Innovative Production Machines and Systems
D.T. Pham, E.E. Eldukhri and A.J. Soroka (eds)

A knowledge diagnostic system for product defects

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Abstract

The need to fulfill customer satisfaction and increase product quality has motivated many manufacturing firms to investigate and diagnose their product failure. To gain a correct and accurate diagnostic, the entire processing root must be recorded and controlled in every step of the manufacturing process. In this research, a prototype system has been developed for a tile manufacturing company to diagnose tile defects and to recommend actions for improvement. This system consists of two main components, the knowledge base and inference engine. The knowledge base has been developed by capturing data and information that are related to tile defects, such as symptoms, probable causes, types of defects, processes, sub processes, tile classifications, etc. On the other hand, the inference engine has been built by implementing the forward chaining and depth first searching methods to search for the causes of defects. The analysis proves that this system can help the workers in the company to diagnose tile defects and solve the problems. Besides this, the system can also help to share and transfer knowledge among the knowledge workers in the company.

Keywords: Knowledge base, inference engine, depth first searching, forward chaining

1. Introduction

The ability to mechanize or automate manufacturing processes has become a major requirement for many organizations that are planning to compete well in the future. Regardless of the precaution and best effort taken by them, a time may come when one of their products 'dies' in the field. Usually the cause is either the improper use or the failure of parts.

Quality concerns have become more important in product design and production. In addition, a major pressure is to develop new products quickly. However, developers often lack the time to fully test their product-quality features. As a result, manufacturing companies must ensure that they have a program in place to effectively and efficiently respond to product failures. Otherwise the rush to market may levy a "pay me now or pay me later" tax on their profits. Manufacturing companies must be prepared their product to react quickly to issues that may arise when one of their products fails. They must also be ready to give customers enough information to correct the problem.

Unfortunately, many manufacturing companies lack a program that outlines how to investigate and diagnose product failures. This can have serious consequences. There must be a prompt investigation to diagnose the root causes of the failures. Some basic questions that could be asked during the diagnostic process include:

- Is the product defective?

- What is the defect?
- How is the condition of the product?
- What are the common causes of defects?
- How to manage or solve the problem?
- Which part of the manufacturing process causes the defect?

Problems that occur in production should be communicated to all employees. Personnel must be aware of their responsibilities if a product fails [1]. Sometimes the causes are related to machine problems, inconsistent production procedures and defective raw materials but it is not impossible that the causes are due to human factors [2], such as the dereliction of duty. Knowing the root causes of a defective or failed product, needs special skills, experiences and knowledge from experts in the manufacturing area. To gain a correct and accurate diagnostic, the entire processing root must be recorded and controlled in every step of the manufacturing process, from the incoming of raw materials, preparation/manufacturing, building/ assembly, inspection to after sales service.

In this study, the researchers propose a prototype system to aid the diagnosis of defects in tile manufacturing. It helps to troubleshoot information entered by the users and propose solutions/actions to address the problems.

This paper is organized as follow. Firstly, section 2 introduces the knowledge base and knowledge management concepts. Then, section 3 describes the system analysis and design, whereas section 4 presents the development and implementation of the prototype system. Finally, section 5 is dedicated to conclusions and future work perspectives.

2. Knowledge base and knowledge management approaches.

2.1. Knowledge base concepts

In this research, the definition of knowledge repository is a knowledge basis contains domain knowledge which may be expressed as any combination of "If-Then" rules, factual statements, frames, objects, procedures and cases [3]. Particularly, the knowledge base captures any condition or variable that relates to the defects found in tile manufacturing, such as the symptoms, types of defects, probable causes, processes and sub processes where the defects occurred, recommended actions to solve the problems and tile grade classifications. On the other hand, the inference engine is part of the prototype system that manipulates the stored knowledge to produce solutions to problems. It uses rule-based reasoning via the forward chaining procedure [4,5,6,7] to search for appropriate solutions, and this is shown in Figure 1.

In the prototype system, the rule-based process starts by diagnosing the defects of the tiles. The defects can be traced from the symptoms that are entered by the users. After diagnosing the defects, the rule-based process will investigate the related sub processes and processes which contribute to the defects.

The final result of the diagnostic is an output that will give some conclusions about the defects, sources of problems, tile grade classifications and solution or recommendation to address the problems.

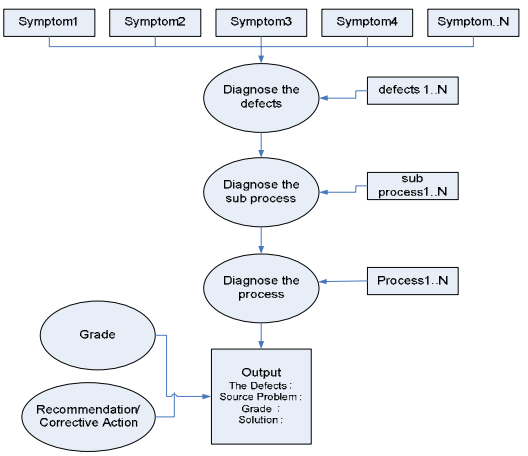

Fig. 1. The rule-based process

Developing the rule-based process in the system [8] can be started with this rule-based pattern as described below:

Rule-based pattern:

R1 : IF (The symptom-1)=" A " AND (symptom-2) = " B " THEN causes1

R2 : IF causes1 = "a" AND (symptom-3)="C" OR (symptom-4)="D" THEN causes2

R3…….RN

RN : IF causes2 ="b" AND (symptom-5)="E" THEN defects="I" AND sub process = "I" AND process= "I" AND rec ="1" AND grade="1"

This rule-based pattern is used to build the searching mechanism in the diagnostic system.

2.2. Knowledge management concepts

Knowledge Management consists of processes and technologies for identifying, capturing, storing, searching, retrieving, and displaying knowledge [9]. The knowledge management approach in the prototype system is used to manage knowledge from the experts or engineers in the company. Every knowledge engineer in the company has the same access to edit and manipulate the knowledge base in the system. For this reason, they can share and contribute their knowledge and thus, produce the best and complete knowledge base. Detail information about the application of knowledge management in the system is shown in Figure 2.

3. System analysis and design

In the analysis and design stage, the prototype system implements an object oriented method by using Unified Modeling Language [10, 11, 12]. Case diagrams, specification diagrams, class diagrams, Class-Responsibility-Collaboration cards and the whole Unified Modeling Language tools have been applied in this system.

The prototype system can be divided into two operating environments. One is the consultation environment and the other is the knowledge development environment. Starting from the knowledge development environment, the knowledge base was first built and verified. Knowledge related to defect symptoms, causes, defect types, sub processes, processes, recommendations, grades and other facts was absorbed from the knowledge engineers and input into the system. Therefore, knowledge acquisition and knowledge management are carried out in this environment. Administrators act as operators to enter or key in the knowledge into the repository. All the activities in this environment will support the inference engine development. To test the inference engine in the diagnostic process, a consultation environment has been built (See Figure 3). It represents an interface that enables users to key in information on defect symptoms and to pose questions to the system.

The types of answers produced by the system are based on pre-established rules or routes to diagnose the defects. Accordingly, the route analysis process is described in Figure 4.

The route analysis process in the consultation environment starts by analyzing the location of the defects, such as the tile surface, tile side, the color of defects and the machine condition (speed, temperature and component/equipment used) will be checked. Finally, the system will check the existing production reports, such as the pressing, glazing, printing and curvature reports.

4. System development and implementation

The system has been developed using PHP (AppServ) [13] and Macromedia Dreamweaver version 7.

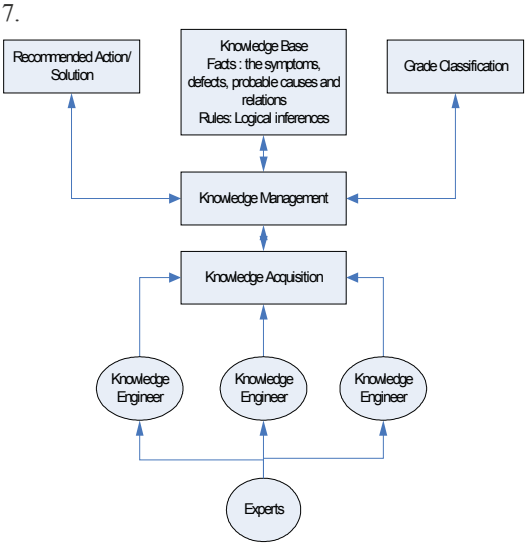

Fig. 2. Knowledge management concept in the system

For the knowledge base development, MySQL PhpMyAdmin has been used. The development of the system focuses on the knowledge base structure development and inference engine process development. Both of these form the foundation for diagnosing and solving the defect problems. For this reason, relationships must be built between entities, such as defects, symptoms, causes, processes, sub processes, recommendations, grades, questions and answers. These relationships can be seen in Figure 5. In addition, relationships between different rules used in the system also need to be established (see Figure 6).

Some features or facilities incorporated into the system are:

(i). Display of information about the causes, symptoms, processes, sub processes, recommendations and solutions in the knowledge base. The system also shows the relationships between different types of

defects.
(ii). Dialogues: In this feature, the system provides two types of dialogue forms, i.e. symptom input and question-answer form. The first dialogue form allows users to insert the symptoms by choosing any kind of symptoms found on the defects. The second, the question-answer form will be used to root the symptoms and defects for diagnosis purposes. One of the interfaces for the system
can be seen in Figure 7.

Possible defect symptoms will be entered into the system and they will be correlated with the possible defects, processes, sub processes, recommendations and grades. As explained earlier in Figure 3, the inference engine will operate to find the solution in the knowledge base by following the rule-based procedure that has been built by the administrators and knowledge engineers.

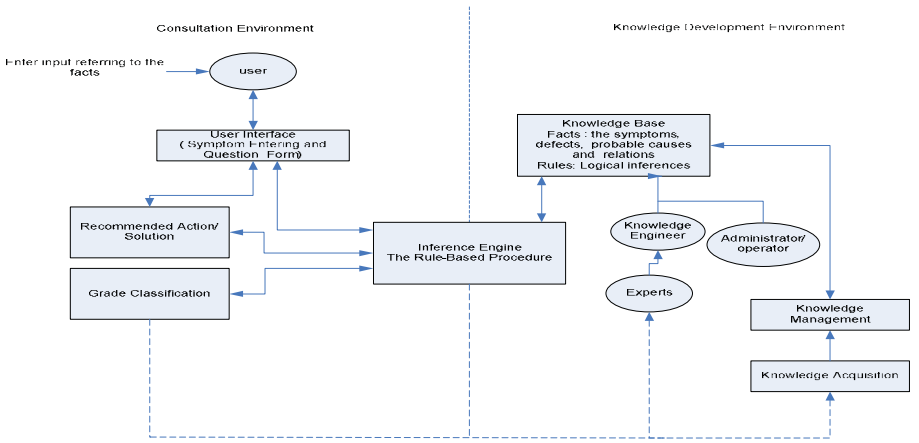

Fig. 3. The structure of the system

It shows a page where the administrators and knowledge engineers can manipulate and create new rules for diagnosing tile defects. Of course the proposed rules must follow the rule-based pattern.

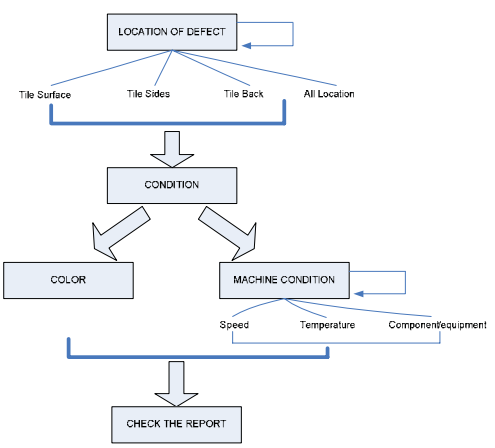

Fig. 4. Route analysis process

By using this system, ordinary users such as quality control, quality assurance, and research and development staff can detect and diagnose tile defects easily. The symptoms that are keyed in will be processed by the inference engine to trace the cause of the problem and to find the correct solution. Subsequently, this information can be disseminated and shared among employees in different departments in real time. Due to this, prompt efforts can be taken to fix the cause of the problem.

With the use of this system, employees will be better equipped to produce higher quality products and increase their company profits. It helps them to improve their technical knowledge on tile defects as well as their managerial capability to address these problems.

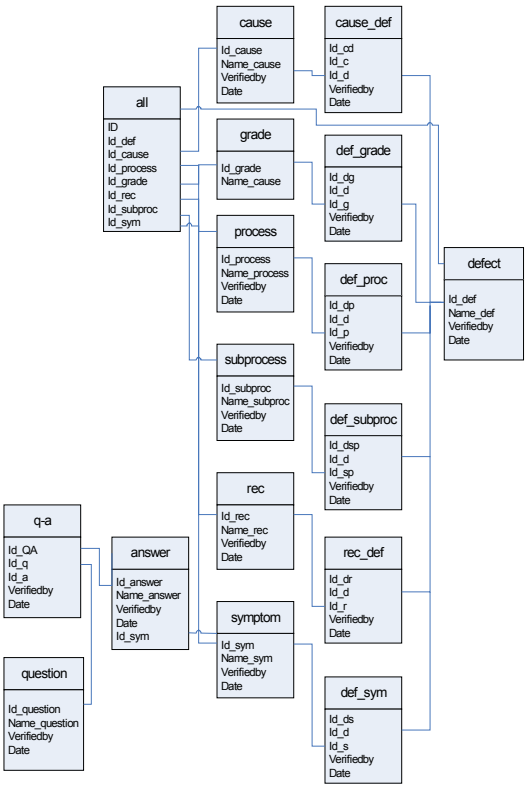

Fig. 5. Knowledge base relationships

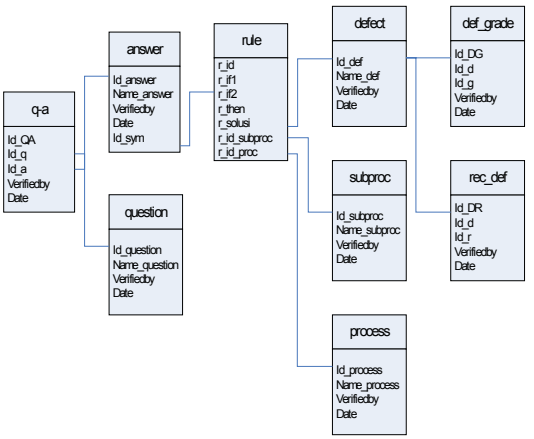

Fig. 6. Rule-based relationships

5. Conclusions

The developed prototype system demonstrated the concept that a computerized interactive system can help to diagnose product defects in tile manufacturing. As revealed in the previous section, the system starts with identifying the symptom or physical defect, tracing the probable cause of the defect, rooting the process and sub process that causes the defect, and ends with some conclusions about the defect, tile classification and recommended action to solve the problem.

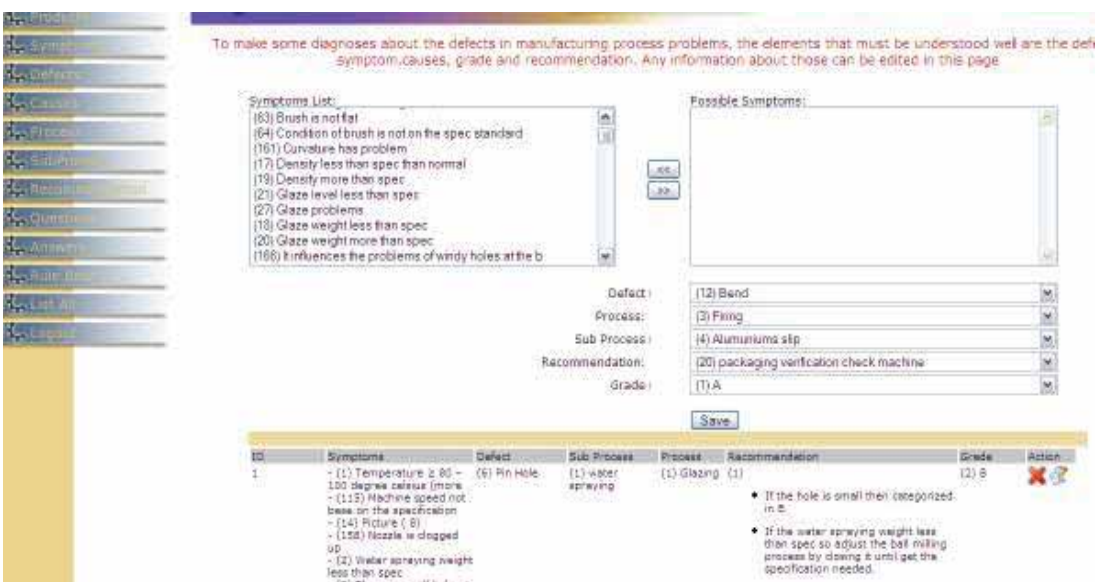

Fig. 7. The rule-based page

A critical investigation and evaluation of the prototype system conducted by the management team of the company shows that the system is able to offer the following advantages.

- The prototype system can help to diagnose product defects in a tile manufacturing firm.
- It can help to diagnose the source of tile defects.
- It leads to better knowledge sharing and application.
- It can be used to help new workers in recognizing tile defects and solving them.

Future development of the system can be conducted in one of the following areas:

- The diagnostic process in the system can be enhanced by using the artificial intelligence concept which is more focused on lingual language dialogues.
- The search mechanism in the system can be made more robust by using others concepts, such as backward chaining, combination of backward-forward chaining and matching search concept.
- Enhancing the knowledge sharing process by automatically distributing the information to the workers after the results are generated.
- Modifying the system to be more interactive to the users.

It is hoped that the system is of benefit not only to the tile industry, but also to a wide range of industries. It serves as a model for them to diagnose their product defects. With a computerized diagnostic system, companies will be able to efficiently manage their production process and increase their product quality.

Acknowledgements

The authors would like to express their appreciation to White Horse Ceramics in Johor Bahru, Malaysia and Universiti Teknologi Malaysia for their support and cooperation during the various stages of conducting this research.

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