UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Topology Optimization of Engine Mounting Bracket using Altair Inspire

CHAI TAO ZHE

B091810392

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE TECHNOLOGY) WITH HONOURS

2021

Faculty of Mechanical and Manufacturing Engineering Technology

Topology Optimization of Engine Mounting Bracket using Altair Inspire

CHAI TAO ZHE

Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

2021

Topology Optimization of Engine Mounting Bracket using Altair Inspire

CHAI TAO ZHE

A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this Choose an item. entitled “Topology Optimization of Engine Mounting Bracket using Altair Inspire” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : Chai Tao Zhe

Name : CHAI TAO ZHE

Date : 18/JAN/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature : 

Supervisor Name : AHMAD ZUL HUSNI BIN CHE MAMAT

Date : 18 JANUARY 2022

AHMAD ZUL HUSNI BIN CHE MAMAT
Jurutera Pengajar
Jabatan Teknologi Kejuruteraan Mekanikal
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

DEDICATION

I would like to express my sincere gratitude to Encik Ahmad Zul Husni Bin Che Mamat, Faculty of Mechanical and Manufacturing Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM), for all of his help, guidance, and inspiration. His unwavering patience in mentoring and offering invaluable insights will be remembered by everyone who have supported my path. Prof. Madya Ts. Dr. Lau Kok Tee, the chairman of the PSM 1 and PSM 2, deserves special appreciation for all of his assistance and guidance with Chapters 1, 2, 3,4 and 5.

Take this opportunity to thank of my heart to my buddy, Lim Chia Jiang, who has selected the same supervisor as me for his encouragements and has been a pillar of strength during all of my projects. He constantly explains and advises me about my work and compares us because we have the same study concept but different themes. Finally, I'd want to express my gratitude to everyone who has helped, supported, and encouraged me to continue my education.

ABSTRACT

A car's and its components' weight is an important aspect in its performance and economy. As a vehicle's weight grows, its fuel efficiency and performance suffer. To increase an automobile's performance, parts should be less in weight and have the necessary strength. The weight of the engine mounting brackets might be reduced by changing the material of the brackets and enhancing the material removal for manufacturing the brackets. To optimise the removal of materials, a topological method was applied. In the age of the vehicle, there is a greater emphasis on decreasing fuel consumption and increasing pollution reduction, which necessitates the use of light-weight structural elements. Manufacturing operations have always been subjected to high demands due to the magnitude of output numbers. Manufacturers place a high priority on cost since there is a demand for components that improve material performance while remaining affordable. Through optimization, the objective is to reduce weight while boosting strength and stiffness. With around 95 percent of the same weight, a CAD model of the base model engine mounting bracket was recreated and constructed using CATIA V5. Altair SIMSOLID and Altair INSPIRE are used to evaluate the analysis of maximum stress and displacement to identify the ideal optimization of the engine mounting bracket utilising strong material. When compared to a based model engine mounting bracket, the researcher determined that Al6061-T6 may be used back as an engine mounting bracket material with a 10% weight reduction and the percentage of maximum stress on the engine mounting bracket has been reduced by 16.94%. The expected result of weight reduction, maximum stress and displacement were achieved in this project.

ABSTRAK

Berat kereta dan komponennya adalah faktor kritikal dalam prestasi dan kecekapannya. Ekonomi dan prestasi kenderaan berkurang apabila berat badannya meningkat. Bahagian kenderaan mestilah lebih rendah dan memiliki kekuatan yang diperlukan untuk meningkatkan prestasi kenderaan. Oleh itu, dengan mengubah bahan pendakap dan meningkatkan penyingkiran bahan untuk pembuatan pendakap, pengurangan berat pendakap pemasangan mesin dapat dicapai. Pendekatan topologi digunakan untuk mengoptimumkan penyingkiran bahan. Keperluan untuk bahan struktur ringan semakin meningkat di zaman mobil, kerana ada penekanan yang lebih besar untuk mengurangi penggunaan bahan bakar dan meningkatkan pengurangan pencemaran. Ukuran kuantiti pengeluaran secara historis meletakkan tuntutan yang ketat terhadap ketahanan proses pembuatan. Pengilang meletakkan nilai yang tinggi pada kos, kerana ada keinginan untuk komponen yang akan meningkatkan prestasi bahan dan menawarkan bahan-bahan ini dengan biaya yang berpatutan. Melalui pengoptimuman, objektifnya adalah untuk mengurangkan berat badan sambil meningkatkan kekuatan dan kekakuan. Dengan kira-kira 95 peratus daripada berat yang sama, model CAD pendakap enjin model asas telah dicipta semula dan dibina menggunakan CATIA V5. Altair SIMSOLID dan Altair INSPIRE digunakan untuk menilai analisis tekanan dan anjakan maksimum untuk mengenal pasti pengoptimuman ideal pendakap pemasangan enjin menggunakan bahan yang kuat. Apabila dibandingkan dengan pendakap enjin model berasaskan, penyelidik menentukan bahawa Al6061-T6 boleh digunakan kembali sebagai bahan pendakap pemasangan enjin dengan pengurangan berat badan 10%, dan peratusan tekanan maksimum pada pendakap pemasangan enjin telah dikurangkan sebanyak 16.94%. Hasil yang dijangkakan daripada pengurangan berat badan, tekanan maksimum, dan anjakan dicapai dalam projek ini.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank and praise to my god, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform.

My utmost appreciation goes to my supervisor, Encik Ahmad Zul Husni Bin Che Mamat, Faculty of Mechanical and Manufacturing Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM) for all his support, advice and inspiration. His constant patience for guiding and providing priceless insights will forever be remembered who constantly supported my journey. My special thanks go to Prof. Madya Ts. Dr. Lau Kok Tee, the chairman of the PSM 1 and PSM2 for all the help and guide to the Chapter 1, Chapter 2, Chapter 3, Chapter 4 and Chapter 5.

Last but not least, from the bottom of my heart a gratitude to my friend, Lim Chia Jiang, someone who has chosen the same supervisor as me for his encouragements and who have been the pillar of strength in all my project. Since we have the same study concept but different topics, he always explains and advises me about our work and compares us. Finally, I'd like to thank everyone who has assisted, supported, and inspired me to pursue my studies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

APPENDIX	TITLE	PAGE

CHAPTER 1

INTRODUCTION

1.1 Background

The engine mounting bracket is one of the important components of an engine mount assembly. Light vehicle performance has its engine supported by a bracket and this engine mounting bracket assembly is used in the chassis' front frame, which has been designed as a framework to support the engine along with the transmission member. The main function of the engine mount bracket is to properly balance the engine and transmission on the vehicle's chassis. The engine mount is an important part of the vehicle because it reduces vibration and noise, allowing for a smooth ride.

Engineers always aim at improvement in each and every part of the automobile system. The automobile industry has continued to improve for many years, with efforts conducted for the purpose of modification of the mechanical parts of vehicles in order to improve their performance response. These characteristics have a vital impact on the mechanical performance of the overall system balance. Furthermore, redesigning the mechanical models plays an important role in improving the system's sustainability against the resulting stresses and displacement, so engineers should take this into account when designing.

As a result, engineers are investigating ways to reduce the weight of the engine mounting bracket while maintaining performance. As a result, the engine mounting bracket can be made at a lower cost than the original. An optimization will be carried out to reduce the weight of the engine mounting bracket by using the topology method and improve the maximum stress and displacement.

1.2 Problem Statement

Vehicles are our primary mode of transportation for this generation. So, the quality of vehicle spare parts also needs to be taken seriously. Engine mounts have an important function of containing firmly the power-train components of a vehicle. Correct geometry and positioning of the mount brackets on the chassis ensures good ride quality and performance. To be a high-performance vehicle, the brackets on the frame that support the engine undergo high static and dynamic stresses as well as a huge number of vibrations. Hence, dissipating the vibrational energy and keeping the stresses under a predetermined level of safety should be achieved by careful design and analysis of the mount brackets. Keeping this in mind, the current paper discusses the modeling, Finite Element Analysis and mass optimization of the engine mount brackets for a car.

The main problem in engine mounting design is that of ensuring that the motions of the engine and the forces transmitted to the surroundings, as a result of unavoidable forces, are kept to manageable levels. In the case of vehicle engines, it is sometimes practice to make use of the same flexible mounts and the same location points as in the vehicle. All of these factors alter the dynamics of the system when compared with the situation of the engine in service and can cause fatigue failures of the engine support brackets.

In this project, static structural analysis was used to determine the characteristics of the engine mounting bracket. To obtain a comprehensive design, the existing model is. The modified bracket was subjected to the same analysis procedure as the original bracket, and the results were compared to both designs.Analysis of the stresses and deformations of brackets that affect engine mounting brackets, and optimization of the design to reduce the weight of the rib of the engine mounting models.

1.3 Research Objective

The main aim of this research is to examine the structural design and the materials used. The objectives are as follows:

a) To remodel the 3D design of the engine mounting bracket in the local market into a Computer-Aided Design (CAD) format.

b) To analyze the maximum stress and displacement response of the engine mounting bracket.

c) Comparison study of weight, maximum stress and displacement between the optimized engine mounting bracket and the model engine mounting bracket.

1.4 Scope of Research

This scope of this research are as follows:

a) To study the engine mounting bracket that is used in the C-segment in the local market.

b) To remodel the actual engine mounting bracket into a CAD format by using CATIA V5.

c) To analyze the maximum stress and the displacement of the engine mounting by using different materials, including gray cast iron, aluminum alloy and magnesium alloy materials, by using ALTAIR SIMSOLID.

d) Weight is reduced by 10% to 20% to optimize the engine mounting bracket.

e) To reduce the percentage of maximum stress of engine mounting bracket by 15%.

f) To perform organic shape comparison between 10% to 20% weight reduction.

1.5 Rational of Study

The rational of study of this research are about:

a) To optimize the structural design and the material used for the engine mounting bracket.

b) The engine mounting bracket structural architecture needs to be improved in order to strengthen maximum stress and displacement, which is better than the model engine mounting bracket.

c) Able to achieve a light weight with good performance in terms of maximum stress and displacement.

d) To make the product more cost-effective

1.6 Expected Result

At the end of the research, the expected result must be achieved as follows:

a) Reverse engineering close to 95 - 100% actual product.

b) A better maximum stress and displacement light weight material which gives between 10% to 20% weight reduction compared to the based model engine mounting bracket.

c) The percentage of maximum stress on the engine mounting bracket has been reduced by 15%.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In a society with advanced science and technology, science and technology play a role in life. For example, cars are a necessary means of transportation for everyday use. Because of the limited resources for vehicle growth, many automakers design a wide variety of cars, but the main goal is to reduce fuel consumption and air pollution. Not only that, the need for light weight structural materials in automotive applications is increasing as the pressure for improvement in emissions. The most effective way of increasing automobile mileage while decreasing emissions is to reduce vehicle weight. Because of the emphasis on cost, component manufacturers have been forced to improve the performance of their materials and find ways to deliver these materials at a lower cost.

2.2 History of the Engine Mounting Bracket Mechanism

The engine mounting bracket plays an important role in reducing engine noise, vibration, and harshness, and thus plays an important role in improving vehicle comfort.The first and foremost function of an engine mounting bracket is to properly balance the power pack on the vehicle's chassis for good motion control as well as good isolation. A longitudinal system that protects other elements of a physical structure is an engine mounting bracket. One of the most important phases in the creation of a modern vehicle is design. The engine mounting bracket is the vehicle's front assembly, which must hold all of the parts and sustain all of the motor and transmission loads.

These loads include the weight of each component and the forces which manifest during acceleration, deceleration and cornering. Therefore, the engine mounting bracket is

considered to be the most important element of the vehicle as it holds all the parts and components together. Having a well-designed engine mounting bracket is important to ensure safety and good performance.

2.3 Types of Engine Mounting

2.3.1 Solid Engine Mounting

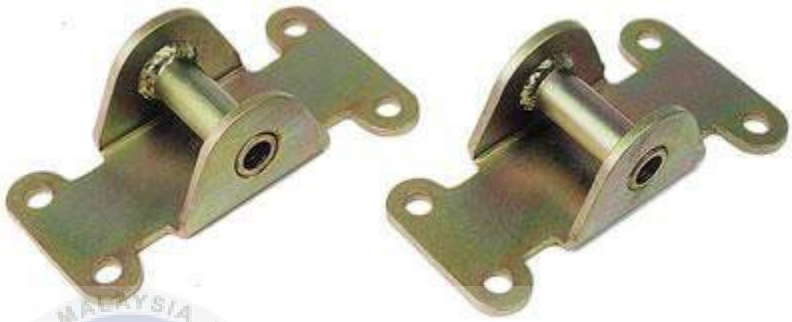

Figure 2.1 Solid Engine Mounting

Since these all-metal mounts don't have any rubber or polyurethane, solid engine mounting is the least accommodating. Because solid engine mounting allows for metal-on-metal interaction, it allows for the most vibration and noise.However, since solid engine mounting bends very little under load, solid engine mounting often passes the most strength to the wheels. (David Fuller, 2016)

2.3.2 Hydraulic Engine Mounting

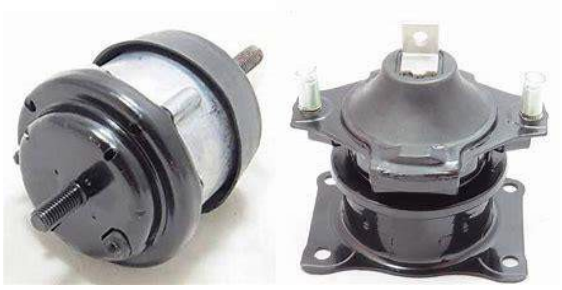

Figure 2.2 Hydraulic Enigne Mounting

Hydraulic engine mounts have an empty area filled with hydraulic oil, which is normally a glycol/water mixture. The mounts must withstand two types of vibration in comparison to supporting the engine:

- Low frequency vibration is caused by shock oscillation, such as fast acceleration or stopping and driving on rough surfaces.
- Unbalanced engine forces, such as firing pulses or other mass imbalances between rotating or exchanging engine components, cause high frequency vibration.

(David Fuller, 2016)

2.3.3 Rubber Engine Mounting

Figure 2.3 Rubber Engine Mounting

Rubber engine mounts, such as those supplied by the manufacturer, have the best friction and noise dampening properties. The old rubber-style mounts, on the other hand, have a few