FINITE ELEMENT ANALYSIS OF LOCALLY MANUFACTURED ENGINE MOUNTING COMPONENTS UNDER CYCLIC STRESSES AND THERMAL LOADING

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This report is submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled "Finite Element Analysis of Locally Manufactured Engine Mounting Components Under Cyclic Stresses and Thermal Loading" is the result of my own work except as cited in the references

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this project report 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 (Structure & Materials).

Signature : ....

Name of Supervisor : ....

Date : ....

DEDICATION

Dedicated to my beloved mother and father who always encouraged and supported me.

ABSTRACT

The main purpose of an engine mounting components is to support the powertrain system in an automobile which subject to thermal loading. This study examines a methodology to predict the fatigue life of an engine mounting component using ANSYS software. An engine mounting component is modeled using CATIA software and FE analysis is carried out using ANSYS software. The critical condition caused by the cyclic load and thermal loading may lead to component failure. The scope of the study is to analyze the design, optimize and compare between the two types of engine mounting component under cyclic stresses and thermal loading. The stress concentration factors were estimated based on the structural analysis. The structural analysis is performed on specified part for a given load and support conditions. In order to use a finite element analysis it is necessary to know the mechanical properties of the material. The tensile test, Rockwell hardness test and thermal inspection were conducted in this study to determine the mechanical properties and thermal behavior of an engine mounting component. The simulation of fatigue analysis by finite element software on the existing PROTON SAGA and PERODUA KANCIL engine mounting component to determine the maximum stress and fatigue life on the model due to the effect of thermal loading and cyclic stresses. The final simulation results obtained in this study shows that the higher thermal loading will cause a lower fatigue resistance or shorter life of an engine mounting component.

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ABSTRAK

Tujuan utama komponen mounting enjin adalah untuk menyokong sistem rantaian kuasa dalam sesebuah kenderaan tertakluk kepada beban suhu. Kajian ini mengkaji tentang kaedah untuk meramalkan jangka hayat kelesuan komponen mounting enjin dengan menggunakan perisian ANSYS. Komponen mounting enjin dimodelkan menggunakan perisian CATIA dan kajian analisis unsur terhingga menggunakan perisian ANSYS. Keadaan kritikal disebabkan oleh beban tekanan dan beban haba yang menjadi punca kepada kegagalan komponen tersebut. Skop kajian ini adalah untuk menganalisis reka bentuk dengan mengoptimumkan dan membuat perbandingan antara dua pengeluar komponen mounting enjin dibawah beban kitaran tekanan dan beban haba. Faktor penumpuan tegasan telah dianggarkan berdasarkan analisis struktur. Analisis struktur dilakukan pada bahagian tertentu dalam keadaan tekanan dan sokongan. Untuk menggunakan analisis unsur terhingga adalah perlu mengetahui ciri-ciri mekanikal pada bahan komponen tersebut. Ujian tegangan, ujian kekerasan Rockwell dan pemeriksaan haba telah dijalankan dalam kajian ini untuk menentukan ciri-ciri mekanikal dan sifat pada komponen mounting enjin. Simulasi analisis jangka hayat kelesuan pada model PROTON SAGA dan PERODUA KANCIL pada komponen mounting enjin untuk menentukan tegasan maksimum dan jangka hayat kelesuan kesan terhadap beban haba dan beban tekanan. Keputusan akhir simulasi yang diperolehi melalui kajian ini menunjukkan bahawa semakin tinggi beban suhu dikenakan akan menyebabkan ringtangan kelesuan menjadi lebih rendah atau jangka hayat yang lebih pendek pada komponen mounting enjin tersebut.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBEREVATIONS

FEA	Finite Element Analysis
CAD	Computer Aided Design
CATIA	Computer Aided Three Dimensional Interactive Application
ANSYS	American Computer-Aided Engineering Software
FEM	Finite Element Model
PROTON	Perusahaan Otomobil Nasional
PERODUA	Perusahaan Otomobil Kedua Sendirian Berhad
NVH	Noise and Vibration Harshness
DOF	Degree of Freedom
ASTM	American Society for Testing and Materials
AISI	American Iron and Steel Institute
SAE	Society of Automotive Engineer
S-N	Stress versus Fatigue Life (N) Relation or Curve
MIG	Metal Inert Gas
TIG	Tungsten Inert Gas
SOF	Safety of Factor

LIST OF SYMBOL

M	=	Mass
K	=	Stiffness
C	=	Damping
σ_a	=	Stress Amplitude
σ_u	=	Ultimate Stress @ Tensile strength
σ_m	=	Mean Stress
σ_f	=	Fracture Strength
σ_w	=	Allowable Stress or Working stress
σ_n	=	Stress at zero mean stress
S_e	=	Stress Endurance Limit or Fatigue Limit
N_f	=	Number of Cycles to Failure
E	=	Young's Modulus
v	=	Poisson's Ratio
ρ	=	Density
ξ	=	Damping Ratio
F_e	=	Excitation Force
l_o	=	Original Length
ε	=	Strain
P_y	=	Load at Yielding
A_o	=	Original Cross-Sectional Area
A_o	=	Operating Frequency

CHAPTER 1

INTRODUCTION

1.1 Background of Project

Engine mounting components are used to grip the main support structure (chassis) across the automotive engine. Figure 1.1 shows the schematic diagram of locally assemble of an engine mounting component system. Basically, engine mounting components are usually made up by metallic and rubber materials. The metal parts are used as the frame of mounting that connects the engine and structure of car's body. The rubber part acting as a stiffener to provide flexibility on the vehicle's engine. If an engine mounting component does not have any appropriate level of stiffness it can cause high noise and vibration. An automotive engine is one of the source of vibrations of the car or vehicle. These vibrations are induced by forces transmitted by the engine mount elements onto the structure frame. Therefore it is very important that an engine mounting components have enough stiffness as well as strength.

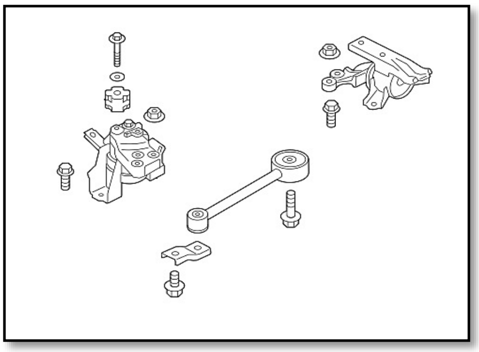

Figure 1.1: The Schematic Diagram of Engine Mounting Component

Source: (Heisler, 2002)

The primary function of an engine mounting is to transmit the vibration. It is filled with rubber to reduce the engine vibration and ensure that there is no direct contact between metal to metal surfaces and between the engine and the structure of the car body. It is the most critically loaded component and experiences a high cyclic loads with thermal loading during its service life. Usually, engine mounts function in very a harsh environment at a low and high temperatures combining with aggressive substances such as oil, gasoline and cleaning liquid (S.H. Lee, Y.S Lim, 2006).

An engine mounting components need to go through analysis to verify the engine mount properties in the design stage (A.Agharkakli,D. P. Wagh, 2013). The cyclic stresses and thermal loading are applied with the boundary conditions during analysis. This study focuses on two type of an engine mounting component for the locally manufactured passenger's car. Figure 1.2 shows an engine mounting component of the Proton SAGA that was used in this study.

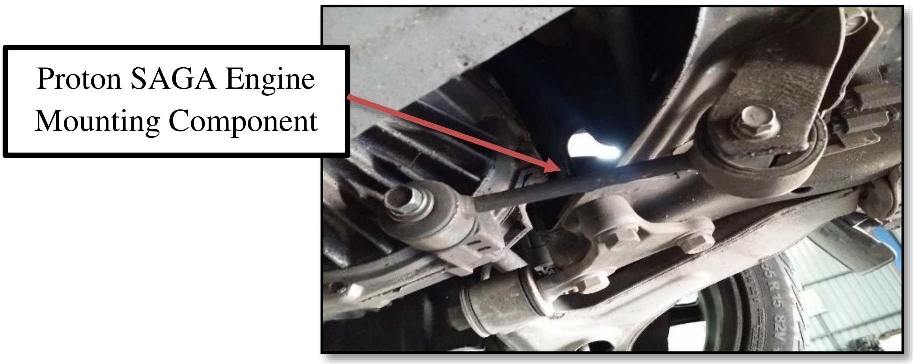

Figure 1.2: Location of Engine Mounting Component

The Finite Element Analysis (FEA) has been developed for the last twenty years as a powerful tool in various fields of product development and research. Thus, in this study FEA will be employed as the tool to carry out stress-strain analysis on the chosen engine mounting component. Figure 1.3 (Maski & Basavaraj, 2015) shows the example of analysis with meshing using FEA on engine mounting bracket. The results are correlated with the mechanical properties and the conclusions are drawn accordingly.

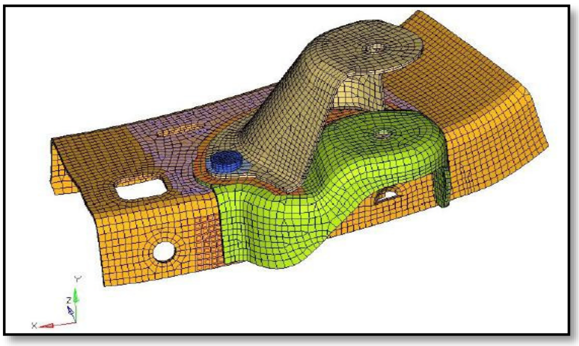

Figure 1.3: Engine Mount Bracket Analysis

Source: (Maski & Basavaraj, 2015)

1.2 Problem Statement

An automotive engine mounting component is the most important part that holds the engine to the structure or body on vehicle system. It also provides insulation to the vibration generated from the vehicle's engine to the chassis. Besides that, it holds the engine at certain position that allowing minimum movement, noise and vibration of the vehicle.

The most common problem of existing engine mounting rod is when its rubber part breaks down due to rapidly increase vibrations of the engine at different speed and various thermal load conditions. The rubber part will eventually degrade and fail over time due to high cycles of loading. A failure of an engine mount can cause an increase in engine noises and vibration. An engine mounting components has been designed to have a specific life-span. It needs to be replaced after a few thousand cycles of loading or when the noise level around the engine compartment becomes very high than its normal level. Thus there is a need to predict the life-span of the component before it causes severe damage to the vehicle.

In this project, the FEA of an engine mounting component is studied and analyzed by focusing on the effects of cyclic stresses and thermal loading for the existing two generation of segment C passenger cars. Lastly, a systematic study is required to undertake a detailed investigation in order to understand the dynamic behavior and structural characteristics of the components.

1.3 Objective

The main objective of this project is to perform FEA on the locally manufactured engine mounting component subjected to cyclic stresses and thermal loading.

1.4 Scope of Project

The computational analysis based on the FEA will be carried out on the selected design of engine mounting components. Two types of brand that were manufactured for C-Segment of passenger cars for the engine mounting component with all constant dimensions will be chosen and analyzed. The two brands of locally manufactured component chosen for the analysis are used for PROTON SAGA and PERODUA KANCIL passenger car. The scope of this project is outlined below;

1. To generate Computer Aided Design (CAD) model of engine mounting component by using the Computer Aided Three Dimensional Interactive Application (CATIA) software.

2. To perform FEA by using the CAD model of engine mounting components under the cyclic stresses and thermal loading using ANSYS software.

3. To analyze the design, optimize and compare between the two brands locally manufactured of an engine mounting component under cyclic stresses and thermal loading.

4. The stress concentration factors will be estimated based on results of FEA. The results of FEA will help to make component's refinement and optimization and also to propose improvement about its life-span.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discuss the literature study which related to locally manufacture an engine mounting component under cyclic stress and thermal loading using finite element analysis (FEA).

2.2 Type of Engine Mount Component

Basically, an engine vehicle mounting system usually consists of an engine and several mounts connected to the vehicle structure. Then, a modern engine mounting system have been used successfully to isolate the driver and passenger from noise and vibration generated by the engine when travelling in the vehicles. The noise characteristics of a vehicle are significantly affected by vibration transferred to the car body through the chassis mounting points from the engine and suspension (Michael Champrenault, 2007) . Generally, the main function of engine mount is to reduce the dynamic force and vibration. The mounting system will provide isolation that will minimize the transmitted forces from the structure body. An engine mount are expected to function in a very harsh environment such as at a very low and high temperatures combined with aggressive substances such as oil, gasoline and cleaning liquid. After that, (Yu, Naganathan, & Dukkipati, 2001) state that the entire engine mounting system is not only depends on the performance of individual mounts, but the optimum design of the whole system. However, there are different kinds of an engine mounting system that can increase the performance of power train system such as passive hydraulic mounts, active mounts and elastomeric mounts. Three different types of engine mount systems are described in the proceeding sections.

2.2.1 Passive Hydraulic Mounts

The automotive industry is widely used this type of mount because it reduces more engine vibration and noise. Moreover, (Kim, 1992) claims that the hydraulic mounts are first introduced in 1962 for use as vehicle mounting systems. The suitable function for this type of mounts for vehicles tends to be small, lightweight and front wheel drive with low idle speeds. A general schematic diagram of the hydraulic mount is shown in Figure 2.1. This mount can be tuned to have high damping at the shock excitation frequency which is used to reduce the vibration levels. Lastly, the dynamic stiffness of these mounts is usually higher than the elastomeric mounts (Y. Naganathan, 2001).

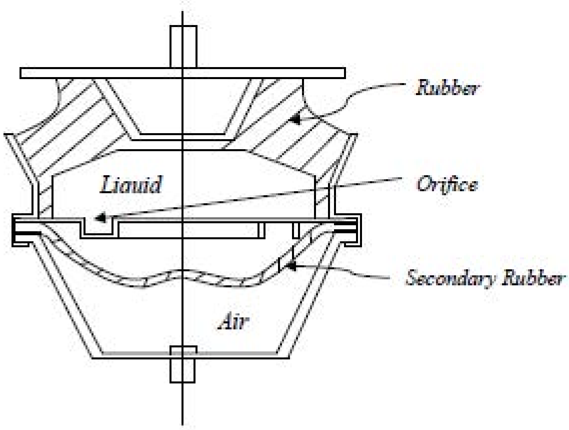

Figure 2.1: Schematic Diagram of Passive Hydraulic Mounts

Source: (J.C.Snowdon, 1968)

2.2.2 Active Mounts

Generally, active engine mount consists of passive mount and elastomer or hydraulic. It provides an effective solution to further improve the acoustic and vibrational comfort of passenger car (Hausberg, 2015). The system can be very stiff at low frequencies because the active mounts use sensors, control unit and an energy source. However, a typical active engine mounts and its control system is shown in Figure 2.2 (Jansson & Johansson, 2003) where it contains fluid as a medium of damping.