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International Review of Mechanical Engineering (I.RE.M.E.), Vol. 6, N. 6
ISSN 1970-8734 September 2012

A Fault Diagnosis System for Industry Pipe Manufacturing Process

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Abstract –*It can be very costly for a process where an expert system and experience human being needed in certain circumstances. Without an expert system, his/her experience is loss where human is unavailable. This 'human replacement' process is certainly a convenient way to be applied. With the expert system, processes or tool that implemented will be standardized and accuracy will be increased comparing to the conventional way. Constrain values for the fault diagnoses are based on design data and experience of the engineer. A case study was conducted to verify the system.*

The development system helps user to find the best solution for the problems that occurred during the piping manufacturing process. The paper describes the used of expert system shell to develop piping fault diagnosis system in pipe manufacturing industries. The main aim of the research is to diagnose the problem of piping process in pipe manufacturing process.

Keywords*: Pipes, Fault diagnosis, Expert System*

I. Introduction

In modern manufacturing activities, computing is essential. With computers, various techniques suc as artificial intelligence, computer numerical control and supervisory control and data acquisition (SCADA) have been developed to assist manufacturing process. In continuing quest to decrease the time interval between conceptualization of a product and first product, information technology has been fused with manufacturing practice. The computer improves the productivity of a company and produces more cost effective products into market quickly and effectively.

Artificial intelligence (AI) is a technology that developed to ease the activities of human and human replacement in conducting a task. There is a wide scope in AI field; for instance, there are expert system (ES), fuzzy logic, neural network, genetic algorithm, etc. [1] – [8] [10]-[12].

An expert system is a computer system that comprises computerized knowledge of an expert in a particular subject domain in order to provide fast and easily accessible knowledge in a useful and practical manner. In the absence of the experts, the ES acts as a support system for the experts in an interactive way [1,2,3].

The pipe manufacturing industry, which is the domain in the expert system development for the research. Piping manufacturing process consist of many steps to produce a good finish pipes such as slitting, forming, annealing, sizing, straightening, end facing, beveling, buffing, pickling as shown in Fig. 1. The development of expert system in these piping industries is to maintain the validity of expert of this domain. To carry out this task, one of the leading pipes manufacturers in Malaysia has given a lot of guidance and essential information of piping processes. The hypothesis of this project is to ease the problem solving method in pipe manufacturing processes without human expertise and to reduce the labor cost in the particular domain.

The developed fault diagnosis systems consist of several modules such as an inference engine module, a user interface module and knowledge acquisition module. The backward chaining method is used in the development of the system. The developed system allows user to diagnose the problem in the piping manufacturing process. A user-friendly interface consisting of images, menu and buttons was achieved for providing user with easily input data to the system, and complete results. The pipe process engineers can choose the right solutions to solve the problem, reduce the time loss and improve the pipe quality during pipes manufacturing process.

II. The Manufacturing Process of Pipe

The piping processes consist of nine essential steps before any single good finished pipe is produced. Each process has to follow its sequences before proceeding to other process. The flow of the pipe manufacturing process as shown in Fig. 1.

The flowchart as in Fig. 2 illustrates the one of the actual path for the pipes in annealing process. Not all pipes have to proceed to every process and that depends on which types of pipes that use, its material of pipes and the purposes of pipes that produced.

Manuscript received August 2012, revised September 2012

II.1. Ornamental Pipes and Industrial Pipes

There are two types of pipes which known as the ornamental pipes and industrial pipes. The ornamental pipe is used for decoration purposes such as the staircase, gate, doorframe and etc. While the industrial pipes is used for construction and piping system. Both types of pipes need to undergo all the processes except for annealing, buffing and pickling.

The ornamental pipes will proceed to buffing process, but does not need to send for annealing process, while the industrial proceed to pickling processes. This is because ornamental pipes need to be buffed until there is a smooth and shinny surface where it is used for decorative purposes. While the industrial pipes need to be pickled to increase hardness and remove any carbon marks on its surface.

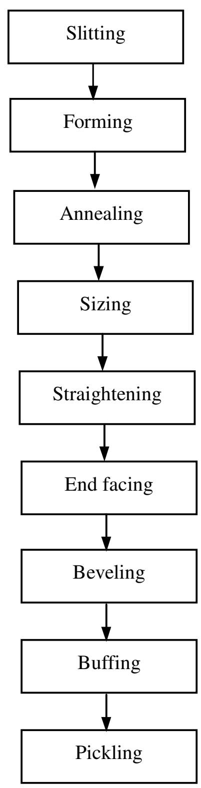

Fig. 1. The piping manufacturing process

II.2. Problems in Pipe Manufacturing Process

Each process has its own problems. The solutions for each problem in this system are used as the rule. Table 1 shows the Problems and solutions for each piping process.

III. Description of the Pipe Fault Diagnosis System

The prototype piping fault diagnosis systems involves a number of major steps. This include selection of a user interface, gathering data for each robot, choosing the selection criteria, developing the program tree structure, writing the program codes, program testing and verifying.

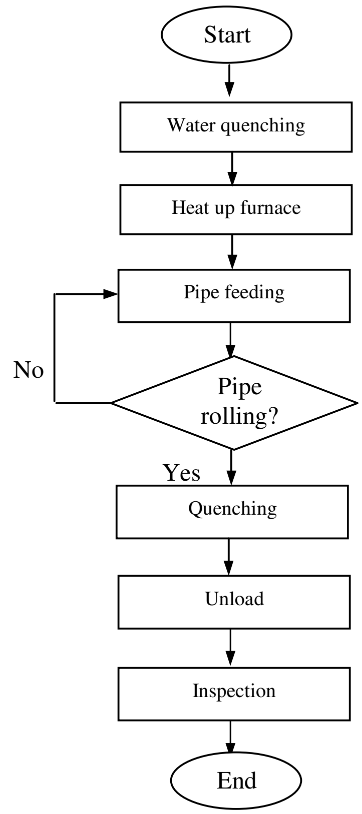

Fig. 2. The annealing process

PC-based expert system shell is being used for the prototype fault diagnosis systems [9]. The basic components of the proposed system consist of the user interface, the inference engine and the knowledge base. The general configuration of the prototype system is shown in Fig. 3.

Knowledge base is used to store all the information on the pipe manufacturing process, problems and solutions. To find the appropriate solutions to the problem, the inference engine runs through the storage by Kappa-PC tool kit applying 'if-then-rules'. The interaction between the inference engine and the knowledge base in forward reasoning mechanism gives the best possible answers. A solution is given after the program handles the user input, checks the rules and does the searching for data.

The developed software and interface consist of a main window, which is the SESSION. In the SESSION, there is nine processes to be selected. If one is encounter a problem with the process of annealing, then the annealing button should be selected. When a process button is clicked, the system will prompt to another session, which is the problem that person is encountered. For example, in the annealing process, there are two problems that maybe take into account. There are overheat and underheat. Fig. 5 shows the flows of the user interface.

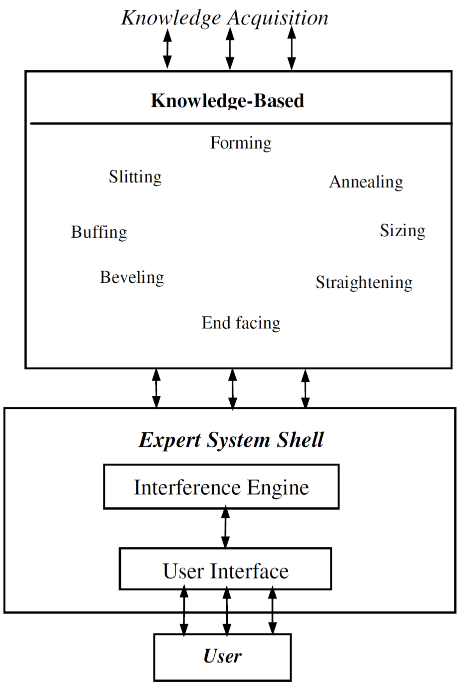

Fig. 3. The configuration of the prototype systems

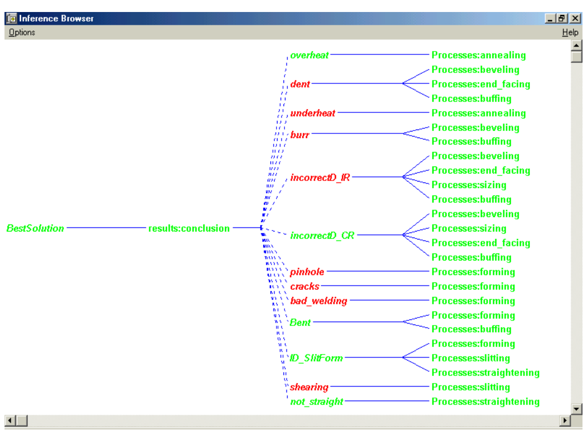

Fig. 4. Inference browser for annealing process

IV. Results and Discussion

Abbreviation and acronyms should be defined the first time they appear in the text, even after the have already been defined in the abstract. Do not use abbreviations in the title unless they are unavoidable.

A prototype fault diagnosis system for the application of industry piping was developed and tested. The problems in the piping manufacturing line can be diagnosed by the proposed system based on the process shown in Table 1. Changes and upgrades of the proposed system's database can be done by the user easily. 25 rules are being interpreted by the proposed system currently before giving an answer. All possible scenarios were tested by the program. An error message will be given by the system if there is mistake made by the user in entering the required data or answering the question. A case study was used to demonstrate the capability of the system for the validation of the proposed system.

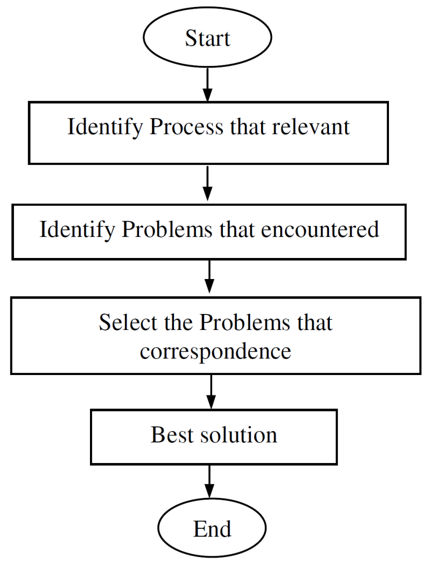

Fig. 5. The flows of the user interface

IV.1. Case Study

If there is an expert invalidity in piping process, any other individual can refer to the system to solve the problems that encountered. In this case, when the manufactured pipes are not welded in the proper way while in the Forming process, the staff or operator in charge may not know what is the main fault.

So by using the developed system, if one select the problem that is “*Bad_welding”,* then the given solution which had been developed will help the staff to overcome the particular problem they faced. As a result, the “*best solution*” is to check the welding parameters correctly and set it. The welding parameters such as the Plasma torch distance from welding pipes, the specific voltage that corresponding to pipe’s material and roller ‘s speed to ensure good welding. All these parameters are standardized and can be found in the Work Instruction Manual in the manufacturing company that is standardized. If all the steps are correctly applied, there should be no faults occurs. In case bad welding still occurs, then a human expert has to be referred. Fig. 6 shows the route and correct steps to be taken to solve the problem faced, and the session windows steps of the forming process solution showed in Fig. 7.

TABLE I
PROBLEMS AND SOLUTIONS FOR PIPE MANUFACTURING PROCESSES

Process	Problem	Solution
Slitting	Shearing	Send for strapping
	Incorrect Dimension	Knives setting
Forming	Pinhole	Welding adjustment
	Cracks	Welding and quenching adjustment
	Bad welding	Welding and quenching adjustment
	Bent pipes	Tight head settings
	Incorrect dimension	Roller settings
Annealing	Under heat	Roll the pipes during heating
	Over heat	Optimum temperature to 1050 °C
Sizing	Incorrect dimension (if rectify)	Roller settings
	Incorrect dimension (can't rectify)	To quarantine area
Straightening	Not straight	Roller linearity
	Incorrect dimension	To temporary storage
End facing	Incorrect dimension (if rectify)	To temporary storage
	Incorrect dimension (can't rectify)	To quarantine area
	Dent	Send to cutting
Beveling	Burr	Send to hammering
	Dent	Send to cutting
	Incorrect dimension (if rectify)	Send to temporary storage
	Incorrect dimension (can't rectify)	Send to quarantine area
Buffing	Burr	End and surface grinding
	Bent	Manual straightening
	Dent	Send to cutting
	Incorrect dimension (if rectify)	Send to forming section
	Incorrect dimension (can't rectify)	Send to quarantine area

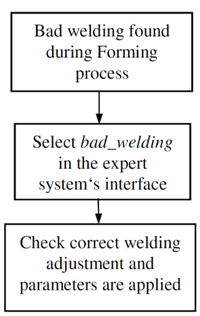

Fig. 6. Solution to "bad welding"

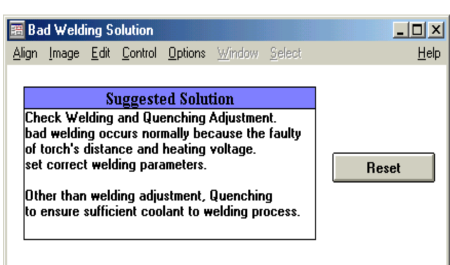

Fig. 7. The solution of "*bad welding*"

Through case study, it shows that the developed system can help an individual when there is no expert in that particular domain to solve any problem that arises. The results show that the correct way and best solution to user to overcome the problem encountered that relevant to the process involved.

V. Conclusion

An object-oriented and rule-based prototype piping fault diagnosis system has been developed. The developed system comprises a fault diagnosis module, a knowledge-based system and a user interface. A major achievement of this system is that it allows user to find the best solution for the problems that occurred during the piping manufacturing process. The prototype system was based on one of local pipe manufacturing industry experience. The system was flexible and modular type where the pipes specification, manufacturing process and pipes parameters can be upgraded to make the system more comprehensive.

Manuscript received August 2012, revised September 2012

Aknowledgements

The author gratefully acknowledges the support of the Faculty of Mechanical Engineering and Centre of Research and Innovation Management (CRIM) of Universiti Teknikal Malaysia Melaka (UTeM) for the support.

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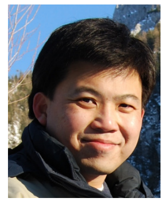

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