrame.title("Symptom III")
    handler = lambda: self3.onCloseOtherFrame(otherFrame)

    Label(otherFrame,text = "Symptom : Set point for heating controller cannot be reached in spite of longer time.\n",font = "Verdana 10").grid(sticky=W)
    Label(otherFrame,text = "Select causes of the symptom :\n",font = "Verdana 10").grid(sticky=W)

    self3.checkBoxA3 = BooleanVar()
    Checkbutton(otherFrame,text = "Temperature sensors are defect. ",font = "Verdana 10", variable = self3.checkBoxA3, command = self3.update_text3).grid(row = 4, column = 0, sticky = W)
    self3.checkBoxB3 = BooleanVar()
    Checkbutton(otherFrame,text = "Heating cartridge is defect. ",font = "Verdana 10", variable = self3.checkBoxB3, command = self3.update_text3).grid(row = 5, column = 0, sticky = W)
    self3.checkBoxC3 = BooleanVar()
    Checkbutton(otherFrame,text = "Wire connections of heating have been confused. ",font = "Verdana 10", variable = self3.checkBoxC3, command = self3.update_text3).grid(row = 6, column = 0, sticky = W)
    self3.results_txt = Text(otherFrame, width=85, height = 10, wrap = WORD)
```

```
    self3.results_txt.grid(row = 8, column = 0, columnspan = 4, sticky = E+W)

    Tk.Button(otherFrame, text="Ok",font = "Verdana 10",bd= 5, height=1, width=4,
command=handler).grid(row=10,column=3,sticky=E)

  def update_text3(self3):
    likes = ""
    if self3.checkBoxA3.get():
      likes += "Causes 1: The temperature sensors are defects.\nRemedy  : The temperature sensor must be
replace since the temperature cannot detect the set point temperature. \n\n"
    else:
      likes += ""

    if self3.checkBoxB3.get():
      likes += "Causes 2: Defect heating cartridge.\nRemedy  : The heating catridge must be replace. \n\n"
    else:
      likes += ""

    if self3.checkBoxC3.get():
      likes += "Causes 3: Wire connections of heating have been confused.\nRemedy  : Check wire
connections and correct the connections. \n\n"
    else:
      likes += ""

    self3.results_txt.delete(0.0, END)
    self3.results_txt.insert(0.0, likes)
  #-----------------------------------------------------------------------
  def openFrame4(self4):
    """"""
    self4.hide()
    otherFrame = Tk.Toplevel()
    otherFrame.iconbitmap('icon.ico')
    otherFrame.geometry("690x360")
    otherFrame.title("Symptom IV")
```

```
handler = lambda: self4.onCloseOtherFrame(otherFrame)


Label(otherFrame,text = "Symptom : Heater does not work.\n",font = "Verdana 10").grid(sticky=W)

Label(otherFrame,text = "Select causes of the symptom :\n",font = "Verdana 10").grid(sticky=W)



self4.checkBoxA4 = BooleanVar()

Checkbutton(otherFrame,text = "Fuses are defect. ",font = "Verdana 10", variable = self4.checkBoxA4, command = self4.update_text4).grid(row = 4, column = 0, sticky = W)

self4.checkBoxB4 = BooleanVar()

Checkbutton(otherFrame,text = "Heating cartridge is defect. ",font = "Verdana 10", variable = self4.checkBoxB4, command = self4.update_text4).grid(row = 5, column = 0, sticky = W)

self4.checkBoxC4 = BooleanVar()

Checkbutton(otherFrame,text = "Controller is defect. ",font = "Verdana 10", variable = self4.checkBoxC4, command = self4.update_text4).grid(row = 6, column = 0, sticky = W)

self4.results_txt = Text(otherFrame, width=85,height = 10, wrap = WORD)

self4.results_txt.grid(row = 8, column = 0, columnspan = 4, sticky = E+W )


Tk.Button(otherFrame, text="Ok",font = "Verdana 10",bd= 5, height=1, width=4, command=handler).grid(row=10,column=3,sticky=E)


def update_text4(self4):

likes = ""

if self4.checkBoxA4.get():

likes += "Causes 1: Fuses are defect.\nRemedy : Check the fuses and replace the heater if the fuses is defect. \n\n"

else:

likes += ""


if self4.checkBoxB4.get():

likes += "Causes 2: Heating cartridge is defect.\nRemedy : Check the heating catridge, replace the heating catridge if defect. \n\n"

else:

likes += ""
```

```
    if self4.checkBoxC4.get():
        likes += "Causes 3: Controller is defect.\nRemedy  : Check the controller and replace when it was defect.
\n\n"
    else:
        likes += ""

    self4.results_txt.delete(0.0, END)
    self4.results_txt.insert(0.0, likes)
  #---------------------------------------------------------------------
  def openFrame5(self5):
    """"""
    self5.hide()
    otherFrame = Tk.Toplevel()
    otherFrame.iconbitmap('icon.ico')
    otherFrame.geometry("690x360")
    otherFrame.title("Symptom V")
    handler = lambda: self5.onCloseOtherFrame(otherFrame)

    Label(otherFrame,text = "Symptom : Indicating temperature is unstable.\n",font = "Verdana
10").grid(sticky=W)
    Label(otherFrame,text = "Select causes of the symptom :\n",font = "Verdana 10").grid(sticky=W)

    self5.checkBoxA5 = BooleanVar()
    Checkbutton(otherFrame,text = "Carbon brush is defect. ",font = "Verdana 10", variable =
self5.checkBoxA5, command = self5.update_text5).grid(row = 4, column = 0, sticky = W)
    self5.checkBoxB5 = BooleanVar()
    Checkbutton(otherFrame,text = "Carbon brush does not contact properly. ",font = "Verdana 10", variable =
self5.checkBoxB5, command = self5.update_text5).grid(row = 5, column = 0, sticky = W)
    self5.checkBoxC5 = BooleanVar()
    Checkbutton(otherFrame,text = "Temperature controller is defect. ",font = "Verdana 10", variable =
self5.checkBoxC5, command = self5.update_text5).grid(row = 6, column = 0, sticky = W)
    self5.results_txt = Text(otherFrame, width=85, height = 10, wrap = WORD)
    self5.results_txt.grid(row = 8, column = 0, columnspan = 4, sticky = E+W)
```

```
    Tk.Button(otherFrame, text="Ok",font = "Verdana 10",bd= 5, height=1, width=4,
command=handler).grid(row=10,column=3,sticky=E)


  def update_text5(self5):
    likes = ""
    if self5.checkBoxA5.get():
      likes += "Causes 1: Carbon brush is defect.\nRemedy  : The carbon brush must be replace since the
carbon brush is defect. \n\n"
    else:
      likes += ""

    if self5.checkBoxB5.get():
      likes += "Causes 2: Carbon brush does not contact properly.\nRemedy  : Give more pressure to the
carbon brush for better contacting. \n\n"
    else:
      likes += ""

    if self5.checkBoxC5.get():
      likes += "Causes 3: Temperature controller is defect.\nRemedy  : Replace the temperature controller.
\n\n"
    else:
      likes += ""

    self5.results_txt.delete(0.0, END)
    self5.results_txt.insert(0.0, likes)
  #---------------------------------------------------------------------
  def openFrame6(self6):
    """"""
    self6.hide()
    otherFrame = Tk.Toplevel()
    otherFrame.iconbitmap('icon.ico')
    otherFrame.geometry("690x490")
    otherFrame.title("Symptom VI")
    handler = lambda: self6.onCloseOtherFrame(otherFrame)
```

```
Label(otherFrame,text = "Symptom : Open sealing or air leaking of package.\n",font = "Verdana 10").grid(sticky=W)

Label(otherFrame,text = "Select causes of the symptom :\n",font = "Verdana 10").grid(sticky=W)


self6.checkBoxA6 = BooleanVar()

Checkbutton(otherFrame,text = "Pressure between two sealing moulds is not enough. ",font = "Verdana 10", variable = self6.checkBoxA6, command = self6.update_text6).grid(row = 4, column = 0, sticky = W)

self6.checkBoxB6 = BooleanVar()

Checkbutton(otherFrame,text = "Temperature for sealing is low. ",font = "Verdana 10", variable = self6.checkBoxB6, command = self6.update_text6).grid(row = 5, column = 0, sticky = W)

self6.checkBoxC6 = BooleanVar()

Checkbutton(otherFrame,text = "Condom is not located in the center of the cavity. ",font = "Verdana 10", variable = self6.checkBoxC6, command = self6.update_text6).grid(row = 6, column = 0, sticky = W)

self6.checkBoxD6 = BooleanVar()

Checkbutton(otherFrame,text = "Lubricant is stained on the sealing area of foil. ",font = "Verdana 10", variable = self6.checkBoxD6, command = self6.update_text6).grid(row = 7, column = 0, sticky = W)

self6.checkBoxE6 = BooleanVar()

Checkbutton(otherFrame,text = "Tensions for each foil are not same. ",font = "Verdana 10", variable = self6.checkBoxE6, command = self6.update_text6).grid(row = 8, column = 0, sticky = W)

self6.results_txt = Text(otherFrame, width=85, height = 15, wrap = WORD)

self6.results_txt.grid(row = 10, column = 0, columnspan = 4, sticky = E+W)


Tk.Button(otherFrame, text="Ok",font = "Verdana 10",bd= 5, height=1, width=4, command=handler).grid(row=20,column=3,sticky=E)


def update_text6(self6):

likes = ""

if self6.checkBoxA6.get():

    likes += "Causes 1: Pressure between two sealing moulds is not enough.\nRemedy : Check the flowers of sealing mould. \n\n"

else:

    likes += ""


if self6.checkBoxB6.get():

    likes += "Causes 2: Temperature for sealing is low.\nRemedy : Check temperature and adjust it until the package been seal properly. \n\n"
```

```
    else:
        likes += ""

    if self6.checkBoxC6.get():
        likes += "Causes 3: Condom is not located in the center of the cavity.\nRemedy  : Ensure the condom shape in round shaped. \n\n"
    else:
        likes += ""

    if self6.checkBoxD6.get():
        likes += "Causes 4: Lubricant is stained on the sealing area of foil.\nRemedy  : Adjust amount of lubricant and check lubricant pump position. \n\n"
    else:
        likes += ""

    if self6.checkBoxE6.get():
        likes += "Causes 5: Tensions for each foil are not same.\nRemedy  : Adjust tensions by weight of friction belt for foils. \n\n"
    else:
        likes += ""

    self6.results_txt.delete(0.0, END)
    self6.results_txt.insert(0.0, likes)
#---------------------------------------------------------------------
def openFrame7(self7):
    """"""
    self7.hide()
    otherFrame = Tk.Toplevel()
    otherFrame.iconbitmap('icon.ico')
    otherFrame.geometry("690x300")
    otherFrame.title("Symptom VII")
    handler = lambda: self7.onCloseOtherFrame(otherFrame)

    Label(otherFrame,text = "Symptom : Double sealing.\n",font = "Verdana 10").grid(sticky=W)
```

```
Label(otherFrame,text = "Select causes of the symptom :\n",font = "Verdana 10").grid(sticky=W)


self7.checkBoxA7 = BooleanVar()

Checkbutton(otherFrame,text = "Condom is slipped from original position when condom is entering for sealing.",font = "Verdana 10", variable = self7.checkBoxA7, command = self7.update_text7).grid(row = 4, column = 0, sticky = W)

self7.checkBoxB7 = BooleanVar()

Checkbutton(otherFrame,text = "Condom is not located in the center of the cavity. ",font = "Verdana 10", variable = self7.checkBoxB7, command = self7.update_text7).grid(row = 5, column = 0, sticky = W)


self7.results_txt = Text(otherFrame, width=85, height = 8, wrap = WORD)

self7.results_txt.grid(row = 7, column = 0, columnspan = 4, sticky = E+W)


Tk.Button(otherFrame, text="Ok",font = "Verdana 10",bd= 5, height=1, width=4, command=handler).grid(row=10,column=3,sticky=E)


def update_text7(self7):

likes = ""

if self7.checkBoxA7.get():

  likes += "Causes 1: Condom slipped from original position when condom is entering for sealing.\nRemedy : Loosen the tension of foils and adjust to enter the under foil should be kept flat. \n\n"

else:

  likes += ""

if self7.checkBoxB7.get():

  likes += "Causes 2: Condom not located in the center of the cavity.\nRemedy : Adjust amount of lubricant and check lubricant pump position. \n\n"

else:

  likes += ""


self7.results_txt.delete(0.0, END)

self7.results_txt.insert(0.0, likes)

#---------------------------------------------------------------------

def openFrame8(self8):

self8.hide()

detail = Tk.Toplevel()
```

```
detail.iconbitmap('icon.ico')
detail.title('Square Foiling Machine')
handler = lambda: self8.onCloseOtherFrame(detail)

detail.columnconfigure(0, weight=1)
detail.columnconfigure(1, weight=1)
detail.rowconfigure(0, weight=1)
detail.rowconfigure(1, weight=1)

left_right_pane = PanedWindow(detail, relief='groove', orient=HORIZONTAL,borderwidth=2)
left_right_pane.grid(column=0, row=0, sticky=(W,S,E,N), columnspan=2)
left_right_pane.rowconfigure(0, weight=1)
left_right_pane.columnconfigure(0, weight=1)
left_right_pane.rowconfigure(1, weight=1)
left_right_pane.columnconfigure(1, weight=1)

leftframe = Tk.Frame(detail,borderwidth=2)
leftframe.grid(column=0, row=0, sticky=(N, W, E, S), rowspan=1)
leftframe.rowconfigure(0, weight=1)
leftframe.columnconfigure(0, weight=1)
left_right_pane.add(leftframe)

rightframe = Tk.Frame(detail,borderwidth=2, bg="light blue")
rightframe.grid(column=8, row=0, sticky=(N, W, E, S), rowspan=2)
rightframe.rowconfigure(0, weight=1)
rightframe.columnconfigure(0, weight=1)
left_right_pane.add(rightframe)

def show_image():
    canvas.delete("all")
    x = canvas.create_image(350, 250, image=tk_img1)
    canvas.configure(state="normal")
    canvas.itemconfigure(x)
```

```
def show_image2():
    canvas.delete("all")
    y = canvas.create_image(350, 250, image=tk_img2)
    canvas.configure(state="normal")
    canvas.itemconfigure(y)
def show_image3():
    canvas.delete("all")
    y = canvas.create_image(350, 900, image=tk_img3)
    canvas.configure(state="normal")
    canvas.itemconfigure(y)

canvas=Canvas(leftframe,bg='#FFFFFF',width=700,height=600,scrollregion=(0,0,800,1800))

vbar=Scrollbar(leftframe,orient=VERTICAL)
vbar.pack(side=RIGHT,fill=Y)
vbar.config(command=canvas.yview)
hbar=Scrollbar(leftframe,orient=HORIZONTAL)
hbar.pack(side=BOTTOM,fill=X)
hbar.config(command=canvas.xview)

canvas.config(xscrollcommand=hbar.set,yscrollcommand=vbar.set)
canvas.pack(side=LEFT,expand=True,fill=BOTH)

tk_img1 = ImageTk.PhotoImage(file='machine.gif')
tk_img2 = ImageTk.PhotoImage(file='spec.gif')
tk_img3 = ImageTk.PhotoImage(file='sop.gif')

Label(rightframe,text = "Machine details are : \n",font = "Verdana 10", bg="light blue",).pack(anchor=W)
RadioButton = Radiobutton(rightframe, text="Full Image", font = "Verdana 10", bg="light blue",value="0",
command=show_image)
RadioButton.pack(anchor = W)
```

```
    RadioButton = Radiobutton(rightframe, text="Specifications", font = "Verdana 10", bg="light blue",value="1", command=show_image2)

    RadioButton.pack(anchor = W)

    RadioButton = Radiobutton(rightframe, text="Standard Operating Procedure", font = "Verdana 10", bg="light blue",value="2", command=show_image3)

    RadioButton.pack(anchor = W)


    Tk.Button(rightframe, text="Ok",font = "Verdana 10",bd= 5, height=1, width=26, command=handler).pack(side='bottom')

  #--------------------------------------------------------------------

  def hide(self):

    """

    self.root.withdraw()

  #--------------------------------------------------------------------

  def onClose(self):

    """

    self.root.destroy()

  #--------------------------------------------------------------------

  def onCloseOtherFrame(self, otherFrame):

    """

    otherFrame.destroy()

    self.show()

  #--------------------------------------------------------------------

  def show(self):

    """

    self.root.update()

    self.root.deiconify()

  #--------------------------------------------------------------------

if __name__ == "__main__":

  root = Tk.Tk()

  app = MyApp(root)

  root.mainloop()
```