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DESIGN OF ENGINE MOUNTING FOR SINGLE SEATED EDUCATIONAL RACING VEHICLE

M. I. S. Sukri[1], F. A. Munir[1], M. Z. Hassan[2], F. Syahrial[1], R. Adnan[1] and D. Sivakumar[1]
[1]Centre of Advanced Research on Energy (CARe), Universiti Teknikal Malaysia Melaka, Malaysia
[2]Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka, Malaysia
E-Mail: fudhail@utem.edu.my

ABSTRACT

The power train system for a single seated educational racing vehicle is consists of an engine and a transaxle. This power train unit is attached to the chassis frame of the vehicle. Therefore, it is desirable that both the engine and transaxle can be easily installed to the vehicle chassis frame. For a racing vehicle for educational competition, an adjustable engine mounting system is provided to allow for fine adjustment of the engine position and the transaxle. The alternative term for transaxle is called as the chain tension that includes a selective lock-out feature. This feature allows an operator to lock out the selected forward or reverse gears to alter the vehicle performance during racing. In this work, three design of engine mounts for the use of single-seated educational racing vehicle are proposed. The design process is carried out using CATIA V5 educational software. Once all the proposed designs of the engine mounts are completed, Finite Element Analysis (FEA) is performed. Furthermore, a modal analysis using ANSYS Workbench Release 16.0 is also conducted to determine the natural frequency of the component. The results suggest that the best design of engine mount is Design 2. This selection is based on the low natural frequency of the component.

Keywords: engine mounts, single-seated racing vehicle, finite element analysis.

INTRODUCTION

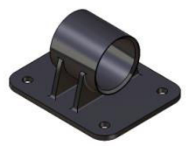
The arrangement of a single seat race car has remained the same since 1960s [1]. A vehicle designed for a race is normally driven on its limit [2]. Therefore, each part of the vehicle is customized to optimize the performance. Modification can be performed on several parts such as the internal combustion engine and body aerodynamics [3] [4]. The power house of this type of racing vehicle is a single cylinder motorcycle engine. The maximum allowable engine volume displacement is 135 cubic centimetres (cc). Engine mounts are needed to attach the engine to the chassis frame of the vehicle. Therefore, appropriate engine mounts are essential to be designed and fabricated. The main function of the engine mounts is to reduce or absorb engine vibration [5] [6]. There are number of methods that have been utilized to minimize engine vibration, namely passive, semi-active and active method. Magnetorheological Elastomer (MRE) engine mounts are the latest innovation pursued by many researchers [7] [8]. The design of the engine mounts can be optimized generally by tuning the natural frequency of the part. In this projects, three designs of engine mounts for the use of single-seated educational racing vehicle are proposed. The design process is carried out using CATIA V5 educational software. Finite Element Analysis (FEA) and modal analysis were performed to determine maximum stress and natural frequency of the engine mounts.

DESIGNED OF ENGINE MOUNTS

The engine mounts are designed by using CATIA V5 software. The dimension of the engine mount is designed in a way it can fit the engine bay of the chassis frame of a single-seated racing vehicle. Engineering analysis has been conducted on all the proposed design to determine the maximum stress and displacement.

Two types of analyses have been carried out to obtain the data for the design stage. These analyses are Finite Element Analysis (FEA) and Modal Analysis, which were performed to determine von-Misses stress, maximum displacement and natural frequency. The final design will be selected that depends on obtained data.

Table-1. Proposed design of engine mounting.

Design 1	
Design 2	
Design 3	

RESULTS OF FINITE ELEMENT ANALYSIS

The designed engine mountings have cylindrical surface since the damper used for the mounting are in cylindrical shape. Table-2 shows the clamping and the load area for all the design of engine mounting. In this analysis, the load is assumed to be a bearing type. This assumption is due is because the surface is a cylindrical shape. The engine type that will be used to power racing vehicle is a 135cc motorcycle engine, which as an

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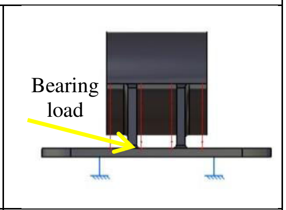
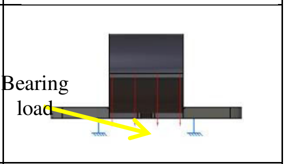
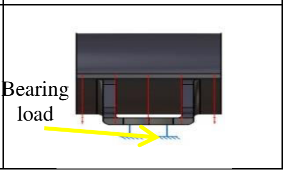
estimated weight of 20kg Therefore, the load that applied on the cylindrical surface is assumed to be approximately200N. This load value is roughly equivalent to the total engine weight.

Table-2. Location of clamping and applied load.

<table>
<tr><th colspan="3">Clamping and the forces area</th></tr>
<tr><td>Design 1</td><td></td><td></td></tr>
<tr><td>Design 2</td><td></td><td></td></tr>
<tr><td>Design 3</td><td></td><td></td></tr>
</table>

The results of finite element analysis in terms of von Misses stress and maximum displacement for all designs are presented in Table-3 and Table-4 respectively.The results for maximum von Misses stress of the design 1 is 2.88 MPa while Design 2 and Design 3 are 66.0 MPa and 31.0 MPa, respectively. Based on these result, the von Mises stress value is acceptable since the value is not more than the yield strength value of steel which is 250 MPa. On the other hand, the maximum displacement forDesign 1, Design 2 and Design 3 are0.000137 mm, 0.0266 mm and 0.000172 mm respectively.

Table-3. Von-misses stress for all the designs.

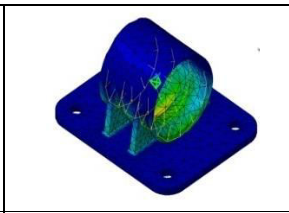
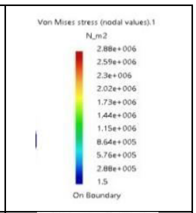
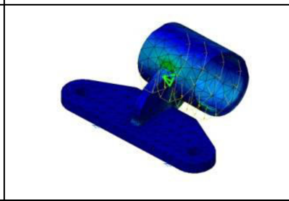
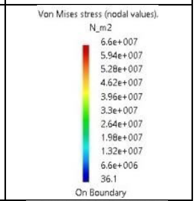
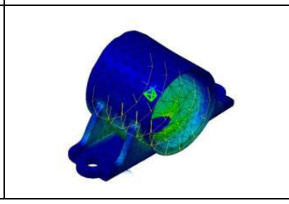
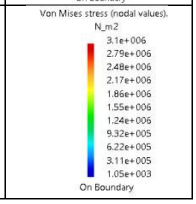
<table>
<tr><td>Design 1</td><td></td><td></td></tr>
<tr><td>Design 2</td><td></td><td></td></tr>
<tr><td>Design 3</td><td></td><td></td></tr>
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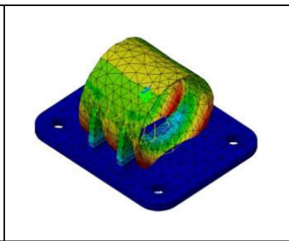
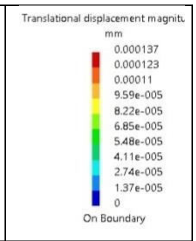
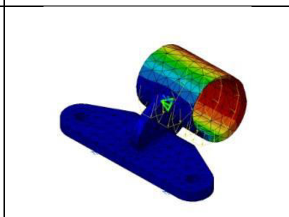
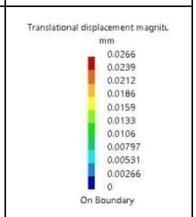
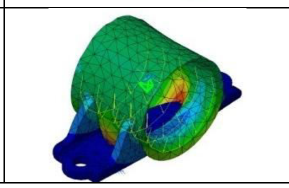
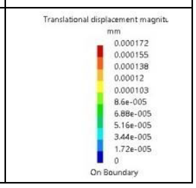
Table-4. Maximum displacement for all the designs.

<table>
<tr><td>Design 1</td><td></td><td></td></tr>
<tr><td>Design 2</td><td></td><td></td></tr>
<tr><td>Design 3</td><td></td><td></td></tr>
</table>

RESULTS OF MODAL ANALYSIS

A modal analysis was performed in ANSYS Workbench 16.0 to determine the natural frequency of all three designs. The obtained mode shapes contours were are shown in Table-5 while Table-6 depicts the numerical values of the natural frequency.

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Table-5. Results of mode shape comparison for all the engine mounting designs.

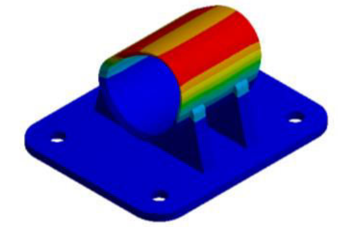
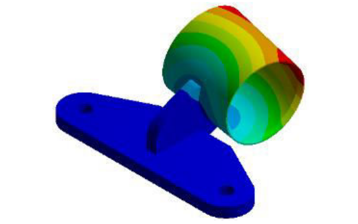
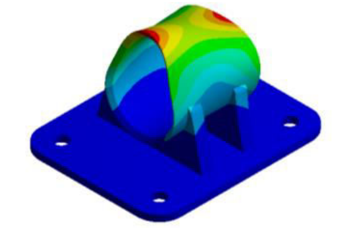
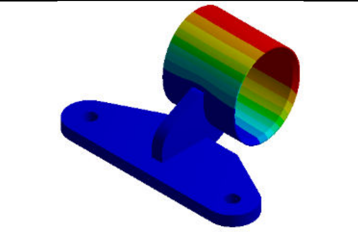
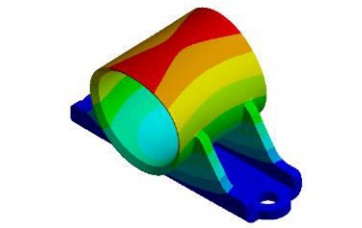
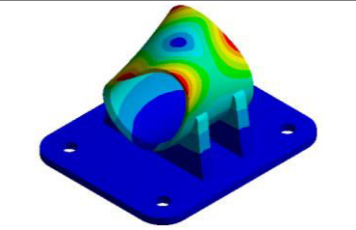
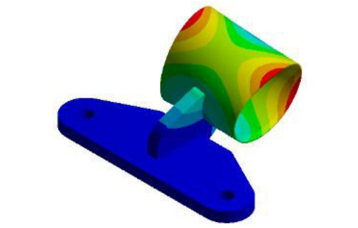
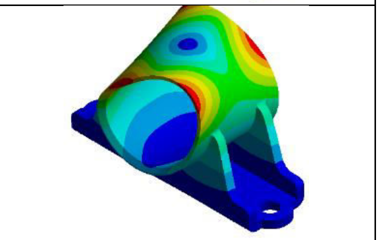
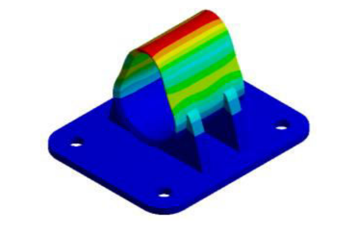
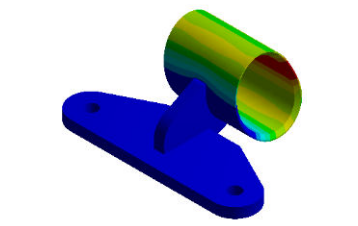
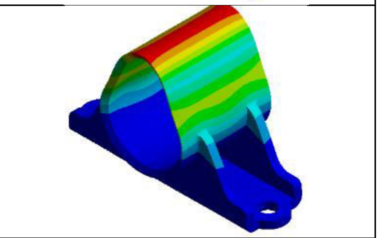
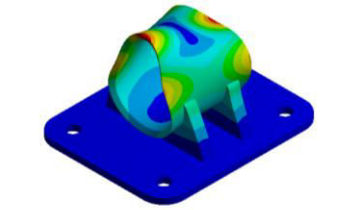
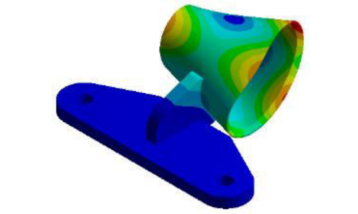
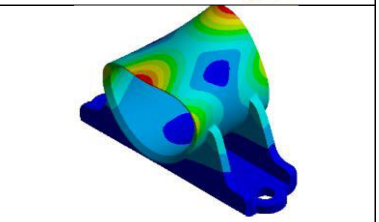
Mode Shape	Design 1	Design 2	Design 3
1			
2			
3			
4			
5			

Table-6. Numerical values of natural frequency for each of proposed design of engine mounting.

Mode shapes (1-5) mounting bracket			
Frequency	**Design 1** (Hz)	**Design 2** (Hz)	**Design 3** (Hz)
1st	4960.10	1352.90	5042.10
2nd	8386.90	1690.10	6031.70
3rd	10335.00	2831.20	8503.60
4th	10447.00	4485.10	10603.00
5th	12964.00	5977.00	10823.00

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Table-6 shows that Design 2 engine mount has the lowest natural frequency for each mode. Meanwhile, the values of von-Misses stress for all proposed designs are significantly lower than the yield strength of steel. Furthermore, the maximum displacement for Design 1, Design 2 and Design 3 engine mounting are less than 1mm, which is considered as acceptable. Since Design 2 engine mount has the lowest natural frequency, the design is deemed appropriate to be selected for the use of single seated educational racing vehicle.

CONCLUSIONS

The design and finite element analysis of engine mounting for the use in a single seated vehicle for educational racing have been successfully demonstrated. Design 2 is selected as the most appropriate design to be fabricated and utilized as engine mounts for the single-seated racing vehicle.

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