DESIGN AND ANALYSIS OF JACKING POINT STRUCTURE TO LIFT HEAVY-WEIGHT CRUDE OIL TANK FOR ANNULAR PLATE MAINTENANCE

NORHAZREEL SAIFULLAH BIN BAHARIN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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 (Automotive)"

Signature: ……

Supervisor: FEBRIAN BIN IDRAL

Date: ……

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NORHAZREEL SAIFULLAH BIN BAHARIN

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DECLARATION

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

Signature: ……

Author: NORHAZREEL SAIFULLAH BIN BAHARIN

Date: ……

I would like to dedicate my thesis to my beloved parents

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First of all, praise is to Allah for protecting us in whatever activity that we had done. I would like to express my full appreciation to all those who always supporting me to complete this report.

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ABSTRACT

The study objective is to design the support component in the jacking process which named jacking point structure. The jacking point structure will act as a mounting point for jacking device to lifting heavy-weight crude oil tank structure. The jacking point structure was designed to comply with codes of practice and design guide such as American Society of Civil Engineers (ASCE), American Institute of Steel Construction (AISC), American Society for Testing and Materials (ASTM) and American Petroleum Institute (API). Engineering analysis on the design of the jacking point structure is a crucial step on this project report to explain the best concept of jacking point structure which satisfies the desired criteria and specification. The finite element analysis was performed and as the result, the best concept design and its configuration were came out to fulfill the requirement in this jacking operation. The analysis results show that the jacking operation is safe to be conducted by using the designed jacking point structures.

ABSTRAK

Objektif kajian dijalankan adalah untuk mereka bentuk satu komponen sokongan di dalam proses jek yang diberi nama struktur titik jek. Struktur titik jek akan bertindak sebagai titik lokasi pemasangan untuk mesin dan alatan jek bagi proses menaikkan struktur tangki minyak mentah. Struktur titik jek telah direka bentuk dengan mematuhi kod piawaian dan panduan seperti American Society of Civil Engineers (ASCE), American Institute of Steel Construction (AISC), American Society for Testing and Materials (ASTM) dan American Petroleum Institute (API). Analisis kejuruteraan ke atas reka bentuk struktur titik jek merupakan satu proses penting di dalam laporan projek untuk menerangkan konsep struktur titik jek terbaik yang mematuhi kriteria dan spesifikasi seperti yang diinginkan. Hasil daripada analisis menunjukkan bahawa proses jek dapat dijalankan dengan selamat dengan menggunakan struktur titik jek yang telah direka.

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LIST OF SYMBOLS

q_z	=	Velocity Pressure, N/m^2
K_z	=	Velocity Pressure Exposure Coefficient
K_{zt}	=	Topographic Factor
K_d	=	Wind Directionality Factor
V	=	Wind Gust Speed, m/s
P	=	Pressure, N/m^2
A_f	=	Frontal Area, m^2
G	=	Gust Effect Factor
C_f	=	Force Coefficient

LIST OF ABBREVIATION

ASCE	American Society of Civil Engineers
AISC	American Institute of Steel Construction
ASTM	American Society for Testing and Materials
API	American Petroleum Institute
CATIA	Computer Aided Three-dimensional Interactive Application
FEA	Finite Element Analysis

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

The crude oil tank is a large structure built to store crude oil after drilling process. The content is stored in this tank before undergoing a distillation process to separate the hydrocarbon type such as petroleum, gas, naphtha, gasoline, kerosene, diesel, lubricating oil, heavy gas and the residues. In this project, one of the crude oil tank is located in Port Dickson, Malaysia which owned by Petron Malaysia Berhad. It is a floating roof type of storage tank built in 1962 which able to store up to 34 million liter crude oil. After 5 decades of service, maintenance project is proposed to service the annular plate of the tank which is located at the bottom. The tank structure needs to be lifted up for the maintenance process on the ground structure. However, there are no jacking points attached at the tank for jacking device installation.

1.2 PROJECT OBJECTIVES

The objectives of this study are:

- To design jacking point structure and its configuration for crude oil tank jacking operation.
- To perform structural analysis of the jacking point structure and the crude oil tank model during jacking operation.

1.3 PROJECT SCOPES

- Literature review on the engineering requirement for jacking operation, designing process and structural analysis of jacking members.
- Conceptual design of jacking point structure.
- Selection of conceptual design by using Weighted Decision Matrix Method.
- Detail design of the jacking point structure and perform structural analysis using CATIA V5 R20 software for crude oil tank jacking process.
- Selection of final design based on required criteria such as simple and safe design.

1.4 PROBLEM STATEMENT

Crude oil was an initial substance before undergoing a distillation process to produce useful fuel such as petroleum gas, gasoline and so on. Due to its long period of service for the storage tank, the changes in ground structure which annular plate has been detected under the tank's body. The change and ground structure effect can caused damage on the tank structure. The concerns of this defect will cause a major problem such as the damage on the tank's shell due to the tilt condition of the tank structure.

In order to overcome this problem, an improvement project was proposed to do maintenance on the tank's basement. The solution is to make replacement of the tank's baseplate or annular plate which is at the bottom of the tank. Four hydraulic jacking devices as additional tools were used to lift the empty crude oil tank so that the replacement process can be done. The main problem occurred due to conducting this project is the method to provide a platform for the jacking device so that the jacking load can be transferred to the tank for lifting process. This jacking point structure is a temporary supporting structure that will attach to the tank's wall for the use during the jacking operation and need to replace at the end of this project. Designing and analysis of the concept of the jacking point structure was the main purpose of this project. The structural analysis of the design is important for

optimization due to reduce the cost of installation and fabrication by only selecting the best design following specifications required.

1.5 METHODOLOGY VIEW

At the beginning, the entire project requirement to design a jacking point structure for crude oil tank jacking operation was studied such as structural materials, Code of Practice and Design Guide such as American Society of Civil Engineers (ASCE), American Institute of Steel Construction (AISC), American Society for Testing and Materials (ASTM) and American Petroleum Institute (API). All this specification should be followed because the standard and regulation was stated for the safety precaution purpose. The design specifications of the crude oil tank such as tank plate thickness, tank wall perimeter, tank mass and the maximum weight. Furthermore, the material for the jacking point structure was defined based on the parameters and criteria of the tank. Five conceptual designs of the jacking point structure were constructed according to the project requirement and the tank's criteria. The proposed design was evaluated by the method of Weighted Decision Matrix to select the three best designs. Further, the conceptual designs were proceeding to 3D modeling design by using Computer Aided Three-dimensional Interactive Application (CATIA) V5 R20 software. By applying the desired jacking load, the tank with the attached jacking point structure model was analyzed by using CATIA Structural Analysis software. Finally, based on analysis comparison result, the best design was selected and improvises to meet the criteria which having appropriate factor of safety and simple design. The methodology chart for this project is as shown in **Figure 1.1**.

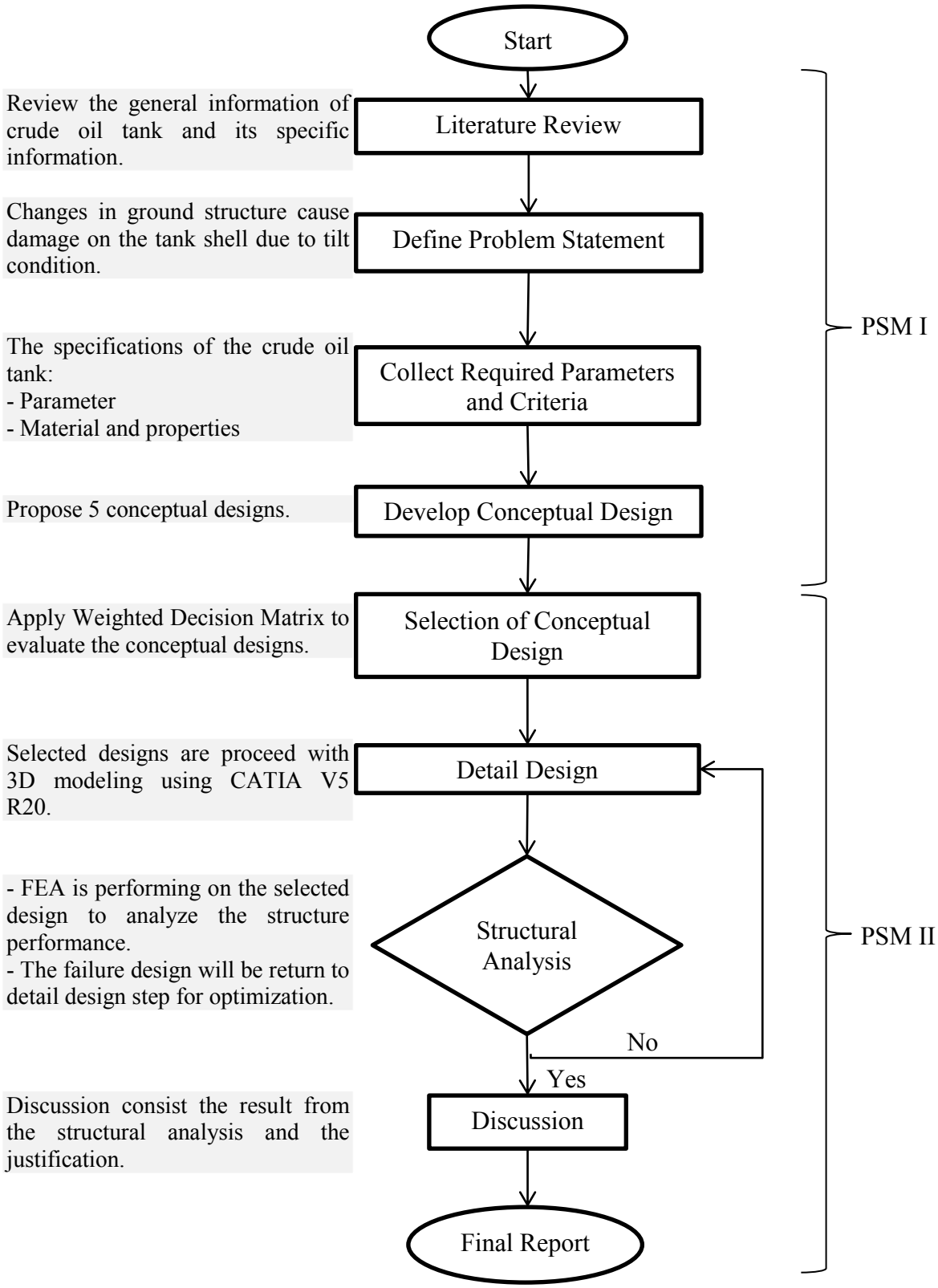

Figure 1.1: Methodology Chart

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

This section explains the literature review of the storage tank itself, the type of tank, type of accidents and the causes of accidents. Besides, the engineering characteristics related to this project are included such as material deflection and related stress involved in this case. The explanation is continued for the method to define Factor of Safety which is the important value in engineering failure analysis. Furthermore, the process of design and analysis of the tank and jacking point structure model is described such as, generating and evaluating of the concept design, and lastly the most important structural analysis process by using Finite Element Analysis (FEA) method. The source of information was collected from variable source such as published standard code of design, academic journal and book.

2.2 STORAGE TANK

The storage tank as shown in **Figure 2.1** is a structure developed to provide storing space for liquid or gas content. According to API Standard 620 (2002), the basic components of low-pressure storage tank shall include the following parts of a single-wall tank; annular plates; roof plates; knuckle plates; compression rings; shell stiffeners; and man ways and nozzles including reinforcement, shell anchors, pipe,

tubing, forgings, and bolting. Basically, the important parts in storage tanks which calculations applied are the annular plate, shell and roof.

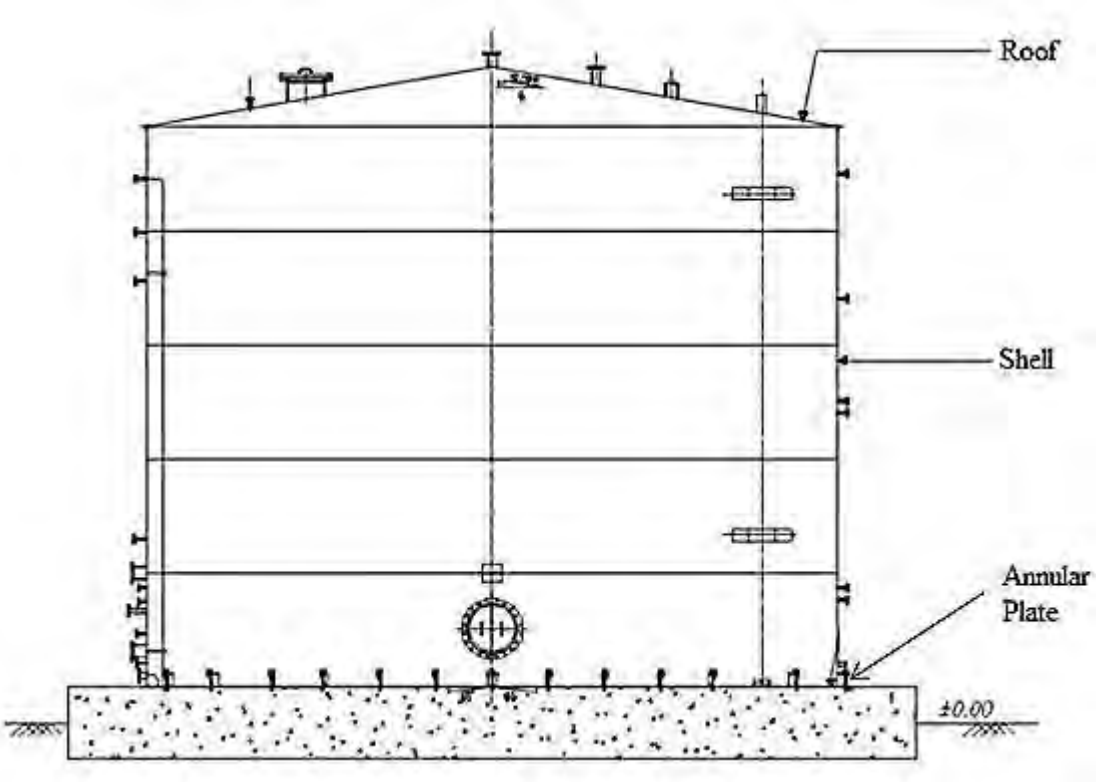

Figure 2.1: Storage tank
(Source: www.parstechnic.com)

2.2.1 Type and Material Contents

The purpose of storage tank is to handle and store gases or liquid product as stated in API Standard 620, (2002). The tanks described in this standard are designed and constructed based on the requirements and limitations of usage, such as pressure, temperature and chemical reactions which resulted from the contents itself. So, it is important to study all these stated criteria before proceeding with the design process. Usually, storage tank type is classified based on the shape of the tank roofs, several types of the crude oil tanks are shown in **Figure 2.2**.

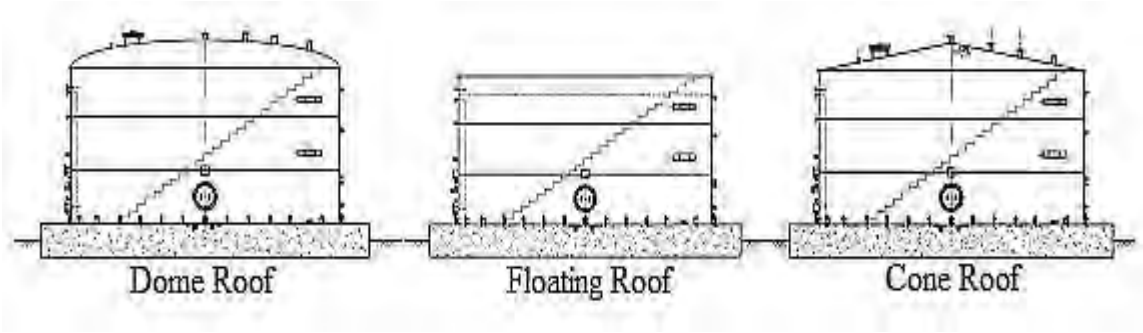

Figure 2.2: Dome, floating and cone roof type of storage tank.
(Source: www.parstechnic.com)

Table 2.1 states the type of storage tank and its respective content, the information is collected by Chang and Lin (2006) for the study of storage tank accidents from years 1960 to 2003. However, the number of storage tank is continuing to increase due to the growth of oil and gas industry.

Table 2.1: Type of tanks and its content (Chang and Lin, 2006)

Content	External floating top	Cone top	Sphere	Cone roof internal floating top	Refrigerated tank	Wooden top	Fiber glass	Total
Crude oil	23	5	0	2	0	2	0	32
Oil products	3	10	0	1	0	0	0	14
Gasoline	20	3	0	3	0	0	0	26
LPG	0	0	11	0	0	0	0	11
Propane	0	0	0	0	1	0	1	2
Hydrochloric acid	0	0	0	0	0	0	2	2
Methyl cyanate	0	0	0	0	1	0	0	1
Subtotal	46	18	11	6	2	0	3	88

The data indicate that the most frequent type of storage tanks was the external floating top type followed by cone top type. Both types of storage tanks were widely used in crude oil, gasoline and oil products storage with low pressure conditions.