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Design and Development of Light Weight Engine Mounting for UTeM Formula Varsity Race Car

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Abstract. This manuscript provides the design of the engine mounting for Formula Varsity Race Car. Several concept designs were generated for the engine mounting and the final design was selected through in 3D modeling software namely CATIA V5 CAD software during the design phase in this project. The Aluminum Alloy 6061 T6 was selected as the lightweight engine mounting material due to high strength, light weight and versatility with many manufacturing processes. The light weight engine mounting was analyzed using finite element analysis in bending and yield strength cases. The result of the engine mounting analysis showed that the engine mounting is able to perform safely as per design requirement.

Introduction

Formula Varsity race event is a student competition based on product they designed and fabricated of the race car. This concept of event also came from SAE championship held in UK, America and Canada but in Malaysia but in Malaysia events have different rules in terms of total capacity engines are used. In developing the race car many critical part system are considered such as brake system, chassis, powertrain system, engine system, electrical system, steering system and suspension system [1].

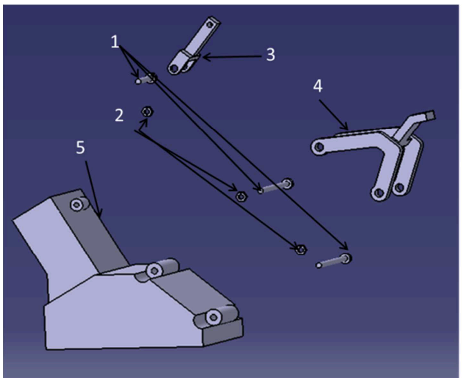
By focusing on the engine mounting to attach on the engine system and pivot to chassis assembly. The engine is one of the important parts in the vehicle where the engines produce the torque to propel the vehicle. While the engine is utilized to drive vehicle, the engine will produce the vibration which the vibration will give the large impact on the structure of the vehicle chassis. In order to overcome this problem the engine mounting was developed to absorb the vibration.
There are three types of engine mounting such as passive, semi-active and active engine mounting that typically used in the automotive sector. Focused on the engine mounting of Formula Varsity Race Car, the new light weight engine mounting was proposed in order to reduce the vibration that produced by engine. The concept design of the new engine mounting was modelled in 3D design software and analysis of design concept using the Von Mises Stress. The analysis result was evaluated on the maximum stress and yield strength critical pivot of engine mounting to chassis.

Acknowledging that engine mounting is one of the most crucial components for a car, the aim of the project was to design and develop a light weight engine mounting which is able to perform safely as per intended application. This paper describes the design process of developing the light weight engine mounting for UTeM Formula Varsity race car.

Engine Mounting Design

The development of the UTeM Formula Varsity race car light weight engine mounting started with evaluation of the location engine on the chassis. The design of the engine mounting will start measure the parameter with the engine should be mount on the chassis with stand. Based on the Rules and Regulations Formula Varsity 2010, the engine must be originated from motorcycles manufacturer and assembled in Malaysia [2]. The volume displacement of the engine is less than or equal to 135 cubic centimeter. The engine of Yamaha LC-135 was selected for UTeM Formula Varsity race car. In designing the engine mounting to the chassis, the dimension of located engine mounting should be measure in order to get an accurate parameter.

Conceptual design is an essential step in product development process. The main concept for engine mounting is to reduce the vibration to chassis, reduce the weight of engine mounting and perform in material selection. For this task, the design and manufacture of the race car was based on reducing weight of engine mounting and easy to manufacture concept. The main idea behind this concept is that the design and fabrication can be replicated with ease [3]. This was made possible due to the minimal fabrication needed in producing the engine mounting and with minimal use of components. Another factor that contributes to this engine vibration to the chassis of the car is by using rubber pad for reducing the vibration. This method are used in the standard car to make the driver comfortable when their driven [4].



1. Bolt 12mm diameter.
2. Nut thread 12mm inner diameter.
3. Upper bracket mounting.
4. Front bracket mounting.
5. Engine LC135

Fig. 1, Exploded 3D Design of Engine Mounting

Material Selection

As stated in the UTeM Formula Varsity 2010 Rules and Regulations, only the chassis material is only allowed to be constructed from ferrous metals as the basic material. Thus, aluminum alloy 6061 T6 was selected as the material for the light weight engine mounting due to light weight, ease to manufacturing and good structural properties. The material properties for the aluminum alloy 6061 T6 are shown in Table 1. The material properties was defined and evaluated from the CES Edu Pack 2010 which to know the minimum and maximum value of the each material properties.

Table 1, Aluminum alloy 6061 T6 material properties [5]

Material Properties	Value
Density	2.5×10^3 2.9×10^3 kg/m^3
Yield Strength	50 MPa – 310 MPa
Young Modulus	73 GPa – 89 GPa
Tensile Strength	58 MPa – 550 MPa
Fatigue Strength at 10^7 Cycle	21.6 MPa – 157 MPa

Engine Mounting Analysis

In designing the engine mounting for UTeM Formula Varsity race car, there are two load cases are required to be analyzed to determine the engine mounting rigidity, which is static bending and yield strength. Baseline static analysis was conducted using the CATIA V5 Generative Structural Analysis Module. All components in the assembly (front and upper bracket) were modeled as solid elements. Although it is common to model sheet metal parts as shells in forming analysis, these components are fairly thick (10 mm) and for structural analysis it can modeled as solid.

For the static bending analysis, the total load acting on the engine mounting structure is assumed to 30 kg which defined from the weight of the engine. In addition, with the value of the force at the bracket holes should be in search of a manual calculation because the hole accommodate in front engine. The calculations for force acting on each hole of engine mounting are shown in Figure 2 below.

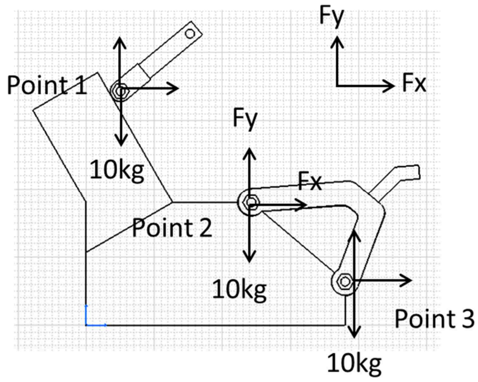


Fig. 2, Free body diagram of front engine mounting point.

From the Figure 2 above, the total force at point 1 was calculated by assuming the weight at the point 1 is 10 kg. The angle of bracket mounting to be mounting on the chassis is 60 degree. The calculation for the point 1 has been described below.

$F_x = 0$

$F_y = mg$ (1)

$Fy \sin 60^o = 9.81\ (10\ kg)$

$Fy = \frac{98.1\ N}{\sin 60}$

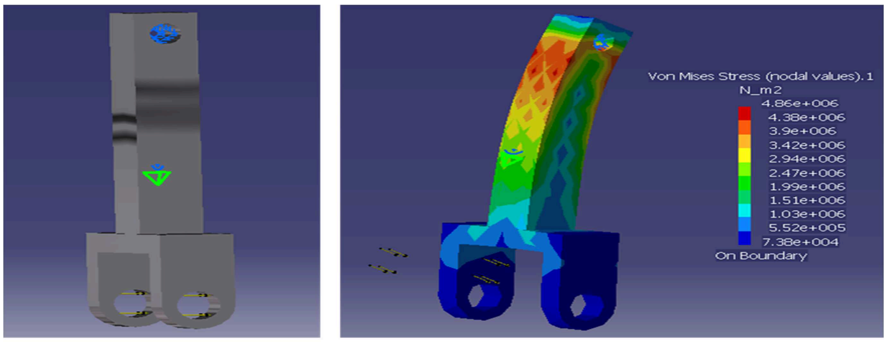
$Fy = 113.28\ N$ $\quad$ $Fy = Ft$

$Ft = \sqrt{fx^2 + fy^2}$

$= \sqrt{0^2 + 113.28^2}$

$= 113.28\ N$

A Von Mises stress map is shown in Figure 3 for the Y loading condition of -113.28 N. The maximum Von Misses stress is 3.67 MPa and is less than the minimum initial material yield strength of 50 MPa material. The stresses on the front bracket mounting are only 92.66% of the material yield strength making them the target components for weight reduction.



(a) (b)

Fig. 3, (a) Location of load and constraints for bending analysis, (b) stress distribution result of the front bracket engine mounting.

The rear bracket mounting is located at the rear engine section. The analysis of the rear bracket mounting involves calculations of loading and stresses shown in Figure 4 below. The result of these analyses will verify the strength of material required. The Aluminum Alloy 6061 T6 which has a yield and ultimate strength of 500MPa and 550MPa. The calculation of upper bracket mounting is defined in Figure 4 below (equation 2 and equation 3).

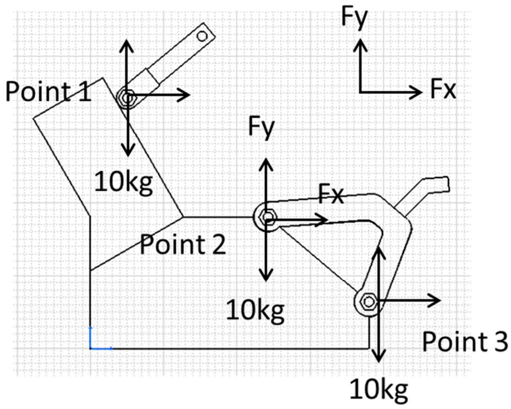


Fig. 4, Free body diagram of rear bracket mounting.

The calculation for point 2 and 3 is same procedure with point 1 but the angle at point 2 and 3 is different where both angle at point 2 and 3 are 70 degrees and 45 degrees from the position of the rear bracket mounting.

At point 2 (Rear Bracket Mounting)

$$Fy = mg \tag{2}$$

$$Fy \sin 70^{o} = 9.81\ (10\ kg)$$

$$Fy = \frac{98.1\ N}{\sin 70}$$

$$Fy = 104.4\ N \qquad Fy = Ft$$

$$Ft = \sqrt{fx^2 + fy^2}$$

$$= \sqrt{0^2 + 104.4^2}$$

$$= 104.4\ N$$

At point 3 (Rear Bracket Mounting)

$$F_x = 0$$

$$Fy = mg \tag{3}$$

$$F_y \sin 45^{o} = 9.81\ (10\ \text{kg})$$

$$F_y = \frac{98.1\ N}{\sin 45}$$

$$F_y = 138.73\ \text{N} \qquad F_y = F_t$$

$$F_t = \sqrt{fx^2 + fy^2}$$

$$= \sqrt{0^2 + 138.73^2}$$

$$= 138.73\ \text{N}$$

From a static loading requirement perspective, the new legs easily meet the maximum stress criterion of 70% of original yield strength.

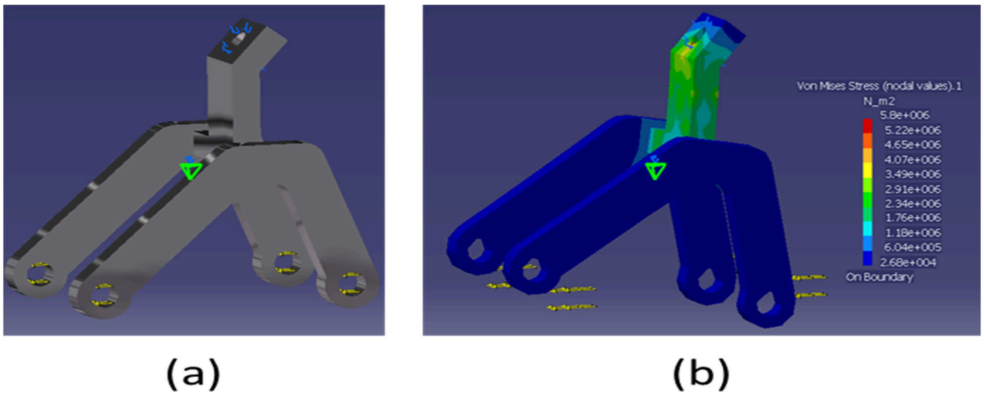


Fig. 5, (a) Location of load and constraints for bending analysis, (b) stress distribution result of the rear bracket engine mounting

The analysis result showed that the designed light weight engine mounting using aluminum alloy 6061 T6 is able to perform safely as per design requirement. The factor of safety in static bending for both front and rear bracket mounting were 13.6 and 8.87.

Conclusion

In conclusion, the new light weight engine mounting for UTeM Formula Varsity race car was developed in this project. Finite element analysis is the utilized to define the structural performance of engine mounting for intended application. The result of analysis showed that the light weight engine mounting is able to perform safely as per design requirement.

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