ASSET MAINTENANCE STRATEGY IN SPARE AND REPLACEMENT FOR HVAC IN OIL AND GAS INDUSTRY

ANTHONY BELAYONG ANAK GEORGE

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE TECHNOLOGY) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted

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2022

DECLARATION

I declare that this thesis entitled "**Asset Maintenance Strategy in Spare and Replacement for HVAC in Oil and Gas Industry**" is the results of my own research except as cited in the references. The thesis is not accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : ANTHONY BELAYONG ANAK GEORGE

Date : 17/1/2022

APPROVAL

I declare that this thesis entitled "**Asset Maintenance Strategy in Spare and Replacement for HVAC in Oil and Gas Industry**" is the results of my own research except as cited in the references. The thesis is not accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Supervisor Name : Ts. Dr. Ahmad Fuad Bin Ab. Ghani

Date : 17/1/2022

DEDICATION

To

My Father

In earning an honest living for us, being a backbone, and giving the best example in always doing the best in life and encouraging me to always step forward much further and to always work hard.

My Mother

A strong and genuine soul that always encouraging me in all I do and never miss to be by my side whether in good or bad times in life and never cease in giving love and support.

My Dearest Siblings

For their love, supports, and encouragement in growing up successfully together.

To Myself

Thank you in believing yourself that you can make it no matter how hard the situation is and there will always be a reason and rewards in everything you do.

ABSTRACT

Advancement of technologies in the world, such that the Oil and Gas Industry, it is quite hard, and it is very competitive in assuring which is the best tools or devices use to solve any solution as in consideration of cutting time and budget to get a good and accurate result. Stress analysis is of the fundamental problems that can cause a failure or a fatal and hazardous results if it is not counter or study deeply. Asset management is becoming more important in boosting operational efficiencies because of increased competition and tighter margins within oil and gas companies. To shield themselves from economic uncertainty and enhance long-term profitability, modern oil and gas facilities are being built on a bigger scale than before, with higher production and storage capabilities. For initiatives like this, a well-designed asset management strategy becomes even more crucial in attaining their ultimate goals. The objective of this study is that to design a tool use in analysing stress in the HVAC system, to study the importance of stress analysis on its effect towards the behaviour of the material and defects and to investigate the finite element analysis method on the parts and component of HVAC. This is because of the condition and the environment of the working condition in oil and gas is quite complicated and dangerous. By studying the non-traditional ways of doing and inspection on the structure, by applying a finite element analysis through modelling, it can save much more time and cost in implementing it on the asset maintenance. In this study, Autodesk Inventor Professional 2020 is used as the software to determine the analysis of stress. Furthermore, the usage of the finite element modelling bring much more efficacy from the perspective of cost and time because it does not any real physical model of testing parts and it can show directly on how the stress works onto the structure. Besides that, Internet of Things has become a sensation medium in many of the current industry. Thus, this thesis also going through on the IoT which will be synergise with the applications of FEA in monitoring displacement of a structure.

ABSTRAK

Kemajuan teknologi di dunia, seperti Industri Minyak dan Gas, cukup sulit, dan sangat kompetitif dalam memastikan alat atau alat terbaik yang digunakan untuk menyelesaikan sebarang penyelesaian seperti mempertimbangkan pemotongan waktu dan anggaran untuk mendapatkan hasil yang baik dan tepat. Analisis tekanan adalah masalah asas yang boleh menyebabkan kegagalan atau hasil yang boleh membawa maut dan berbahaya sekiranya tidak berlawanan atau belajar dengan mendalam. Pengurusan aset menjadi lebih penting dalam meningkatkan kecekapan operasi kerana peningkatan persaingan dan margin yang lebih ketat dalam syarikat minyak dan gas. Untuk melindungi diri dari ketidaktentuan ekonomi dan meningkatkan keuntungan jangka panjang, kemudahan minyak dan gas moden dibina pada skala yang lebih besar daripada sebelumnya, dengan kemampuan pengeluaran dan penyimpanan yang lebih tinggi. Untuk inisiatif seperti ini, strategi pengurusan aset yang dirancang dengan baik menjadi lebih penting dalam mencapai tujuan utama mereka. Objektif kajian ini adalah untuk merancang penggunaan alat dalam menganalisis tekanan dalam sistem HVAC, untuk mengkaji kepentingan analisis tekanan terhadap pengaruhnya terhadap tingkah laku bahan dan kecacatan dan untuk menyiasat kaedah analisis elemen hingga pada bahagian dan komponen HVAC. Ini kerana keadaan dan persekitaran keadaan kerja dalam minyak dan gas cukup rumit dan berbahaya. Dengan mengkaji cara-cara dan pemeriksaan non-tradisional pada struktur, dengan menerapkan analisis elemen hingga melalui pemodelan, ia dapat menjimatkan lebih banyak masa dan kos dalam melaksanakannya pada penyelenggaraan aset. Dalam kajian ini, Autodesk Inventor Professional 2020 digunakan sebagai perisian untuk menentukan analisis tekanan. Tambahan pula, penggunaan pemodelan elemen hingga membawa lebih banyak keberkesanan dari perspektif kos dan masa kerana tidak ada model fizikal sebenar bahagian pengujian dan dapat menunjukkan secara langsung bagaimana tekanan berfungsi pada struktur. Selain itu, Internet of Things telah menjadi medium sensasi dalam kebanyakan industri semasa. Oleh itu, tesis ini juga melalui IoT yang akan bersinergi dengan aplikasi FEA dalam memantau anjakan struktur.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

FEM	-	Finite Element Modelling
FEA	-	Finite Element Analysis
HVAC	-	Heating, Ventilation, And Air Conditioning
CAD	-	Computer-Aided Design
CAE	-	Computer-Aided Engineering
DOF	-	Degree of Freedom
FOS	-	Factor of Safety
N	-	Newton
Mpa	-	Mega Paschal
Max	-	Maximum
Min	-	Minimum
%	-	Percentage
≥	-	Greater than or equal to

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

In this chapter, it will cover up an introduction of this project, the problem statement, objectives, and the scope of the project.

Asset Integrity, or asset integrity management systems (AIMS) is a phrase used to describe an asset's capabilities to accomplish efficiently and effectively. while also safeguarding the health and safety of all employees and equipment with whom it comes into contact – as well as the safeguards in position in ensuring the asset's long-term viability (Oil & Gas IQ, 2019). Assets Integrity is crucial throughout the asset life cycle, from operation to replacement and decommissioning. As a result, there is always an impediment and a need to discover a solution to balance the asset design, repair, and replacement costs, as well as the effort expended in terms of finance, time, and energy through the life cycle of their assets. Moreover, design, construction, commissioning, operation, modifications, and decommissioning are the five primary roles or principles that must be followed to assure an asset's life cycle. Each piece ensures the asset's integrity, with the integrity principles influencing every stage of creation and implementation. It is dynamic process (Hossam Aboegla, 2017).

Furthermore, in one of the elements of Assets Integrity, in the early cycle of the concept, there are principles that comply with stress analysis, such as construction and design, which are used as one of the non-destructive tests in the field. Stress analysis is a set of tests that will show how the materials and structures design behave when it subjected to stress or pressure. It is critical to understand any structural reliability. Stress analysis is a set of experiments used to determine how materials and structures react when subjected to stress or pressure. It is critical to understand any structural dependability. As a result, the stress analysis assists in determining the structure's reliability by displaying how internal stresses are distributed throughout a structure system and describing how external forces acting on the structure interact on the material or object use in the testing. Besides that, stress analysis

can also be use in any form of components or parts of any machinery or connection such that flange of a pipe, ducting or any high stress absorbent area such that in the HVAC system where the vibration of the compressor would affect the joint between ducting.

Stress analysis is commonly operated by using finite element analysis (FEA) on a high-end performance of computer system. Thus, it is one of the most effective techniques to simultaneously know how to handle and deal with any given circumstance. The finite element approach is based on the discretization of a complicated area defining a continuum into understandable geometric shapes. (Crisfield M.A, 1997). Thus, as a result, the finite element approach is one of the simplest and least complicated processes or applications to grasp. Aside from that, it may be used to nearly any word by using mathematical formulae to help understand the stress placed on an object or a structure Finite element method quite a practical tool use for numerical solution to mainly solve any engineering problems including stress analysis, flux, and flow problems (Chandrupatla, T. R. and Belegundu, 2002).

Despite squandering valuable resources such as money and time fixing assets or getting busy rejuvenating assets before they completely fail, stress analysis can be used to predict the outcome of any project or construction life span utilizing the correct formula and calculation. This is critical to know in the early stages of building or production by putting varied loads on the structure's materials. Stress analysis can also provide an overview of where the structural region has been subjected to the most stress, which may be addressed in the early stages of any project by enhancing and devising a remedy, such as developing a modification. It is so important to be able ensure the safety and the reliability of any structure.

There are several gadgets, tools, and other testing instruments available for determining any first failure or total breakdown. Digital Image Correlation is a well-known method of assessing non-destructive surface deformations that was originally used about three decades ago. Basically, it is broadly use because it is commonly used to compensate a diversified number of ranges of material samples and specimens including examining the emergence and uniformity of strain in materials testing, crack tip and crack propagation studies, detecting the defect of damage development in composites, structural deflections, strain modelling at high temperatures as well as dynamical vibrational analysis (Nick McCormick, 2010). It can analyse any stress or deformation that may occur on the structural. A speckled specimen of research, a camera, and a stabilized light source are typically used in the 2-D Digital Image Correlation idea or procedure. It is a random concentration

distribution of visual created by a finite number of pixels on the test sample surface, which could be naturally present or purposefully created (Zhao et al., 2019). Therefore, the goal of this project is to create a tool to analyze the stress or changes in the test specimen, that can be use such that by using Digital Image Correlation by implying it on an Autodesk Inventor software by using finite diagram method and by detecting a pattern change through ultrasonic sensor by targeting on the displacement of the structure.

Nonetheless, wireless connectivity to test probes and sensors already entering the Non-Destructive Testing (NDT) sector. Artificial Intelligence is already used in many industries to interpret data (A.I.). Simultaneously, cloud-based data storage has engulfed the NDT field, with practically every NDT user utilising cloud storage for production data, processing tools, and reporting. (*Asia Pacific Conference for Non-Destructive Testing (APCNDT2017), Singapore. The Future of NDT with Wireless Sensors, A.I. and IoT Janko Meier † , Isaak Tsalicoglou † and Ralph Mennicke † †*, n.d.). Thus, technology has advanced in the past year where, NDT has used IoT in doing the non-destructive testing which are much more proficient and less time consuming rather than using the old traditional ways because some of the NDT equipment are difficult to operate and need days, weeks, and even months of training to be able to carry out the work as a competent person in both executing the testing and also interpreting up the data correctly.

1.2 Problem Statement

As for the advancement of technologies in the world, it is quite hard, and it is very competitive in assuring which is the best tools or devices use to solve any solution as in consideration of cutting time and budget to get a good and accurate result. Stress analysis is one of the fundamental problems that can cause a failure or a fatal and hazardous results if it is not counter or study deeply. Thus, as many of the tools used to identify this problem, Digital Image Correlation is a graphical skill that integrates image verification and monitoring methods to provide a precise 2D assessments of alterations in collected pictures, as well as a study of the image's pattern.

In the meantime, even though it is acknowledgeable efficient by using Digital Image Correlation to do a small-scale testing, it is still much haste to execute because the setup of the testing needs to be done as precise as it can be. The observed surface would have to be a flat plane and level. where the photographic lens' optical axis must be set perpendicular to the measured plane, and the source of light must be very mild and steady. (Zhao et al., 2019).

Besides, it needs to be speckled whereas the speckle pattern acts as a mechanism of deformity details in DIC measurements. It can be said that it is quite a manually and traditionally conduct type of testing. Thus, in this project it will focus more on suggesting unorthodox way or a tool that can be access and use by everyone which is by using a Finite Diagram method in using Autodesk Inventor. Finite Diagram method is also giving more advantage in time spent as for the preparation and the money spends. Besides, it is quite efficient to calculate the stress of a much huge scale such as HVAC system, whereas the vibration exerted from the compressor to the ducting or calculating the stress amount when fixed crane's boom extended while lifting of certain value of load.

Besides, for software predictive maintenance, surely it can be done directly by using the results from the testing such that by using Autodesk Inventor, but failure sometimes can happen with a pattern that is visible and just need to be monitored from time to time. Thus, here the Internet of Things are also one of the ways that can be used to indicate the early stage of any deformities of the structure where as instance, the changes of the patter from the reading can be tabulated to graph where it can be identifies which is one of the ways to achieve the asset maintenance strategy.

1.3 Research Objective

Specifically, the objectives are as following:

i. To study the importance of stress analysis on its effect towards the behaviour of the material and defects.
ii. To investigate the finite element analysis method on the parts and component of HVAC structure.
iii. To design and build a monitoring device use in displacement sensing by implementing Internet of Things to be use for field activity circulating around the strategy of asset maintenance.

1.4 Scope of Research

The scope of this research are as follows:

i. To study precisely way of using Autodesk Inventor by conducting a stress analysis and make it as a tool to identify stress.

ii. Constructing Finite Diagram Modelling for HVAC structure and applying testing on the modelling based on finite element analysis.

iii. Investigation is based on the Oil and Gas Industry of HVAC system and revolve around the application and similarities of Digital Image Correlation method.

iv. To study on tools use in detecting a displacement of a structure.

1.5 Significance of Study

i. Be able to differentiate the methods and the application of each of the testing and methods ways by taking precautions of time consumption and budget clarification in observations through studies.

ii. To imply much more efficient ways in identifying stress analysis in many other forms of experimental comparison and find out the most suitable type of testing needed for some different type of situation.

iii. Study the analysis created by using Autodesk Inventor in the current studies to be as much efficient as DIC in analysing stress in major and minor scale of parts, components, or structure in HVAC system.

iv. Identified the pros and con of the tool that is use in current studies and relate the outcome with Digital Image Correlation method of engaging the deformation based on analysing the stress.

v. To build an initial continues monitoring tools that can be used in monitoring the structure throughout the activity of the asset maintenance strategy.

1.6 Research Structure

The arrangement of this thesis is based on the thesis format and guideline of Universiti Teknikal Malaysia Melaka (UTeM) for the publication of this study that are conduct. This thesis consists of five (5) chapter which is consist of Introduction, Literature Review, Methodology, Results, thus follow by Discussions and Conclusions. The overview of this thesis are as follows:

Chapter 1

An overall introduction on the thesis and the problem that inaugurate this thesis were stated clearly in this chapter. Besides, the significance of why the thesis is conducted and the scope area of the study were also explained.

Chapter 2

On this chapter, it gives an overall review of any literature in any previous study on any related field or area that were related to the thesis. Furthermore, the chapter distinct the study of the thesis and any previous study related to the topic.

Chapter 3

This chapter covers up the methodology use in the thesis. Thus, Finite Element Analysis modelling were used in this chapter to demonstrate how it will be implemented.

Chapter 4

This chapter will present on the result, any theory or study on the Finite Element Modelling use in the structural analysis. The findings of the stress analysis, displacement of the deformed shape, contour plot will be explained in this chapter. In additions, the findings were also addressed in this chapter and contribute to the purpose of this thesis.

Chapter 5

This chapter present the overall conclusion of the study as a whole and will gives future recommendations, including the improvement of this study in the future. In addition to this chapter, are also the potential of the project.