CHONG SHENG WAH BACHELOR OF MECHANICAL ENGINEER (DESIGN AND INNOVATION) 2015 UTeM

TOPOLOGICAL OPTIMIZATION OF VEHICLE JACK FOR WEIGHT PERFORMANCE

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This report is submitted in fulfilment of the requirements for the award Bachelor of Mechanical Engineering (Design & Innovation)

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DECLARATION

"I hereby declare that the work in this report "TOPOLOGY OPTIMISATION OF VEHICLE JACKS FOR WEIGHT PERFORMANCE" is my own except for summaries and quotations which have been duly acknowledge."

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ABSTRAK

Pada masa yang terkini, industri automotif telah menumpukan kepada berat kenderaan kerana kajian menunjukkan bahawa kenderaan yang ringan dapat menjimatkan minyak. Oleh itu, kebanyakan kajian tertumpu kepada mengurangkan berat kereta melalui reka bentuk struktur kenderaan. Bahan binaan kereta dam struktur turut dikaji selidik untuk menghasilkan produk yang paling ringan. Model yang dipilih dalam kajian ini ialah jek kereta kerana berat jek kereta ini akan meningkatkan beban kereta secara tidak langsung. Oleh itu, teknik pengoptimuman topologi digunakan untuk mengurangkan berat jek kereta. Bahan asal dikenal pasti sebagi keluli. Akan tetapi, cara yang paling baik untuk mencapai pengurangan berat ialah menggunakan cara pengoptimuman topologi. Reka bentuk jek kereta dilukis dengan menguunakan CATIA V5R20 supaya ia dapat dioptimumkan dengan menggunakan perisian Altair Optistruct. Dalam Optistruct, ia mencadangkan reka bentuk jek kereta supaya berat jek kereta dapat dikurangkan dengan berkesan. Analisis statik linear turut dijalankan untuk mengkaji ketahanan jek kereta selepas daya dikenakan ke atas jek kereta tersebut. Berat asal jek kereta ialah 2.5 kg dan selepas ia dioptimumkan, berat jek yang baharu telah dikurangkan kepada 2.22 kg atau sebanyak 11%.

ABSTRACT

Nowadays, automotive industry is focusing more on lightweight vehicle because the weight of the vehicle can affect efficiency of the car itself. Therefore, to improve the weight of the car, it is a good idea to design a vehicle, which is high efficiency and lightweight by doing the research on material of existing car so that other material could be used to replace the existing material. Besides that, the structure of the car can be change so that it can achieve the target of lightweight vehicle. In this project, scissor car jack is chose as the subject that its weight should be reduced so that at the same time it can reduce the burden of the car. Moreover, topology optimization technique is used to solve the weight reduction of scissor car jack. The material of the existing scissor car jack will not be change in order to reduce the weight of the scissor car jack in the aspect of topology optimization only. The scissor car jack is developed to 3D model before it can be optimized using the Altair Optistruct software. The design of the scissor car jack will be recommended from the software after the constraint and boundary conditions are set in the software. Linear static analysis is performed to study the deflection of the scissor car jack after a set of load is applied on the jack. In this project, the design constraints are displacement and stress while the objective function is volume fraction of the model. Lastly, the original weight of the scissor car jack is 2.5 kg and after it undergoes topology optimization, the weight of the new design is 2.22 kg where the weight of the original design is reduced around 11%.

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LIST OF NOMECLATURE

AMSES	-	Automated Multi-level Sub-structuring Eigen Solver
BDOT	-	Big Design Optimisation Tool
CAD	-	Computer Aided Drawing
DOFs	-	Degree Of Freedom
DOT	-	Design Optimisation Tool
F	-	Force
FEM	-	Finite Element Method
ISE	-	Isotropic Solid or Empty
NVH	-	Noise Vibration Harshness
RON	-	Research Octane Number
SIMP	-	Solid Isotropic Material Penalization
FBD	-	Free Body Diagram
RBE	-	Rigid Body Element
QUAD	-	Quadrilateral
TRIA	-	Triangle

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Based on the research done by The Information Centre For and About The Global Auto Industry (WARDSAUTO), the numbers of vehicles have surpassed 1 billion since 2010 and it is obviously to see that vehicle is essential for human being since there are many benefits of vehicle.

Vehicle is the transportation of property or people from a place to a place and it brings many ease to people by reducing the usage of time to reach a destination or transferring property therefore the demand of the car increases annually. Uprising of the industry of automotive has also bring up the industry of oil and gas. Fuel is very important because it acts as the source of energy of the vehicle.

In Malaysia, Research Octane Number (RON) 95 is introduced from the year of 2009 and it costs RM 1.75/litre. At 2011, the price of the RON 95 is RM 1.90/litre and it is increased to RM 2.10/litre on 2013. Then the price continues to raise until RM 2.30/litre on 2014. There is a dramatic increase in the fuel price due to demand is higher than supply thus it is important to reduce the fuel consumption of the vehicle. There are many ways to reduce the fuel consumption of the vehicle but the most effective way is to consider the weight of the vehicle.

So far, lightweight vehicle is the most successful production nowadays with the approach from topology optimization. This optimization method would be applied on scissor car jack because it is the component that can be found in boot of the car. Scissor car jack is a mandatory component in the car which cannot be neglected for emergency purposes. Its function is to lift up the car to ease the user while changing the tyre that has problem. Thus, this study will focus on reducing weight of the scissor car jack by using topology optimization.

1.1 PROBLEM STATEMENT

Fuel is the power source for a car to function yet it can be diminished in one day. Hence, it is important to save the fuel consumption. There are many methods taken to save the fuel consumption, such as change the car shape, reduce the car weight and improve the car engine. In fact, fuel consumption is affected by the weight of the car since the heavier the car, the more the power required to move a car.

Furthermore, the most common example that we could encounter is, the existence of the vehicle jack which may cause the difference in the fuel usage. When the car jack is removed from the boot of the car, the weight of car would be reduced and it may bring down the fuel consumption as well. Therefore, the easiest way is to

reduce the weight of the car jack that can be found in car boot and it is used to lift up a car when changing tyre. Software of Optistruct is the analysis solver that can be used to solve problems under static and dynamic loadings for a lightweight design and it can be used to improve the weight of the car jack by reducing the volume of the car jack without changing the layout of the carjack.

1.2 OBJECTIVE

To reduce the weight of an existing car jack using optistruct software for reducing fuel consumption.

1.3 SCOPE

To develop a 3D design of car jack using CATIA V5 R20 and get the best layout of the car jack that facilitated by Optistruct with the given set of load and boundary condition. Linear static analysis of the structure and optimize the topology using optistruct.

1.4 COMPONENT OVERVIEW

Car jack is a mechanical jack and device that helps human to lift a vehicle by manual force alone. Scissor car jack as shown in Figure 1.1 is a standard equipment where can be find in the boot of every car because it plays an important role when there are emergency. User can use it to lift the car up and change the tyre in the middle of road. The mass of the scissor jack is in the range of 2.5 kg and it is easy to use and small enough to store in the boot. However, there are many types of scissor car jack and it can be categorizes according to the load that it can support. There are 1 ton, 1.5 ton, and 2 ton of car jack where it is based on the weight of the car.

Figure 1.1: Scissor car jack (Source: Banzai Ltd, 2010)

Table 1.1 Description of the model of the scissor car jack (Source: Banzai Ltd, 2010)

Model	P-10
Capacity	600 kg
Minimum height	100 mm
Maximum height	390 mm
Mass	2.5 kg

From the Table 1.1, it shows that the maximum load that can be supported by the car jack is 600 kg and it has mass of 2.5 kg. Height of the car jack is defined as the height from the ground until the loading bracket. In this project, the scissor car jack chosen is the same as the research that done by Mehmet Bariskan in 2014.

1.5 FLOW CHART

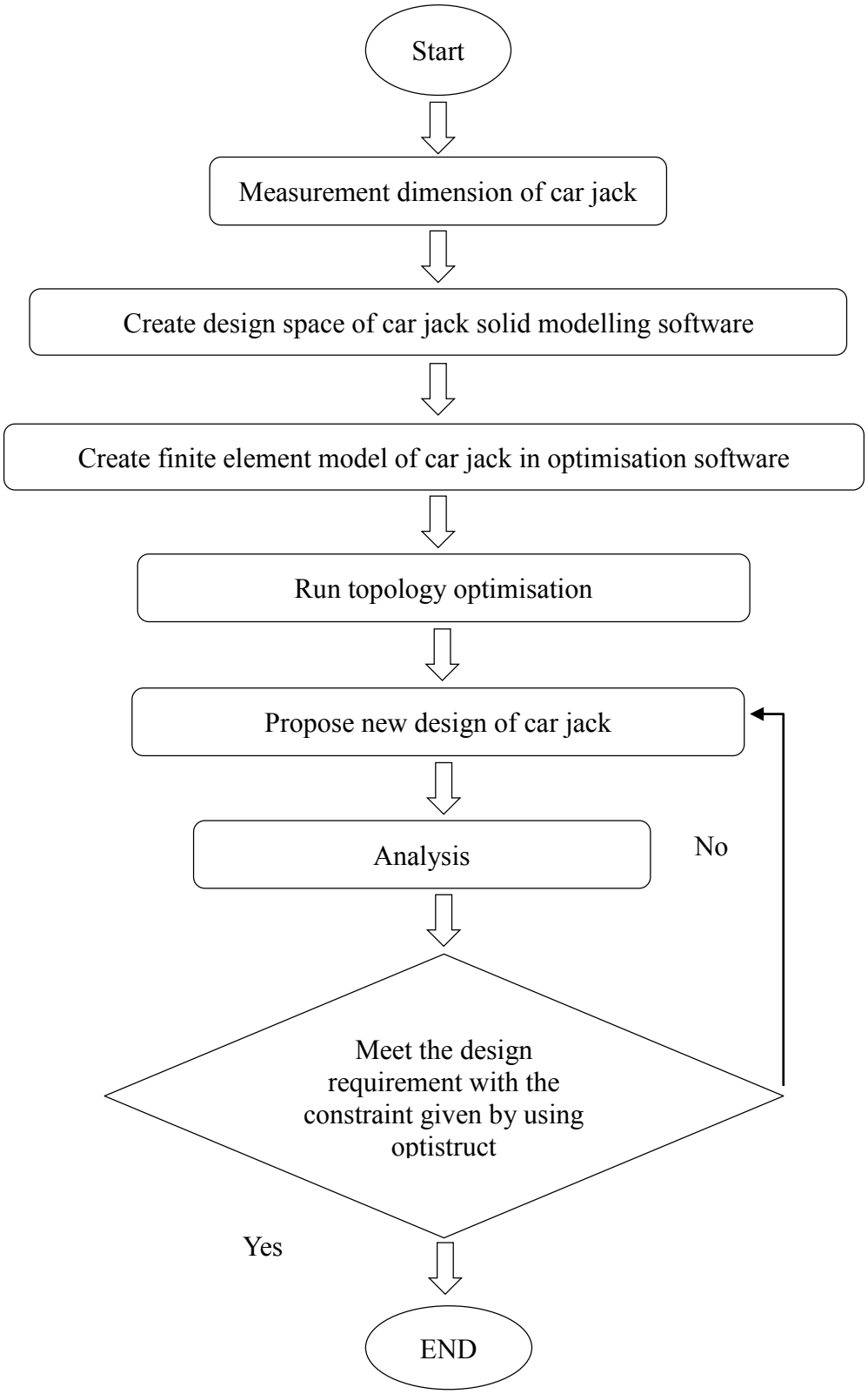

Figure 1.2: Flow Chart of the Project