

## A Rule-Based Industrial Boiler Selection System

**C F Tan<sup>1</sup>, S N Khalil<sup>2</sup>, J Karjanto<sup>3</sup>, B T Tee<sup>4</sup>, L S Wahidin<sup>5</sup>, W Chen<sup>6</sup>, G W M Rauterberg<sup>7</sup>, S Sivarao<sup>8</sup> and T L Lim<sup>9</sup>**

<sup>1,2,3,4,5,8</sup>Centre for Advanced Research on Energy (CARE)

Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka  
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

<sup>6,7</sup>Designed Intelligence Group

Department of Industrial Design, Eindhoven University of Technology  
Eindhoven, the Netherlands

<sup>9</sup>Intellogic Technology Private Limited

Puchong, Malaysia

E-mail: cheefai@utem.edu.my

**Abstract.** Boiler is a device used for generating the steam for power generation, process use or heating, and hot water for heating purposes. Steam boiler consists of the containing vessel and convection heating surfaces only, whereas a steam generator covers the whole unit, encompassing water wall tubes, super heaters, air heaters and economizers. The selection of the boiler is very important to the industry for conducting the operation system successfully. The selection criteria are based on rule based expert system and multi-criteria weighted average method. The developed system consists of Knowledge Acquisition Module, Boiler Selection Module, User Interface Module and Help Module. The system capable of selecting the suitable boiler based on criteria weighted. The main benefits from using the system is to reduce the complexity in the decision making for selecting the most appropriate boiler to palm oil process plant.

### 1. Introduction

There are various types of boiler with different specification, fuel base, construction and capacity. Different industries need a specific boiler in order to manufacture its products. In other words, boiler selection is based on the product that is being manufactured. There may be many criteria that can be considered when selecting a boiler to meet the application needs. Some of the criteria are i) steam capacity of boilers, ii) steam pressure of boilers, iii) boiler efficiency, iv) type of fuel, v) weight of boiler, and vi) volume of water.

Currently boiler selection is a manual process in order to fulfil the requirements heat production for a specific product. It is a time consuming and costly affair to determine the specification and requirements of an industry boiler. Boiler specification and selection is very important to produce a good and high quality product. In some cases, some boilers is not able to achieve the optimum

---

<sup>1</sup> To whom any correspondence should be addressed.



efficiency because the failure to diagnose the criteria needed for boiler due to the lack of knowledge. Boiler that does not fully utilize in capacity or problematic is detrimental to the environment. The Expert System is a technique that can help to improve industry boiler selection by providing guidelines for the optimum boiler selection. By using expert system, the experienced person who is not familiar in determining the type of boiler that is needed for a specific industry is able to gain information and knowledge correctly to select the appropriate industry boiler.

Expert system has been used in different applications, such as selection, diagnosis, gaming and feature recognition. Arezoo et al. [1] demonstrated the used of expert system to select the cutting tools and conditions of turning operation. In addition, an expert system for turning and rotating tool selection also developed by Moorkherjee and Bhattacharyya [2]. The aim of the work was to select the most suitable material for the automotive engine components. Another work by Massod and Soo [3] used rule based expert system to select the rapid prototyping. The input for the developed expert system is the commercial available rapid prototyping systems in the market. Chu and Lin [4] developed a fuzzy method for robot selection. It uses various rating alternatives verses subjective criteria and the weights of all criteria are assessed in linguistic terms represented by fuzzy numbers. Work by Chan et al. [5] used expert system to select the material handling equipment selection.

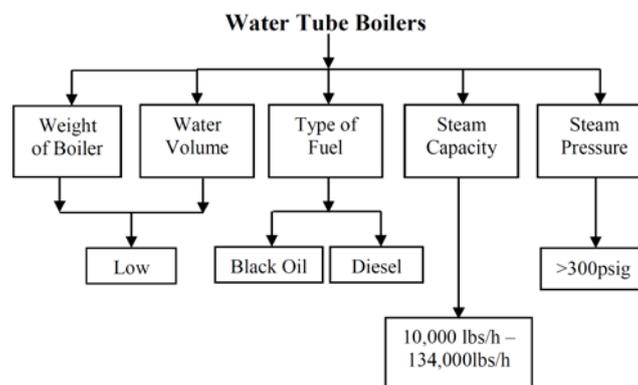
This paper describes the development of rule based expert system to select the industrial boiler for palm oil process industry. The system involves the user providing answers to specific questions or entering the required data. The system uses rule based and multi-criteria weighted average method (MCWA) [6] as the decision-making approach. Recommendations and suggestions of the suitable boiler based on input requirement are displayed on the screen at the end of the program.

## 2. Methodology

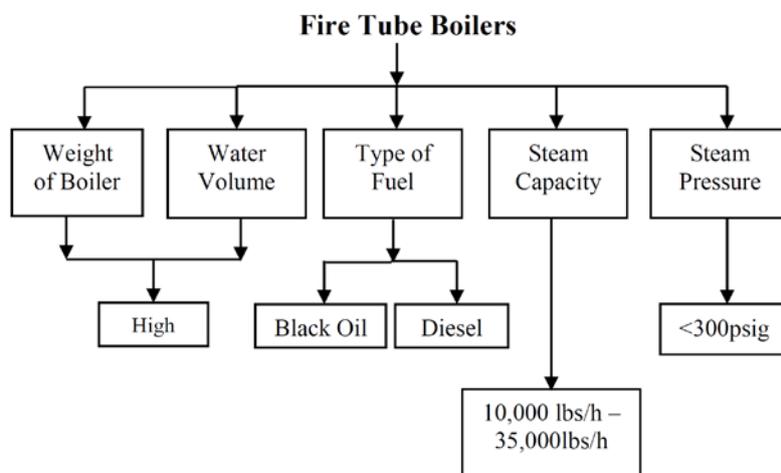
The expert systems are well-known and widespread applications of artificial intelligent research. There are many methods of expert system developing, but these different methods can be applied efficiently in large, commercial development projects. During our researches a new development process was created, which can be used in experimental projects for rapid development of small, prototype expert systems, considering special characteristics of applied expert system shells namely Kappa PC. The Kappa-PC expert system is a hybrid PC tool that combines critical technologies essential to the rapid development of low-cost and high-impact business applications [1].

### 2.1 Knowledge Acquisition Module

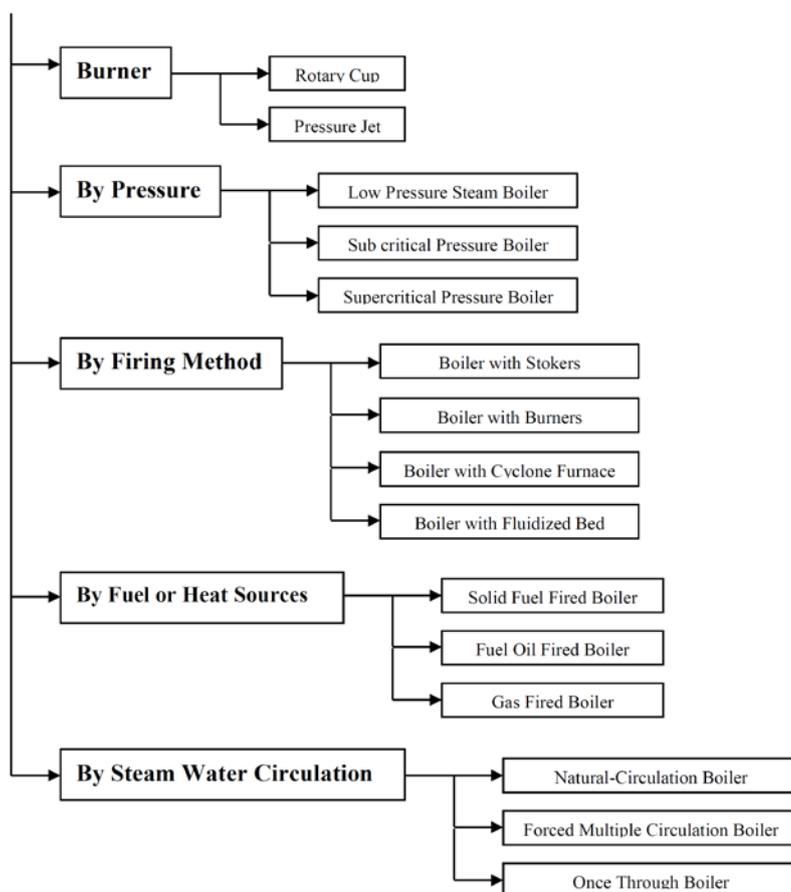
The knowledge for the developed system was gathered from the guidelines, specification, operators, technician and engineers. The specification of the water tube boiler (Figure 1) consists of the weight of boiler, water volume, fuel type, steam capacity and steam pressure. The fire tube boiler as shown in Figure 2 consists of the different specification from the water tube boiler. The general specification of the industry boiler is shown in the Figure 3.



**Figure 1.** The water tube boiler specification.



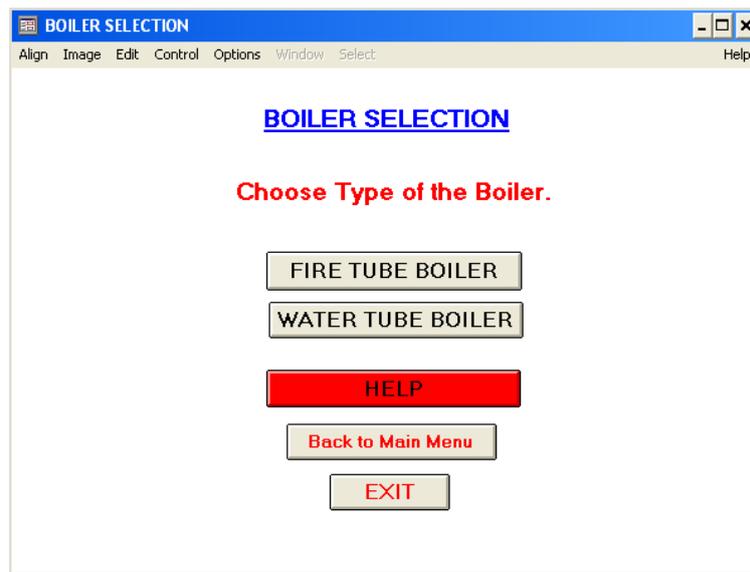
**Figure 2.** The fire tube boiler specification.



**Figure 3.** The overall boiler specification.

## 2.2 Boiler Selection Module

Grouping the detail of machines into the database is the next step in the methodology of development of boiler selection system (Figure 4). Since different machine manufacturers use different terms in describing the machine parameters, the development of the database needs more effort to recognize the same parameters.



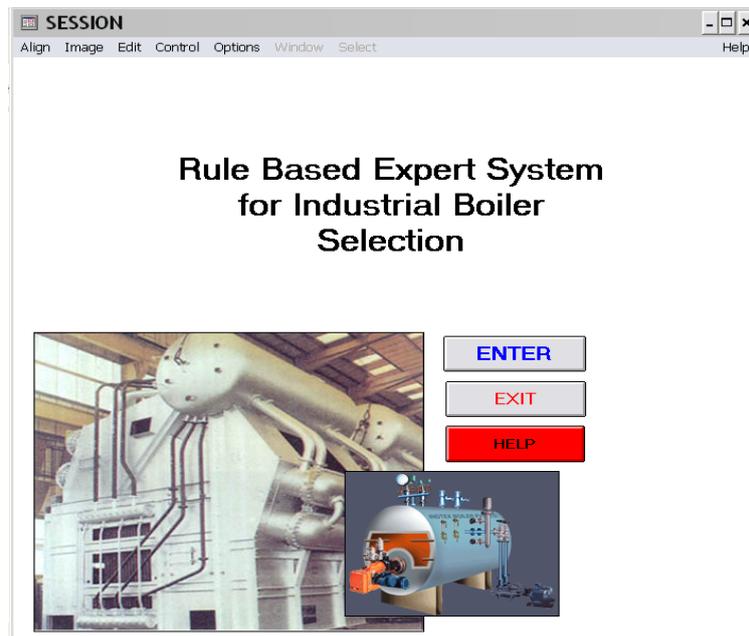
**Figure 4.** The boiler selection window.

The domain of rule-based expert system consists of frames or objects. The objects can be classes or instances within classes [13]. The relationship between the objects is linked together by a tree hierarchy. Information related to machine tool manufacturer are represented as objects, and machine tool types are classes. Slot represents important properties of an object or class. The characteristics or specification of machine tools such as number of axis, programming language, number of tool holder are defined as slot in KAPPA-PC.

This system uses rule-based with “IF-THEN” rules and multi-criteria weighted average method (MCWA) is used as the decision-making approach in forward chaining principle. Each turning machine tool in the database is assigned a score according to its properties in relation to the data input. After this, the system will rank the turning machine based on the input scores by the user. The machines are ranked using Multi-Criteria Decision Making (MCDM) Method where the ranking is from best to worst using machine specifications and criteria weights. The alternatives are weighted average and hierarchy tree is used for the selection process.

## 2.3 User Interface Module

Another important step in the development of expert system is the designing of the user interface. The user interface windows are linked to one another by using functions. A user-friendly interface is created using button, text images and bitmaps. A session window, which is the basic components of KAPPA-PC interface is used to create application interface. Figure 5 shows the main user interface developed in this system.



**Figure 5.** Main menu.

### 2.3 Help Module

User's guide and some extra information are also included in the system. This system provides machinability calculation to assist the user in determining some machining parameters for particular machine tools.

### 3. Conclusion

A rule-based expert system for boiler selection has been developed. The system uses rule based and multi-criteria weighted average method (MCWA) as the decision-making approach. Recommendations and suggestions are displayed on the screen at the end of the program. Furthermore, on line help facilities are also include in the system. Currently the database in the system is not exhaustive for all applications. Nevertheless, it does illustrate the basic concept in developing an expert system for boiler selection. One of the capability and potential of this system is to become a useful tool for mechanical engineer in chemical process industries.

### 4. Acknowledgment

Special thanks to the Centre of Research and Innovation Management and Faculty of Mechanical Engineering for the support.

### 5. References

- [1] Arezoo B Ridgway K & Al-Ahmalim A 2000 Selection of cutting tools and conditions of machining operations using expert system *Computers in Industry* **42** 43-58
- [2] Moorkherjee R & Bhattacharyya B 2001 Development of an Expert System for Turning and Rotating Tool Selection in a Dynamic Environment *Journals of Materials Processing Technology* **113** 306-311
- [4] Massod S H & Soo A 2002 A rule based expert system for rapid prototyping system selection *Robotics and Computer Integrated Manufacturing* **18** 267-274
- [5] Chu C T & Lin Y C 2003 A Fuzzy TOPSIS Method for Robot Selection *The International Journal of Advanced Manufacturing Technology* **21** 284-290

- [6] Chan I P & Lau 2001 Integration of expert system with analytic hierarchy process for the design of material handling equipment selection system *Journal of Materials Processing Technology* **116** 137-145