SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of
Bachelor of Mechanical Engineering (Plant and Maintenance)"

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DESIGN OPTIMIZATION OF SADDLE SUPPORT FOR HIGH CAPACITY PRESSURE VESSEL

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A thesis submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Mechanical Engineering (Plant & Maintenance)

Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

JUNE 2015

DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature: ....
Author: ....
Date: ....

Praised to Allah the almighty and to my beloved Father and Mother,

And my beloved siblings and friends

ACKNOWLEDGEMENT

I would like to convey my appreciation and highest gratitude to those who has been helpful to me on completion of this project and bring it to success in respect with constructive advice and realistic solution.

In this golden opportunity also I would like to express my millions of thanks to my supervisor, Dr. Haryanti Samekto for her kindly advice and guidance during the project.

Special thanks to my friends for being always lend me a helping hand during conducting this project. Thanks extended to FKM lecturer especially in the department of Plant and Maintenance who had provided technical help and assistance throughout the project.

Lastly I would like to thank my family, who has been the loveliest advisor to give continually support and inspiration throughout my campus life. With this my sincere and genial thanks to everyone I have not mentioned above from the bottom of my heart.

ABSTRACT

Saddle support is used to hold a horizontal high pressure vessel on its desired location. Fabrication of saddle support regularly by referring to the existed code and standard that is contained in code of ASME Code of Section (VII), Division 1 and Division 2 (Boiler and Pressure Vessel Code). This project will presented the optimization of structure of saddle support for a horizontal pressure vessel used in upstream operation and thus search for the saddle requirement in order to enhance its factor of safety. First, the existence design of saddle is gathered from the local industrial site. Finite element analysis method (FEM) is used to analyze the design. The 3D model of saddle is constructed using SOLIDWORKS 2013 software. A result of analysis is then obtained after meshing the model in the software by using ANSYS 15 and tested for static and cyclic loading condition. During the static loading analysis, the factor of safety was reduced from 1.26 to 3.64 after optimization was made to the original design based on von mises criterion. In cyclic loading analysis, once again the optimized design from static loading analysis showed high factor of safety that is 3.20 compare to the original design tested for cyclic loading factor of safety, 0.41 based on modified Goodman fatigue criterion. Cyclic loading simulation analysis predicted that the life of original design of saddle support was about 5.7 years after subjected to cyclic load. Optimized design develops before in the static loading analysis lives were predicted to be 456.6 years which is increased about 801% of its original design. It is proven that the optimized design can embrace the load by referring to this factor. However, this prediction was not cover the effect of vibration, corrosion and thermal condition of pressure vessel.

ABSTRAK

Sokongan pelana biasanya digunakan untuk menyokong tanki tekanan tinggi pada kedudukannya. Kebiasaannya sokongan pelana difabrikasi dengan merujuk kepada *ASME Code of Section (VII), Division 1 and Division 2(Boiler and Pressure Vessel Code).* Projek ini akan membentangkan pengoptimuman struktur pelana sokongan tangki tekanan tinggi jenis mendatar dan meningkatkan factor keselamatannya. Langkah pertama adalah untuk mendapatkan rekabentuk sokongan pelana sokongan yang sedia ada digunakan di kilang tempatan. Kaedah Unsur Terhingga digunakan untuk dalam kajian ini. Kaedah ini digunakan kerana berkelebihan untuk menyelesaikan dan menganalisa struktur struktur yang kompleks. Model 3D sokongan pelana dibina menggunakan perisian SOLIDWORKS 2013. Keputusan analisis kemudian diperoleh setelah mesh dilaksanakan ke atas model menggunakan perisian ANSYS 15 dan kajian bebanan statik dan bebanan kitaran. Semasa analisis beba statik dijalankan berjaya meningkatkan faktor keselamatan dari 1.26 kepada 3.64 selepas pembaikan dibuat ke atas model asal berdasarkan kriteria von mises. Dalam analisi bebanan kitaran pula, model yang diperbaikan menunjukkan peningkatan pada faktor keselamatan iaitu kepada 3.20 dan model asal hanya 0.41 berdasarkan kriteria Goodman. Analisis bebanan kitaran menunjukkan hayat asal sokongan pelana adalah 5.7 tahun dan berjaya di tingkatkan kepada 456.6 tahun. Peningkatan sebanyak 801%. Ini membuktikan pembaikan kepada model asal telah berjaya tetapi jangkaan ini hanyalah berdasarkan faktor beban mekanikal dan tidak merangkumi getaran, karat dan kondisi termal *pressure vessel*.

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NOMENCLATURES

W_W	Width of wear plate
b	Width of rib
$W_b\ Side$	Thickness of side rib
$W_b\ \ Base$	Thickness of base plate
$W_b\ In$	Thickness of intermediate rib
T_w	Thickness of wear plate

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CHAPTER 1

INTRODUCTION

1.1 Background

Pressure vessels are widely used in petroleum refining, chemical industry, power industry or pharmaceutical industry. The purpose is to store high pressure chemical in form of fluid or gas. Pressure vessels are of vertical and horizontal type. It is designed to stand high pressure from internal or external of the vessel itself. Commonly the fabrication of saddle support for pressure vessel are referring to the present standard and no studies such as finite element analysis is carried out to define the strength of the design. This project will focusing on the study of saddle support to search its requirement plus optimize the available saddle support design to increase the safety factor by using finite element method. Finite element analysis is the one of preferred tool among researcher to study and analyse complex structure that almost impossible to be solve manually. A proper design of saddle support could improve safety and facilitate to operate at higher pressure which might leads to higher efficiency (Pallavi et al, 2013).

1.2 Problem Statement

The fabrication of saddle support usually did not going through any analysis in fact only referring to the existence manuals and standards. The design of saddle support requires more attention to several parts such as metal thickness and joint to ensure it is safe to operate for a long period and allow the pressure vessel operate in its highest safety.

1.3 Objectives

The objectives of this project are to:

i. To search the requirement and standard of high capacity pressure vessel and increase its safety factor.
ii. To produce 3D model geometry of the saddle support
iii. To conduct finite element analysis for design optimization under static and cyclic loading

1.4 Scope of Study

The scope of this project is:

1. Research not considering corrosion, thermal condition or vibration.
2. Optimization is carried out for saddle support only.
3. For fatigue analysis, cyclic loading will be applied according to the operation condition.

1.5 Report Organization

This report will describe the process of analysis in determining the requirement of saddle support used by high pressure vessels that really exist in industrial. The report is divided into five chapters. Chapter one enlightens the purpose of doing this project and provides general explanation on the subject matter. In chapter two all the publish information is described and summarize in sequence include discussing the previous studies. Next chapter, chapter three describe the method used in conducting the research. Within this case, finite element method is selected and modelling software (Solidworks 2013) is used to analyse the data. All the results is collected and evaluated in chapter four. The discussion of result obtained by the studies is described in chapter five. Nevertheless, the conclusion and recommendation is compiled in chapter six.

CHAPTER 2

LITERATURE REVIEW

2.1 Saddle Support

Saddle support is common support used for horizontal pressure vessel. It is usually connected with pressure vessel by welded on the surface of the cylindrical vessel. Saddle support is usually placed on foundation such as cement foundation or attached on rig. For the offshore used, the main problem of the saddle support is it always exposed to acidic environment such as sea water which will cause serious corrosion problem and besides, it is also harmed by vibration generated by other equipment from its surrounding and much more from ocean waves. But not to focus on the corrosion and vibration problem, the design method itself could not give the saddle support a longer life span. To design a saddle support it is important to consider the location where it should support the vessel efficiently without causing any failure [1]. The distribution of stress along the saddle needs to be thorough. In almost design, there will be two saddle support supporting pressure vessel and one will be left to move freely and not fasten to the foundation or fix in its location. This is to reduce the stress exerted on it mostly cause by the change of temperature of the material due to chemical inside or any external source such as heat from sun. Best design of saddle support could smooth the operation and reduces the operating cost of pressure vessel by reducing the maintenance cost.

2.1.1 Type of Saddle Support

Saddle support is used by horizontal pressure vessel. It is typically supporting at two locations underneath the vessel and one of it is attached to the foundation using foundation bolts. This is to prevent an excessive stress on the support and shell when the material of vessel undergoes deformation due to thermal expansion.

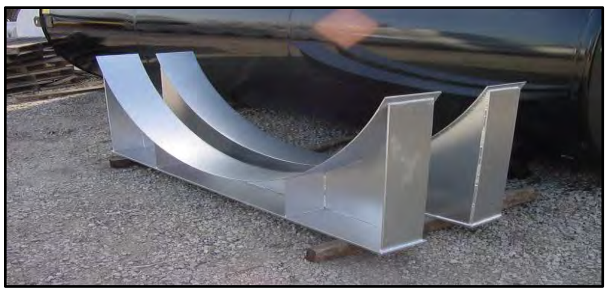

Figure 2.1: Horizontal Saddle Support [11]

Leg support is a small vertical drum support on leg that welded onto the lower portion of the shell. It can be used by all type of vessel. Number of leg is depending on the load to be carried. Cross bracing is added to the leg to absorb wind or earthquake loads.

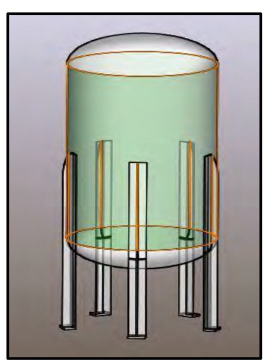

Figure 2.2: Leg Support Attach at the Bottom of Horizontal Pressure Vessel

2.2 Pressure Vessel

Pressure vessel is storage or a separation tank used to separate oil, gas and water. It is commonly used in oil and gas industry, and chemical industry. According to Aditya, usually the design of vessel will coat the surfaces of vessel to avoid direct contact with reactive fluid in it [1]. Direct contact of reactive material in the vessel and the vessel's material could change its material properties. The design of pressure vessel is regularly by referring to the existing manual such as ASME Code Section (VII), Division 1 and Division 2 [1]. The operations of pressure vessel always have different pressure and temperature from ambient pressure and temperature. That situation makes it experience cyclic pressure and thermal. This circumstance will affect the life of saddle support.

2.2.1 Type of Pressure Vessel

A. Horizontal Pressure Vessel

Horizontal vessel is normally used as storage, separation tank or settling drum. Settling drum is used to particulate settles to form a deposit on to the bottom of the liquid. Horizontal pressure vessel is the best design to be applied the method. Size of this vessel is depending on the usage and the volume required by the industry. Large vessel can be as large as 84 inches in diameter and length about 30 feet long. Commonly used elliptical ratio is 2:1.

Figure 2.3: Horizontal High Pressure Vessels [9].

B. Vertical Pressure Vessel

Vertical vessel regularly used as a surge drum or a knock out drum. As a surge drum, it acts as an absorber that maintaining the flowrate of the liquid out of the vessel regardless of flowrate into it. Meanwhile when it is used as a knock out drum, a flow of mixture of a gas and liquid into the vessel is separated into a gas and liquid component as there is a compartment in the vessel. As the act of the gravity, gas with less density flow out through top of the vessel while the higher density liquid is flow out at the bottom of the vessel. The design of this vessel is regularly using elliptical ratio of 3:1.

Figure 2.4: Vertical High Pressure Vessels [7]

C. Spherical Pressure Vessel

A sphere is the optimal geometry and most efficient structural shape for a pressure vessel. This is because of this shape is easy to fabricate and transported.

Figure 2.5: Spherical High Pressure Vessels [7].

2.3 Material for Saddle Support

Range of steel used in the fabrication of saddle support is ASTM A516. This steel commonly used in oil and gas, chemical and power generation industry. It is tested to exceed the specified requirement. This material is good machinability and forming capabilities. It can withstand bigger tensile and able to operate even in lower service temperature.