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DEVELOPMENT OF ELECTRIC FORMULA VARSITY RACE CAR FOR GREEN CAMPUS

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FACULTY OF MECHANICAL ENGINEERING
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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ABSTRACT

(Keywords: *Electric car, Formula Varsity; Race car*)

Among of motorsports events, the Formula Varsity organize by University Teknikal Malaysia Melaka (UTeM) is the most popular motorsports for higher education institutions. Formula Varsity was held once for two years. The main objective of this project is to design and develop a Electric Formula Varsity Race Car that consist of several components such as driver's cockpit, the strength and lightweight for the new design of control arm, the nose cone, and knuckle racing electric ear with high performance and reliability for the upcoming Formula Varsity race. Methods used for this project in accordance with the engineering design process and engineering software. The result of this project, a driver cockpit will be developing. At the end of this project, a new better cockpit and can satisfy the driver when use it will be develop and will be used for the next series of Formula Varsity race. The aspect of handling performance cannot be missed. Fabricating new design of control arm will need an initial view of the detail design. CATIA is 3D CAD modelling that help to create and develop a new design of control arm. With this software, the embodiment design for detail drawing can be done early and help us to proceed to fabricating process based on the clear dimensions to be measure on the element of fabricate. To check the effect of camber angle and other suspension geometry aspect for this project analysis, Adams/View providing a Real-time analysis for kinematics and dynamics analysis. The final fabrication will be test in real world to check the reliability and quality of the control arm. Development consisting on designing, analyzing and fabricating the nose cone section. The design must be tested for its aerodynamic in virtual and real world analysis using Ansyst-FLUENT software that been add-on into CATIA V5R20 designing software. The 3D model also will be generated to a scale. The best design will be mounted onto the Electric Racing Car for Formula Varsity 2012 event.

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1.0 INTRODUCTION

Formula university is an event for teams of student to be applied their knowledge and skills for design, build, test, and race a small-scale formula style racing car. The development process include base theory of Automotive Engineering subject for car building by following all safety measure of automotive rules.

It also challenges the students to design, manufacture and race their single seat open-wheel formula style racing car in real track condition. This event is inspired by similar student based formula style racing events such as Formula SAE and Formula Student. The aim of the event is to provide a platform for Malaysian students with interest in motorsport engineering to put into practice their engineering knowledge and skills in developing a working model of a formula style racing car. The event hope to foster the tie and collaboration between all Malaysian and international higher education institutions especially among the students as well as to help create the needed competent human capitals for our country automotive industries.

Just like Formula SAE event, the students must complete their racing car by themselves with help from lecturers and technicians. The student should manage the team's money in building the racing car and also finding sponsor for additional finances. The students also have to present their marketing strategies to the judges on how they manage their financial system and sponsorship. By this means, Formula Varsity is an event not only applied the students' knowledge of engineering, but also applying the students' knowledge of financial and marketing.

Formula Varsity event is an event that uses internal combustion engine taken from motorcycle under 135 cc. The engine must have single cylinder and a carburetor. The only allowed fuel to be used as the racing fuel is petrol.

For Formula Varsity 2012, our team has been given a task to develop a Single Seated Electric Formula Varsity Racing Car. This racing car will use electric engine to replace conventional internal combustion engine that been used in recent Formula Varsity events. The electric racing car will used an approximately 10 kilo Watt

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electric motor with equivalent horsepower of 12 HP that as same as another 135 cc internal combustion engine.

For an electric racing car, the car must be light to avoid too much load to be put on the electric motor. This is because, if higher load is given to the electric motor, higher power consumption the motor will take. If the power consumption for the motor is high, more battery should be inserting on board the racing car and this will add more weight onto the car.

For these events, we are focusing in building lighter race car than the normal weight of the race car before. So, the new design must have considered the aspect of aerodynamic and weight of the front nose cone. To achieve the best aerodynamic for the Single Seated Formula Varsity Electric Racing Car, all the aspect should be taken into consideration. Aspects like the angle of attack of the front nose cone and wind displacer are essential in assuring that the racing car stay on the ground while traveling in high speed and high velocity wind. The racing car aerodynamic helping the car to travel in high speed much more stable and avoid the racing car from having a lift off from the ground.

Formula university is an event for teams of student to apply their knowledge and skills for design, build, test, and race a small-scale formula style racing car. The development process include base theory of Automotive Engineering subject for car building by following all safety measure of automotive rules.
Other thing that important is a Cockpit. In the cockpit, there are located steering wheel, driver seat, throttle and brake pedal and gauges. It is like a control room to the car. It is important to design a cockpit that can comfort the driver. Improper design of the cockpit can make the driver difficult and feel uncomfortable. Also it can affect the driver driving performance.

Comfort in the human-machine interface and the mental aspects of the product or service is a primary ergonomic design concern. Comfort is one of the greatest aspects of a design's effectiveness and is a primary ergonomics design concern. The utility of an item is the only true measure of the quality of its design. The job of any designer is to find innovative ways to increase the utility of a product. Physical

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comfort while using an item increases its utility. The mental aspect of comfort in the human-machine interface is found in feedback. The look, feel, use and durability of a product will make a mental determination about a product or service. Better ergonomics means better quality which means it will be more comfortable with the value of the item.

For the control arm, the builder is should be focusing in building lighter race car than the normal weight of the race car before. So, the new design must have considered aspect for reliability, robustness and lighter control arm suspension. Also, the design for this concept of the suspension should have longer cycle time and can be test and use for many times.

The regulation of suspension design and development is fixed for independent suspension. Most of the competitor choosing double wishbone arm (known as *double A-arm*) for control arm of their formula car suspension. Hence, the new design of suspension must have an easy factor for fabricating and development process.

For the knuckle, the weight will affect the performance of the car. This project also focuses on reducing the upright component weight as it helps to improve the performance of the car upright or knuckle is stated as a linkage or a bracket to the parts of suspension arms, transmission parts and brake parts.

1.1 Ergonomics Seat in Cockpit

1.1.1 Competition Rules

Adhering to the rules that govern the chassis for the competition is a pivotal part of the research. If one small sub-section rule is not followed by the chassis, it will disqualify the whole car from the competition.

Within the competition rules that are solely for the chassis, when attempting to insure all the rules are met, it is easy to miss small details when the rules are set out in this form as shown in Figure 1.1 and 1.2. So, to simplify this process a summary of the

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rules was created and broken down into all individual areas of the chassis layout. These areas were, Main Hoop, Front Hoop, Bulkhead, Main Hoop Bracing, Front Hoop Bracing, Bulkhead Support, Other Bracing and Side Impact Members. The design of the seat will determine the seating position of the driver it will affect the height of the roll cage and indirectly, will affect the chassis design.

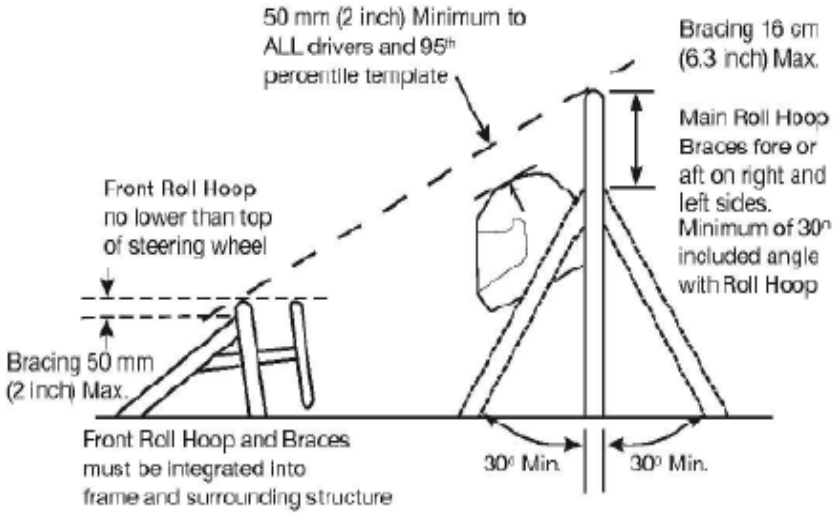

Figure 1.1 : Illustration of the clearance required above the drivers head [1]

A two dimensional template used to represent the 95th percentile male is made to the following dimensions:

- A circle of diameter 200 mm (7.87 inch) will represent the hips and buttocks.
- A circle of diameter 200 mm (7.87 inch) will represent the shoulder/cervical region.
- A circle of diameter 300 mm (11.81 inch) will represent the head (with helmet).
- A straight line measuring 490 mm (19.29 inch) will connect the centers of the two 200 mm circles.
- A straight line measuring 280 mm (11.02 inch) will connect the centers of the upper 200 mm circle and the 300 mm head circle.

Figure 1.2 : 95th % percentile male dimensions as depicted in the 2010 rules [1]

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1.1.2 Driver Seating Position

The driver seating position in Formula One car is ultimate fit. A seat is manufactured by sitting the driver in full suit, in a bag full of seating foam positioned inside the car. The driver will choose either want an arched back or straight back. Once the seat is manufactured, it is perfectly fit to the contours of the driver's body. In Formula One seat, there is no cushioning for comfort, in fact there is no room for movement once the seatbelts are done up tightly. Driver also can choose either want laid back sitting position or sit more upright position. The design of the chassis will allow the choice to be made. In laying back position, more strength required turning the wheel but it is aerodynamically efficient and the center of gravity will be lower. The line of sight of the driver also will effect due to the driver sitting position. With different driving position, different driver's head will be at different heights. The reach of the driver is critical, and the steering wheel is positioned to be held with arms slightly stretched, but bought close to the body. Having fully outstretched arms can consider as a bad driving position, as the driver must support the arms full weight which, when totaled up, is 5.1% of the overall body weight [2]. In open-wheel car, the body is very shallow in height and the cockpit very narrow. The driver's legs are relatively straight out with a slight bend in the knee and the feet just barely below the hips. The pedals also require little more than a flexing of the ankle to go from 0-100% depression. The driver also has to make sure that his butt sits all the way to the back of the seat where exactly the base and back of the seat are joined. A more upright stance can be enjoyed by the driver and the natural curvature of the spine would be maintained and this would actually reduce the stress on the ligaments of the spine. A slouched position result in restricted head rotational movements and this can actually reduce the line of vision for the driver. Moreover, backward bending of the head becomes almost impossible when one is slouched forward and such a posture can even result in a whiplash injury from a slight rear end impact. Figure 1.3, 1.4, and 1.5 show the several positions on driver seating.

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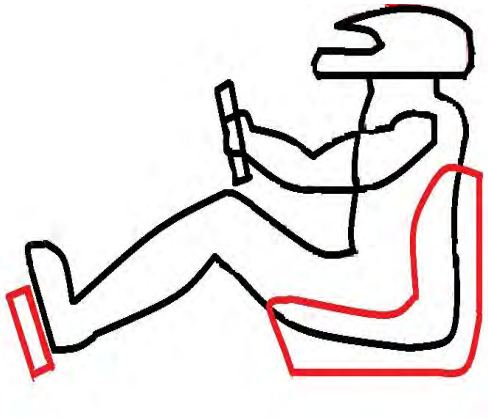

Figure 1.3 : Previous driver sitting position on UTeM Formula Varsity car

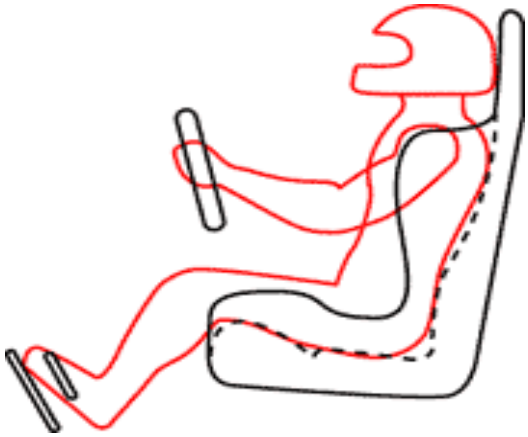

Figure 1.4 : Sitting position on street car [3]

Figure 1.5 : Laying back sitting position [2]

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1.1.2.1 Arm Positioning

The arm position while driving is important to prevent muscle stress at the shoulder. The arms should be relaxed as possible and elbow should bent 20 to 30 degree of angle. Most of cars have an adjustable steering wheel, so, adjust it in the mid to lower position. The steering wheel shouldn't obstruct the view of the instrument panel like speedometer and fuel gauge. When the driver is tightly strapped into to the seat, the arms when fully extended should allow the wrist to rest at the top of the steering wheel. This will allows the arms to be slightly bent at the elbow when fully extended during turns and it is an ideal condition to drive without stretching one's arms. The shoulder should not need to lift from the seat back even in full arm crossover condition. The effects of overextending the arms are the driver to lose sensitivity to the vibration at the steering wheel and will cause them to tire quickly. This action also can reduce to a great extent of stress on the shoulder. Hands should be positioned at the 10 and 2 o'clock. This position is the traditional favorite because, in theory, a higher grip allows a driver to keep the car running smoothly without needing to jerk the wheel suddenly if cut off or there is hazard in the road. Most racing car including Formula Varsity car steering wheel only can turn about 80 to 90 degree of angle to the right side and same maximum angle to the other side. So the 10 and 2 o'clock hand position is the best arm position on steering wheel for racing car especially for racing car that has narrow cockpit. Figure 1.6 below show the proper hand position on the steering wheel.

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Figure 1.6 : The 10 and 2 o'clock hand positioning

1.1.3 Ergonomics

Ergonomics is concerned with the design of system in which people carry out work. Its name comes from the Greek words *ergon* which means "work" and *nomos* which means "law" [4]. When designing any system where humans and machine work together to produce something, we need to know about the characteristics of the people involved and be able to apply this knowledge to the design. This activity is the fundamental function of ergonomics. Ergonomics aims to ensure that human needs for safe and efficient working are met in the design of work systems. Figure 1.7 show the human machine system. Ergonomics needs to be considering enhancing desirable human value such as [5]:

i. Improved safety of the product.
ii. Reducing fatigue strength and stress.
iii. Increased comfort to the user.
iv. Greater user acceptance.
v. Increased job satisfaction
vi. Improved quality of life.

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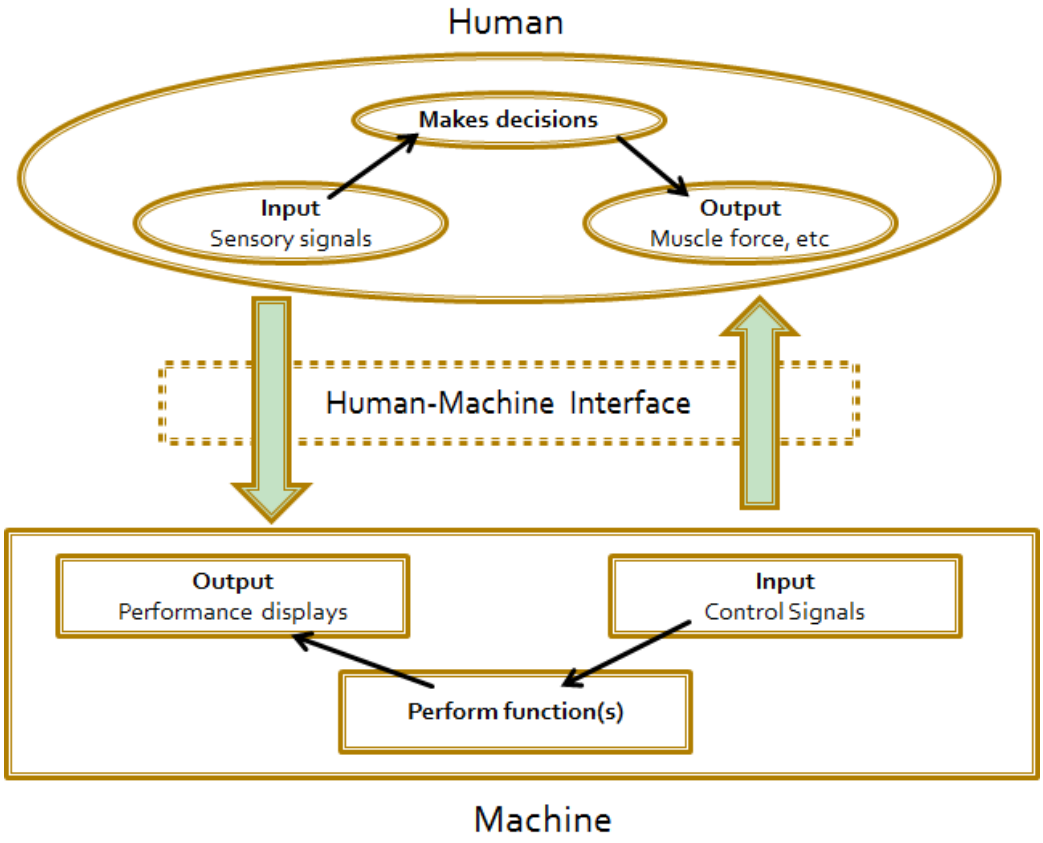

Figure 1.7 : Human machine system

1.1.3.1 Ergonomics Cockpit

Ergonomics is important to race cars because the main control of the car belongs to the driver. The poorly placed controls means that the driver will lose concentration while the race. So the main focus is on the cockpit. An open race car, the cockpit should recline seat back angles so that the driver remains at a comfortable driving position and the overall center of gravity of the car for possible increased lateral acceleration. The ergonomics of a race car cockpit consist of several elements such as the driver's sight line, the steering wheel position, the gauge position and the pedal, gear lever and kill switch.

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1.1.3.2 The Driver's Line Of Sight

The driver visibility is the main importance factor in cockpit. The main factor in designing cockpit is to ensure enough vision of the track in front, and enough visible sight on the left and right. The side mirrors also should place as an extension of the visible field. The driver doesn't need to turn their neck to view the side mirror. Just need to drive their eye in small angle to see the side mirror. Figure 1.8 show the driver vision while driving the open wheel racing car.

Figure 1.8 : Formula one driver sight

1.1.3.3 The Steering Wheel Position

The steering wheel positions also not too far and too close to the driver. The effect of too far steering wheel from the driver is the driver's arm will straighten, and ultimately limit the range of motion easily provided. If it doesn't stop the driver from driving properly, it will cause fatigue. While if the steering wheel too close to the driver, it will limit the range of motion and can cause interface with other cockpit controls [6]. The proper distance is largely a matter of comfort and clearance which means the arms are bent at the elbow when driving in straight road and it still comfortable when turning the wheel. The arm distance also depends on the driver because the physical of every person is different. Figure 1.9 shows the proper distance of steering wheel from the driver.

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