An Expert Fault Diagnosis System for Vehicle Air Conditioning Product Development

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Abstract. The paper describes the development of the vehicle air-conditioning fault diagnosis system in automotive industries with expert system shell. The main aim of the research is to diagnose the problem of new vehicle air-conditioning system development process and select the most suitable solution to the problems. In the vehicle air-conditioning manufacturing industry, process can be very costly where an expert and experience personnel needed in certain circumstances. The expert of in the industry will retire or resign from time to time. When the expert is absent, their experience and knowledge is difficult to retrieve or lost forever. Expert system is a convenient method to replace expert. By replacing the expert with expert system, the accuracy of the processes will be increased compared to the conventional way. Therefore, the quality of product services that are produced will be finer and better. The inputs for the fault diagnosis are based on design data and experience of the engineer.

1. Introduction

Nowadays, the advancement of computer system has enabled the application of computer to solve the engineering problem such as product development problem, line balancing problem, etc. Computer system is able to support the manufacturing industry especially for the production support function. The production support system is includes the internal customers that represent the end user in terms of cost, quality and delivery. The cost is represented by the robust designs and processes, the quality represented by the ease of manufacture and the delivery is represented by the efficient of communication [1].

Expert system (ES) is a computer program that can used to represent the defined knowledge and experience of expert. ES has been used by various researchers [2-7] to solve the problem of expert absent when needed. ES has been used to diagnose the problem of the gear box of the wind turbine [2]. The ES for the gear box is able to provide a precise and shorter maintenance time. In addition, ES also used to diagnose the faulty of the EAST cryoplant [3]. The developed ES is able to ensure the safe operation of the cyroplant. For the power system, ES has been used to diagnose and assess its

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operation for error reduction [4]. Yang et al. [5] developed an expert system, namely VIBEX, to diagnose the condition of rotating machinery based on vibration approach. The developed ES is able to assist plant operator in rotating machinery diagnosis. In the similar development by Qian et al. [6], an expert system for lubricating oil condition diagnostic, namely LUBRES, has been developed. LUBRES is able to diagnose the refining process of lubricating oil. ES also can be used to select the casting processes [7].

The main objective of the development of an expert fault diagnosis system is to achieve an integrated diagnostic procedure for air-conditioning development. The research was done in a subsidiary of the largest automotive parts manufacturing group in Malaysia. The developed system is to diagnose problems in the product development process in the vehicle air-conditioning manufacturing company. The developed ES will trace the error and defect in the various phases in the development processes. The developed ES is able to shorten the product development time and increase the efficiency in the decision making process.

2. Vehicle Air Conditioners
Vehicles air-conditioning systems is the standard component for vehicles. There are 3 main components in the vehicle air-conditioning system, which is compressor, condenser and evaporator.

2.1 Compressor
The compressor is the heart of the vehicle air-conditioning system. The compressor is attached with the vehicle engine via belt to compress and transfer the refrigerant gas.

2.2 Condenser
The condenser in the vehicle air-conditioning system is used to dissipate the heat from the refrigerant gas. Normally, it is located in front of the radiator. The fan will cool the refrigerant gas by dissipate the heat. Then, the refrigerant gas will flow back to the system.

2.3 Evaporator
The evaporator is located near the dashboard of the vehicle. The evaporator is used to absorb and remove the heat in the vehicle. In addition, the evaporator also used to dehumidify the air in the vehicle.

3. Product Development
In the design methodology, the total design process as shown in Fig. Product development is a step on the quality planning road map to determine the product features required to meet the customer needs. In competitive situations, product development i should comply with the following criteria:

- Meet the need of the customers.
- Meet the needs of the supplier.
- Be competitive,
- Optimize the combined cost of the customers and supplier.

Quality planning is part of the product development activity. Product designers, quality specialists operating personnel, or some combination of personnel in all these categories, may involve in quality planning.

3.1 Air-Conditioner Development Procedures
First of all, Marketing Department will discuss with companies that are interested in developing an air conditioning system for new model vehicle about the requirement of the air conditioners. A meeting will be held as soon as possible between Marketing Department and Product Development Department for the latter to know the customer requirement. The prototype complete-built-up vehicle will be sent

for a certain period (normally one month) to allow Product Development Department to develop the air conditioning system for the vehicle. The air conditioners will be based on previous design or new design depending on the requirement. The vehicle may come in two types: i. complete original air-conditioning system, and ii. without air conditioning system. The activity of Product Development Department is shown in Figure 1.

After the air conditioning system has been developed, a complete set of drawings for each newly developed component will be prepared. Then, the vehicle will send back to the customer for testing over the newly developed air conditioning system and evaluated the proposed air conditioning system, or change some components. The engineer will issue the specification for costing. After evaluation, customer will negotiate with the Marketing Department with the price of air-conditioner and decide whether to accept the proposed air conditioning system. After that, the engineer will prepare the installation manual for the proposed air conditioning system. Lastly, the final specification will issue and production will start by Production Department.
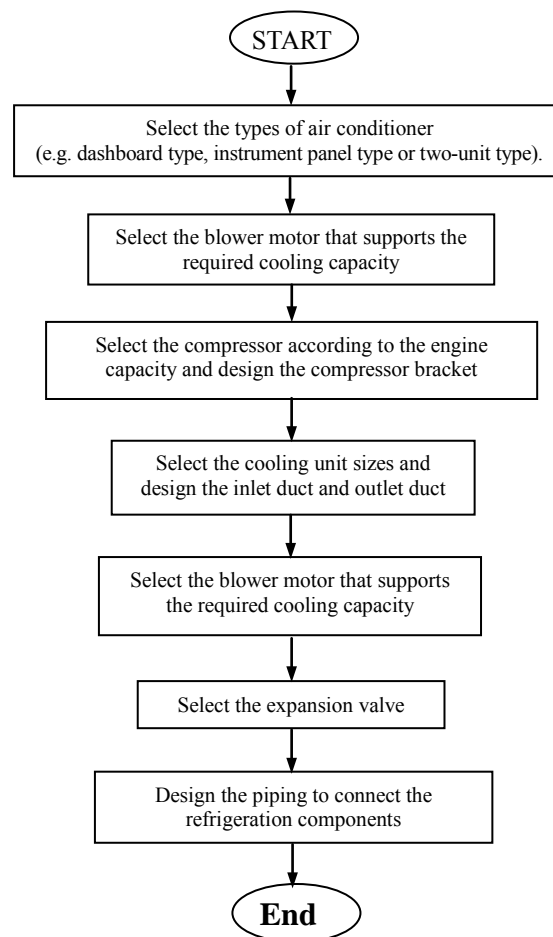

Figure 1. The activities of Product Development Department.

First of all, the Marketing Department will receive the inquiry from the customer for new product. Then the customer will send the original model, sample or drawing to Product Development Department. The executive will check whether the product drawings, specification or sample information sufficient or not. If not, PD department will collect more information from the customer.

Then, the model will be redesigned according to customer specification. The technical drawing for the model will be generated. Executive checks the drawing before it is approved by the manager.

Then, the process of generates the product development schedule & preliminary specification will be done. If the customer requires non-standard component, the component will be fabricated. If not, the sample core and piping will be made by Engineering Department. The sample will be checked by Quality Assurance Department according to the dimension in the drawing. If the sample is not in correct dimension, the checker will refer to the person who draws the drawing or executive for confirmation. If the sample is really not right condition, it has to be remake. Sample in good and right condition will be send to customer for approval. If the sample is not approved, the model will be redesign until the customer is satisfied with the sample. If the model still cannot be redesign, the order for this model will be rejected.

After the customer is satisfied and approved the sample, the final specification will be prepared and released. The Engineering Department will fabricate the jigs and fixtures according to the volume of the product. At last, the model is to be mass-produced.

4. Overall Description of the Expert Fault Diagnosis System
There are six development steps in the Rule Based Expert Fault Diagnosis System for Vehicle Air-conditioner Production System such as knowledge acquisition module, determination of user interface, define the knowledge hierarchy, programming, validating and testing of the program. The expert knowledge is heuristic and difficult to gather. All information regarding the product development processes for the vehicle air-conditioners is compiled from the manager, senior engineers, technicians and operators. Figure 2 shows the framework of the proposed system.
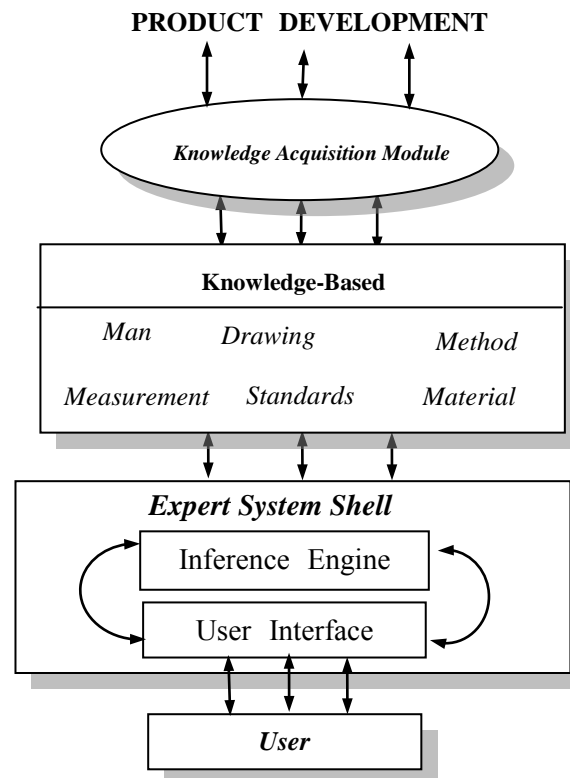

Figure 2. The framework of the developed system.

The knowledge acquisition module is used to store the information about the product development processes. An inference engine will examine the knowledge module. Next, "if-then-rules" will be applied to select the suitable solutions of the problem. The inference engine interacts with knowledge-based in backward chain method to search for right solution. The user interacts with the system

through user interface as shown in Figure 3 and Figure 4. Figure 5 shows the object browser for original market in the system.
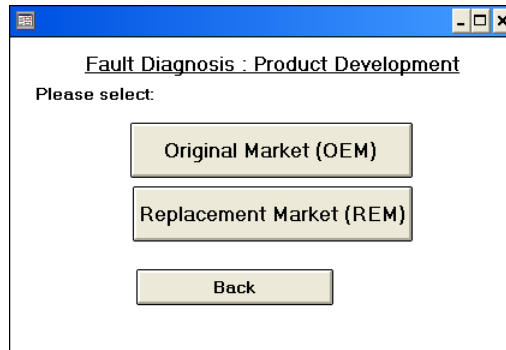

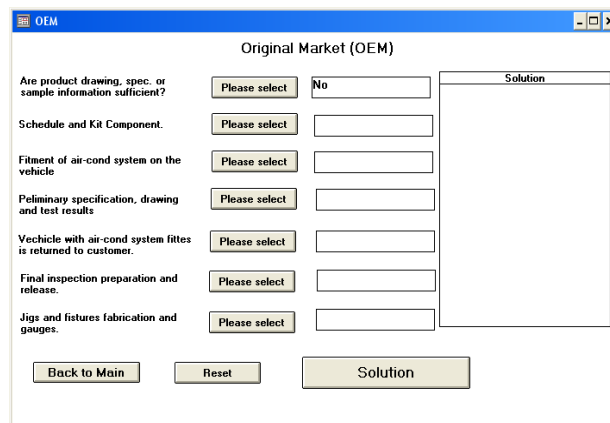**Figure 3.** The window of product development.

Figure 4. The fault diagnosis window for OEM of product development.
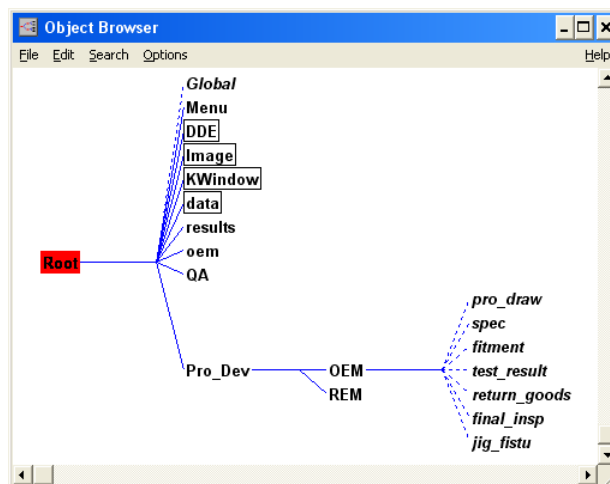

Figure 5. The object browser of the system.

4. Result and Discussion

A prototype expert fault diagnosis system for vehicle air conditioning product development process was developed and tested. The proposed system enables user to diagnose the problem in the development of vehicle air conditioning system. The developed system is able to guide the experienced and non-experienced worker in trouble-shooting the product development process. The database of the proposed system can be changed and upgraded by user easily. Currently, the proposed system interprets 21 rules before giving a solution. Lastly, a few scenarios were used to validate the program for any error. The corrective action will be taken to improve the developed program.

5. Conclusions

The developed rule-based fault diagnosis system for vehicle air-conditioning comprises a product development module. The module includes OEM and REM of the vehicle air-conditioning. In addition, the developed system includes the knowledge-based module and a user interface. The developed system is able to solve the problem of the development process of the vehicle air-conditioning. The system was developed to be flexible and modular-based where the database such as manufacturer, standards, method and materials can be upgraded to make the system more comprehensive.

6. Acknowledgment

7. References

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