UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF AN EXPERT SYSTEM FOR MECHANICAL DESIGN OF PRESSURE VESSELS

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ABSTRACT

An expert system for mechanical design of a pressure vessel, known as **DePV**, was developed in this study. Expert system is a branch of Artificial Intelligence that can replace the role of human expert in form of knowledge based system. There are two methods involved, namely object – oriented programming and rule based programming. Object - oriented programming is a composition of data structure which is called an object. While, rule based programming comprises forward and backward chaining. **KAPPA PC®** expert system shell is used as a tool to develop this prototype software. It supports the conceptual mechanical design procedure as stipulated in the American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Design Code: Division 1 from the initial to final design stages. For stress analysis purposes, British Standard (BS5500) Design Code is chosen over ASME because design approach is simple and can obtain accuracy of the results. The expert system methodology used facilitates the development of **DePV** which consists of knowledge acquisition, knowledge based construction and prototype implementation. The study rationalized the design procedure and the factors affecting the pressure vessel design such as the design pressure (either internal or external), temperature, shell thickness, selection of materials of construction, stress analysis procedure, its supports and ancillary items. The hierarchy of the mechanical design was developed in the form of a schematic flow diagram. The data for process designs, formulation and case studies were first input into **DePV**. One can then obtain information and results on which series of design units will be calculated, selection of design pressure for vessel will be considered as well as for the stress analysis. The realization of this study will improve the database design of the pressure vessel system for petrochemical industries. **DePV** is a rich – database, user friendly system integrating mechanical design of a pressure vessel calculation and minimizing the design technique in the form of software package. A case study from the existing chemical plant, i.e Brundrett & Liu (2002) and Company X (2006) was applied in **DePV** interpretation in which the pressure vessel was filled with water as its content. The vertical orientation vessel with cylindrical shape, selection materials of carbon steel and stainless steel (Type 316 and 304) are also incorporated in **DePV**. The head type selection is also determined by **DePV**. It can be in the form of circular flat head or domed head. Some types of domed head are ellipsoidal, torispherical, hemispherical, conical and toriconical. Skirt support is recommended in this study due to its vertical orientation. The prototype software is run and validated using the pressure vessel with water content. It is found that the minimum required thickness is 0.231 in (5.867 mm); the analyses for circumferential and longitudinal stresses are found to be 68331 kN/m^2 (9910.63 psi) and 136663 kN/m^2 (19821.26 psi), respectively.

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CHAPTER 1

INTRODUCTION

The chapter introduces the background and rationale for the study. It also highlights details of the objectives, significance and research outlines in terms of expert system development for mechanical design of a pressure vessel (**DePV**).

1.1 Background

Throughout the world, the use of process equipment has expanded considerably. Pressure vessel is one type of the process equipment. They are used in a wide variety of industries such as petroleum refining, chemical, power, pharmaceutical, food and beverage (Carucci, 1999). Thus, the petrochemical industry makes the greatest use of pressure vessels. This type of the process equipment can be heat exchangers, impregnators (which may be subject to both pressure and vacuum), vacuum drying stills and others. Pressure vessel is subject to either internal or external pressure (Pilborough, 1971). It can be defined as a container with a pressure differential between inside and outside pressure. The inside pressure is usually higher than the outside, except for some isolated situations. The fluid inside the vessel may undergo a change in its state as in the case of a chemical reactor. Normally, pressure vessels have a combination of high pressure together with high temperatures, and in some cases flammable fluids or highly radioactive materials. Because of such hazards it is imperative that the design be such that no leakage can occur. Thus, these vessels have to be designed carefully to satisfy the operating temperature and pressure requirement. In certain condition, pressure vessels are used in a number of industries such as in the power generation industry for fossil and