UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OPTIMIZATION OF STIFFENED SQUARE PLATE UNDER UNIFORMLY DISTRIBUTED PRESSURE OF 5 PASCAL

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) Bachelor‟s Degree in Mechanical Engineering Technology (Maintenance Technology) with Honors.

By

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Engineering Technology Mechanical Department) Bachelor‟s Degree in Mechanical Engineering Technology (Maintenance Technology) with Honors. The member of the supervisory is as follow:

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(Project Supervisor)

ABSTRACT

The structure of stiffened square plate are widely use in engineering began in the nineteenth century and now is used in many modern industries applications. The pressure that occur in ship structure will bring stress and strain failure to stiffened square plate. When the stiffened square plate was imposed to excessive load, it will lead to deformation failure. The project research are carried out to find the solution in optimizing the structure of stiffened square plate and hence improve the performance of stiffened square plate through a various factor. The structure of square plate will be analyzed by applying uniformly distributed pressure using Inspire 2014 by Altair HyperWorks. The plate is assumed to be clamped or simply supported at the side of the plates. The software that used in this project to make an analysis is SolidThinking 2014 and the model of square plate is make using SpaceClaim 2015. The material was selected and analysis will be done to know the strength of stiffened square plate if 5 Pascal pressure was is placed. The optimization is created using SolidThinking 2014. Based on the objective of the project, the result shows the performance of stiffened square plate can be improved if the stiffener design are change correctly.

ABSTRAK

Struktur plat segi empat sama yang dikeraskan telah digunakan secara meluas dalam bidang kejuruteraan bermula pada abad kesembilan belas dan kini digunakan dalam pelbagai industri aplikasi moden. Tekanan yang berlaku dalam struktur kapal akan membawa kegagalan tegasan dan terikan kepadas plat segi empat sama. Apabila plat persegi yang dikeraskan dikenakan kepada beban yang berlebihan, ia akan membawa kepada kegagalan yang akan menguubah bentuk plat persegi. Kajian projek ini dilaksanakan untuk mencari penyelesaian bagi mengoptimumkan struktur plat persegi yang dikeraskan dan dengan itu dapat meningkatkan prestasi plat persegi yang dikeraskan melalui pelbagai faktor. Struktur plat persegi akan dianalisis dengan menggunakan tekanan teragih seragam menggunakan Inspire 2014 oleh Altair HyperWorks. Plat diandaikan akan diapit atau disokong dibahagian tepi plat. Perisian yang digunakan dalam projek ini untuk membuat analisa adalah solidThinking 2014 dan model plat persegi di lukis menggunakan SpaceClaim 2015. Bahan akan dipilih dan analisis akan dilakukan untuk mengetahui kekuatan plat persegi yang dikeraskan jika tekanan5 Pascal diletakkan. Pengoptimuman dibuat dengan menggunakan solidThinking 2014. Berdasarkan objektif projek, hasilnya menunjukkan prestasi plat persegi yang telah dikeraskan boleh diperbaiki jika reka bentuk "stiffener" dibuat dengan betul.

DEDICATIONS

To my beloved parents and family.

Mr. Utok bin Hassan and Mrs Junaida binti hussin.

To all my friends that involve, my supervisor and all my lecturer.

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TABLE OF CONTENTS

DECLARATION iv

APPROVAL v

ABSTRACT vi

ABSTRAK vii

DEDICATIONS viii

ACKNOWLEDGMENTS ix

TABLE OF CONTENTS x

LIST OF FIGURES xiii

LIST OF TABLE xiv

LIST OF SYMBOLS AND ABBREVIATIONS xv

CHAPTER 1 1

1.0 Introduction 1

1.1 Background 1

1.2 Optimization 2

1.3 Motivation of Research 2

1.4 Problem Statement 3

1.5 Objectives of Research 3

1.6 Scope of Research 4

CHAPTER 2 5

2.0 Introduction 5

2.1 Engineering Analysis 5

2.1.1 Theoretical Real Analysis 6

2.2 Computer Aided Engineering... 6

2.2.1 Multibody Dynamic (MBD) 7

2.2.2 Computational Fluid Dynamics (CFD)... 8

2.2.3 Multidisciplinary design optimization (MDO) 9

2.3 Finite Element Analysis (FEA) 9

2.3.1 Dynamic analysis 11

2.3.2 Structural Analysis 12

2.4 Software.. 13

2.4.1 Solid Thinking – Inspire 2014 (Altair HYPERWORKS 13

2.4.2 SpaceClaim 2015 14

2.5 Types of Optimization in Altair Hyperworks.. 14

2.5.1 Topology Optimization 14

2.5.2 Topography Optimization 15

2.5.3 Shape Optimization... 15

2.5.4 Sizing Optimization 16

2.6 Material Selection.. 16

2.6.1 Plate thickness... 17

CHAPTER 3 19

3.0 Introduction 19

3.1 Design Model 20

3.1.1 Construct Model using SpaceClaim.. 21

3.2 Material Selection 23
3.3 Analysis using inspire 2015 23
3.4 Optimization 24
CHAPTER 4 27
4.0 Introduction 27
4.1 Basic Stiffened Square Plate 27
4.2 Regular Optimization of Stiffened Square Plate 28
4.3 New Optimization of Stiffened Square Plate 30
4.4 Result of Design 32
CHAPTER 5 38
5.0 Introduction 38
5.1 Summary of Research 38
5.2 Achievement of Research Objectives 39
5.3 Significance of Research 39
5.4 Problems Faced During Research 39
5.5 Suggestion for Future Work 39
APPENDICES 41
APPENDIX A 42
APPENDIX B 44
APPENDIX C 46
APPENDIX D 48
APPENDIX E 50
REFERENCES 52

LIST OF FIGURES

Figure 2.1: General frame element 10
Figure 2.2 : common 2-d element 10
Figure 2.3 : plate and shell elements 11
Figure 2.4 : common 3-d elements 11
Figure 2.5 : topology optimization to an SUV body (Leiva, 2007) 15
Figure 2.6 : shape optimization (Anton Olason, 2010) 15
Figure 2.7 : sizing optimization (Anton Olason, 2010) 16
Figure 3.1: Flow chart of research 19
Figure 3.2 : Isometric View 20
Figure 3.3 : Front View 20
Figure 3.4 : Side View 21
Figure 3.5 : Bottom View 21
Figure 3.6 : drawing Rectangular on the base 21
Figure 3.7 : the extruded square plate 22
Figure 3.8 : bottom view of rectagular sketch on the model 22
Figure 3.9 : the complete model of the stiffened square plate 23
Figure 3.10 : support and pressure on the model 24
Figure 3.11 : side view of sample model (Yousif, 2008) 25
Figure 3.12 : bottom view of the sample model (Yousif, 2008) 25
Figure 3.13 : meshed plate-stiffener in ANSYS program (Yousif, 2008) 26
Figure 4.1 : pressure that give to the stiffened square plate 27
Figure 4.2 : result from the topography analysis on basic stiffened square plate 28
Figure 4.3 : Isometric View of Regular Optimization of Stiffened Square Plate 28
Figure 4.4 : result of the topography analysis on the regular optimization stiffened square plate 29
Figure 4.5 : the first optimization of stiffened square plate 30
Figure 4.6 : the second optimization of stiffened square plate 31
Figure 4.7 : the third optimization of stiffened square plate 32
Figure 4.8 : comparison graft of bending displacement 34
Figure 4.9 : comparison graft of tension occur to the stiffened plate 35
Figure 4.10 : comparison graft of compression occur to the stiffened plate 35
Figure 4.11 : comparison graft of shear stress occur to the stiffened plate 36
Figure 4.12 : comparison graft of von mises stress occur to the stiffened plate 37

LIST OF TABLE

Table 2.1: general properties of steels at room temperature (25˚C) 17
Table 2.2: sample of yield strength and tensile strength based on plate thickness (Narasimha-Rao, 2008) 18
Table 4.1 : Comparison Of All Result 33

LIST OF SYMBOLS AND ABBREVIATIONS

FEA	=	Finite Element Analysis
CAE	=	Computer-Aided Engineering
CFD	=	Computational Fluid Dynamics
MBD	=	Multibody Dynamics
AI	=	Artificial Intelligence
CAD	=	Computer-Aided Design
MDO	=	Multidisciplinary Design Optimization
MSDO	=	Multidisciplinary System Design Optimization
FEM	=	Finite Element Method
Pa	=	Pascal"s
GPa	=	Giga Pascal"s
m	=	Meter
mm	=	Millimetre

CHAPTER 1

INTRODUCTION

1.0 Introduction

The structural of stiffened plate are widely use in engineering began in the nineteenth century and now used in many modern industries applications. It starts with the application of steel plates for the hulls of ships and with development of steel bridges and aircraft structures. Stiffeners in a stiffened plate make it possible to resist highly directional loads, and introduce multiple load paths that may provide protection against damage and crack growth under both compressive and tensile loads. The biggest advantage of the stiffeners is to increase bending stiffness of the panel with a minimum of additional material, which makes these structures highly desirable for out-of-plane loads and destabilizing compressive loads. (Ramaswamy, 1999)

1.1 Background

Finite element analysis is originally initiated for solving a solid mechanic problems using a numerical method. In 1909 an effective virtual method for the approximate solution of problem in the mechanics of deformable solids was developed by Walter Ritz. All function that used in this method should satisfy to the boundary conditions of the problem that exists. Finite element analysis is a numerical method to calculate the responses of a structure to combination of applied load such as pressure and force to a support. With all the information that required, the proposed design can be determine if the design meets the design requirements. The finite elements analysis nowadays is considered as a practicable technique for the computer solution of complex problems and well established in different fields of engineering. FEA can be used to check the design object for its functionality to carry out an engineering analysis.

1.2 Optimization

Optimization is a solution to a problem to get an optimum function of its design. Optimization techniques is a spectacular problem solving method and modelling. Optimization has a widespread used in applications in management science, engineering technology and industry. The application of optimization problems in engineering is well known in two special classes that is linear least squares and linear optimization problems. There are four category of optimization to get an excellent design and to improve stiffened square plate performance of design. The four category is topology, topography, shape and sizing. Optimization technique is now view as the tool of the utmost importance for an engineer in many industries, especially the aerospace, manufacturing industries, automotive and chemical industries. Some optimizations techniques are known as design optimization that include shape optimization, topological optimization, inverse optimization, structural design, product designs and processing planning.

1.3 Motivation of Research

The motivation is to optimized stiffened plate in developing inspection and correction of stiffened plate in the ship plating and a typical web frame of a tanker obtained by using these element. This is important to increase the quality and the performance of the stiffened plate in the hull of ships. The use of regular stiffened plate in the hull of ships need to be improved so the performance of plate can be increased. The optimization of stiffened plate is required to increase the quality and performance of stiffened square plate.

1.4 Problem Statement

Square plate is a simple shape of plate and widely used in industry and daily life. A stiffened square plate is widely used in industry especially in ship structure and water tank base. Ship structure and base of water tank are considered as thin-walled structured. The pressure that occur in ship structure and base of water tank will bring stress and strain failure to stiffened square plate. When the stiffened square plate was imposed to excessive load, it will lead to deformation failure. To optimize the performance of stiffened square plate and then increasing the performance, the analysis is carried out by using topography optimization use solid thinking software – inspire 2014 by Altair Hyperworks. If the stiffened square plate are exposed to excessive pressure it will lead to deformation such as the bending fracture problem, shear deformation, and crack tip stress. The bending fracture problem of stiffened square plate structure have different analysis theory that is used. In this project the bending fracture will be minimize using topography optimization analysis.

1.5 Objectives of Research

From the background and the problem statement that have been stated, the objectives of this project are as follows:

1) To analyse the structure of stiffened square plate under uniformly distributed pressure.
2) To optimize the design of stiffened square plate and improve its performance through topographic factor.

1.6 Scope of Research

The aim of this project is to make an improvement to the structure of the stiffened square plate. To improve the performance of stiffened square plate, the work scope of this project are shown as follow to support the objectives of this project.

1) Analysing the structure of stiffened square plate by applying uniformly distributed pressure.
2) Make an optimization on stiffened square plate to improve the performance so it can withstand 5 Pa pressure.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will discuss mainly on the theory and current development in stiffened square plate. This chapter also will discuss all the finding to make an optimization to the stiffened square plate.

2.1 Engineering Analysis

Engineering analysis is a process to reveal the properties of mechanisms under study and state of the system through the applications of scientific analytic principles. In point of fact, analysis deal with sets of numbers and operations on numbers. Engineering analysis tell the difference between "tinkering" and true engineering design. Engineering analysis helps to make a decisions and then guide the engineer to make a better design process. A design project with analysis is very important to get an optimum design project and minimize failure occur to the project. There are several types of engineering analysis start with mathematical method and was developed to computer-aided engineering (CAE). CAE is an advance technique that use to make an engineering analysis such as stress analysis on part or components using finite element analysis (FEA), fluid flow and thermal analysis using computational fluid dynamics (CFD) and also to analyzed the dynamic reaction of flexible bodies or interconnected rigid using multibody dynamics (MBD).

2.1.1 Theoretical Real Analysis

The understanding of the behaviour of real functions was increased largely in the seventeenth century when Newton and Leibniz discover the calculus method (Ciesielski, 1997). The beginning of analysis is often discover in the early nineteenth century when the exact definitions of concepts such as continuity and limits for real function are introduced by Cauchy. Different techniques such as pointwise and uniform convergent in limiting operations were studied and have been used as the theory and indirectly gave rise to various approximation technique. At the same time with the lead of stochastic convergence idea in the 1920‟s, functional analysis was developed from application of topology to analysis (Ciesielski, 1997).

A new research trend has been appeared in the last few years from 1997 which indicates the emergence of a yet another branch of inquiry that is known as „set theoretical real analyses‟. Using the modern technique of set theory, this analysis was study the family of real functions. Set theoretical real analysis is closely federated with the descriptive set theory, but the point of study between this two major are different. Set theoretical real analysis study the real function and is interested predominantly in more pathological objects, the modern set theory are used as a tools to make an analysis. The result referring to subsections of the deep studies of the duality between measure and category and are considered only remotely related to the subject. The discovery of powerful new techniques in set of theory give rise to the new emergence of the field. The development of set theoretical analysis is not even close if compared to the parallel development of set theoretical topology during the late 1950‟s and 1960‟s (Ciesielski, 1997).

2.2 Computer Aided Engineering

Computer-aided engineering (CAE) is the spacious usage of computer software to help in making analysis for engineering tasks. There are many types of analysis that can be done by using computer-aided engineering such as finite element analysis (FEA), multibody dynamics (MBD), and Computational Fluid Dynamics (CFD). Computer-aided engineering also can make an optimization to the analysis that have been done. Computer-aided engineering systems can also provide an information to help support in making a decision for design team. Computer-aided engineering is widely used in many field of area such as automotive, shipbuilding industries, aerospace and others.

Usually, there are three phases in computer-aided engineering working principle that start with pre-processing, analysis solver and then post-processing. The cycle of this process is usually ingeminate many times, either manually or with the aid of optimization software that provided nowadays. The purpose of computer aided engineering is to construct computer programs that use both ways formal and implicitly that can express and use a significant fraction of the knowledge engineers. Artificial intelligence (AI) is very good technology for engineering, because it can help engineers to discover new material and processes. Engineering applications give Artificial intelligence (AI) an important chance to making product more efficiently and fast without delay (Forbus, 1988).

2.2.1 Multibody Dynamic (MBD)

Multibody dynamics (MBD) also known as multibody system dynamics. MBD is the study of the dynamics behaviour based on analytical mechanics. Interconnected rigid or flexible bodies that may cause large translational and rotational displacement is the dynamic behaviour that study in multibody system. Fundamentally, the motion of bodies is explained by their kinematic behaviour. At the present time, the number of research in engineering fields such as robotics and vehicles dynamics are analyzed using multibody system. The important features of multibody system formalisms normally offer an algorithmic and computer–aided way to optimize the arbitrary motion of possibility thousands of interconnect bodies by analysis and simulation of the model that create using CAD. Multibody system dynamics are applied to a wide diversity of engineering system as well as to biochemical problems. The summarize of fundamental and recursive multibody dynamics for rigid and flexible bodies shows that multibody dynamics is an excellent foundation for multivariable vibration analysis and sophisticated control design (Schiehlen, 2006).

2.2.2 Computational Fluid Dynamics (CFD)

Computational fluid dynamics also known as CFD. CFD is another subsection from fluid mechanics and use numerical method and algorithms to analyse the problem that involve either with gas or fluid flows and then help to solve the problem. Computer is used to make a simulation to show an interaction of liquids and gases with surfaces defined by boundary conditions. In achieving better solutions high speed super computer can be used. To make an analysis in CFD, firstly the problem must be define based on the physical bound in the geometry. The fluid is then divided into discrete cells by the volume occupied, the discrete cells also known as the mesh and it can be uniform or non-uniform. After that, the physical modelling is determined such as the equation of motion, species conservation and many more. The simulation can start after the conditions boundaries are determined.

The basic theory of CFD methods is to determine the values of the flow quantities at a large number of points in the system. The numerical grid or mesh are connected together and the system of differential equations that representing the flow is converted to a system of algebraic equations using some procedures. The finding system of algebraic equation usually large which can be linear or non-linear and it needs a digital computer in solving corresponding problem. The system is solve using flow quantities at the grid points (sayma, 2009).

The applications of Computational fluid dynamics (CFD) are used widely in industries. CFD can be used to simulate the flow over a vehicle. Most of CFD methods nowadays are used in aerospace industries to predict the component performance and also can be used to analysis the interaction of propellers or rotor of the aircraft. Other than that, CFD can be used to obtain the temperature distributed of a mixing manifold. The engineering field in bio-medical is growing rapidly and CFD also use in the growing of bio-medical applications to analysis the circulatory and respiratory systems (Schiehlen, 2006).

2.2.3 Multidisciplinary design optimization (MDO)

Multidisciplinary design optimization (MDO) is an optimization methods in engineering field to decipher design problems. MDO also called as MSDO (multidisciplinary system design optimization) or just multidisciplinary optimization only. MDO enables designers to incorporate all applicable disciplines. Multidisciplinary design optimization (MDO) techniques have been used widely in aerospace engineering field such as aircraft and spacecraft design. Other than that, MDO also used in automobile design, architecture, electronics, computer and electricity distribution. MDO have been provide an optimal set of solutions in solving engineering problems (Depince, 2007).

Multidisciplinary optimization are applied to the design of engineering systems to account the physical subsystems such as engine and wing or for interactions between multiple disciplines such as aerodynamics and structural analysis. The main objective of multidisciplinary optimization is to make an integration disciplinary analysis and make a design activities to returns better system performance and reduces the cost and time elapsed from system development (Allison, 2013).

2.3 Finite Element Analysis (FEA)

Finite element analysis are numerical method to determine approximate interpretation to boundary value problems or partial different equations. Finite element analysis (FEA) also known as Finite element method (FEM) that use to solve the problem by simplifying the problem part domain. Finite element analysis are being extensively used in many complex real life system to analysis and design. Initially, finite element analysis is an extension of matrix method of structural analysis. Nowadays finite element analysis has grown and used in many field from bio-mechanics to electromagnetic problems. Finite element analysis can solved simple linear static problem and complex non-linear transient dynamic problem effectively (Seshu, 2012).