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DESIGN AND FABRICATION OF A RACE CAR VEHICLE FOR UTeM FORMULA VARSITY 2012

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Abstract

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(Keywords : Chasis and Frame, formula Varsity race car, chasis frame fabrication)

The arrangement of a single seat race car has remained the same since 1960s. A vehicle designed for a race is normally driven on the limit. For this reason each part of the car is customized in order to optimize the performance. Changes can be made to the aerodynamic factor and also suspension system for better handling. Aerodynamic is significantly exploited in the design of modern race car. A single seat race car was built by student and staff of Automotive Engineering Department in order to participate in Formula Varsity 2010 which was held by the Faculty of Mechanical Universiti Teknikal Malaysia Melaka. The three day race event was divided into static and dynamic categories. The competition require each team from twenty higher learning institutions to design, build, and test a small, open wheeled, single seat race car. The design specifications are set by the event organizer and each designed car need to comply with the specifications. The main objective of participating in the competition is to develop the knowledge and skills base of the automotive industry at the university level. In addition to that, by participating in the event enable students to have practical and hands-on experience particularly in automotive engineering. Apart from that, students will gain valuable experience in motorsport racing can be gained by the students. Last but not least, students can also enhance their soft skills since they are working in a team to build the race vehicle. The Formula Varsity Race car was succesfully developed and compete in the UTeM Formula Varsity 2012 competition with 2nd Place overall. In additional, the result of these study have been published in several journal and proceedings.

Key Researchers:

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1.0 INTRODUCTION

The arrangement of a single seat race car has remained the same since 1960s. A vehicle designed for a race is normally driven on the limit. For this reason each part of the car is customized in order to optimize the performance. Changes can be made to the aerodynamic factor and also suspension system for better handling. Aerodynamic is significantly exploited in the design of modern race car.

A single seat race car was built by student and staff of Automotive Engineering Department in order to participate in Formula Varsity 2010 which was held by the Faculty of Mechanical Universiti Teknikal Malaysia Melaka. The three day race event was divided into static and dynamic categories. The competition require each team from twenty higher learning institutions to design, build, and test a small, open wheeled, single seat race car. The design specifications are set by the event organizer and each designed car need to comply with the specifications.

UTeM Formula Varsity is a competition that challenges students to design, develop and produce a single seat open-wheel formula style racing machine to be race in a real circuit environment. They will have to produce a race machine within a given specification and this will give a good challenge as well as experiences for the students to implement their knowledge to a real engineering work.

Beginning from 2006 UTeM have organized biennial event and this year it will be the 4th Formula Varsity held in Melaka International Motorsports Circuit (MIMC). With Melaka government support to include this event as the Melaka Tourist calendar and also the support from the University and Ministry of Higher Education Malaysia, the event will be a very good place for student to show their capabilities to people outside the universities.

The main objective of participating in the competition is to develop the knowledge and skills base of the automotive industry at the university level. In addition to that, by participating in the event enable students to have practical and hands-on experience particularly in automotive engineering. Apart from that, students will gain valuable experience in motorsport racing can be gained by the students. Last but not least, students can also enhance their soft skills since they are working in a team to build the race vehicle.The design of the race vehicle will be focusing on several parts as mentioned below:

1.1. Chassis Frame Design

Cylindrical tubular steel with 5 mm thickness is used to construct the chassis frame. The main reason cylindrical type of steel is used for the design is it has higher bending stress compared to rectangular type of steel. Static analysis will be done on the completed design of the chassis frame. If the results obtained satisfy the requirement, then the fabrication of the frame will take place. The results of the static analysis are presented in results and discussion section.

1.2. Drive Shaft & Arm

Drive shaft is an important component in a car to move. Early in our assembly of the car, we have been adjusting the drive shaft to make it suitable with the chassis. A drive shaft is a mechanical component for transmitting torque and rotation. Usually, it is used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them

1.3. Engine Modification

We use LC motorcycle engine, to take measurement we replace it from motorcycle into behind car chassis to do mounting. There are three places for mounting engine, first mounting in above engine, second below engine, and third behind engine. This mounting to make sure that position engine static and no movement when the car brakes. When place engine in car chassis we must take measurement about position engine gear chain and differential gear chain became parallel.

1.4. Brake Disc Design

In the current design models for Formula Varsity and vehicle uses 850 cc car brake system. Since the single seat vehicle only use 135 cc engine as it power generator, the current brake

system deem to be unsuitable as it incur unnecessary weight to the vehicle. Generally, during braking process, friction involves generates high heat flux. Therefore, it is vital to ensure that the brake disc is designed so that the target heat flux remains low.

1.5. Suspension System

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two.[1] Suspension systems serve a dual purpose — contributing to the vehicle's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and reasonably well isolated from road noise, bumps, and vibrations and etc

1.6. Gear

Differential gear allows the driving road wheels to rotate at different speeds. This is necessary when the vehicle turns, making the wheel that is travelling around the outside of the turning curve roll farther and faster than the other.

1.7. Bodywork

Body design is an important criterion for race car. Its level of importance can be easily seen through the amount of investment from some major car manufacturers. Ferrari, BMW, Toyota, Renault, Honda and Mercedes have spent up to 400 million dollars per year to design a successful Formula One (F1) car body. Race car body is particularly important in aerodynamic. It reduces drag and hence provides smooth air flow along the race car.

1.8. Extra Features

Extra features are something special or different that we add to our vehicle. We have added a semi – automatic transmission. A semi-automatic transmission is an automobile transmission that does not change gears automatically, but rather facilitates manual gear changes by dispensing with the need to press a clutch pedal at the same time as changing gears.

2.0 DESIGN & CHASIS

2.1. Design concept

The concept of designed is like Formula One. It is rally race to see who is the fastest among the fastest car that their build. There were also have a static competition to see their design and presentation of the car that their build.

There is several design that we have to make up which is design on our chassis first, then design for its bodywork. The duration that it takes to design the chassis is 2 weeks by Chassis department. Then, when we meet the agreement, we start to manufacture and produce the chassis according to the specific dimensions given.Figure 2.1: The final drawing of chassis Formula Varsity carFigure 2.1 is the final drawing of chassis Formula Varsity car:

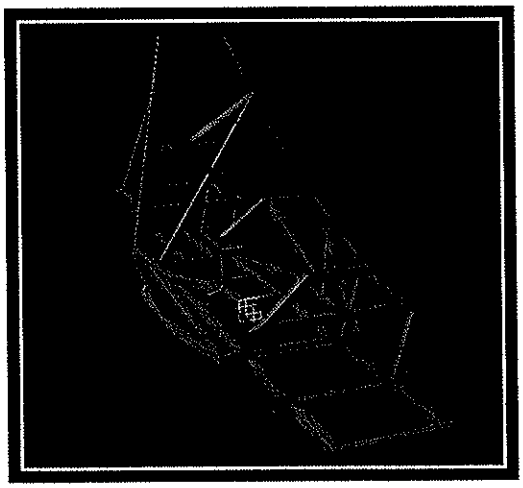

Figure 2.1: The final drawing of chassis Formula Varsity car

This chassis is building starting we enter the laboratory before the Engineering Practice start. Initially, we want use to old one create by last year student, but there have some problem regarding to the dimension of the chassis. The chassis is made up from metal-square steel which is approximately 1.5-inch square

2.2. Chassis

Chassis consists of an internal framework that supports a man-made object. It is analogous to an animal's skeleton. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted) with the wheels and machinery. In the case of vehicles, the term chassis means the frame plus the "running gear" like engine, transmission, driveshaft, differential, and suspension. A body (sometimes referred to as "coachwork"), which is usually not necessary for integrity of the structure, is built on the chassis to complete the vehicle. For commercial vehicles chassis consists of an assembly of all the essential parts of a truck (without the body) to be ready for operation on the road. For our chassis, we have dedicated a lot of time for doing research in order to produce a light yet strong chassis. The material used for the making of the chassis was a 1.6 cm thick square metal. The construction of our chassis has included several factor of worst case scenario which are:-

2.2.1. Acceleration

Based on the Von Mises stress value in Figure 2.2 below, it is safe to say that the value of failure for the chassis is very low and from the diagram above we can see there is no red spot present on the chassis. The rate of bending for the chassis might be lower as the weight of the driver is not entirely 6000 N.

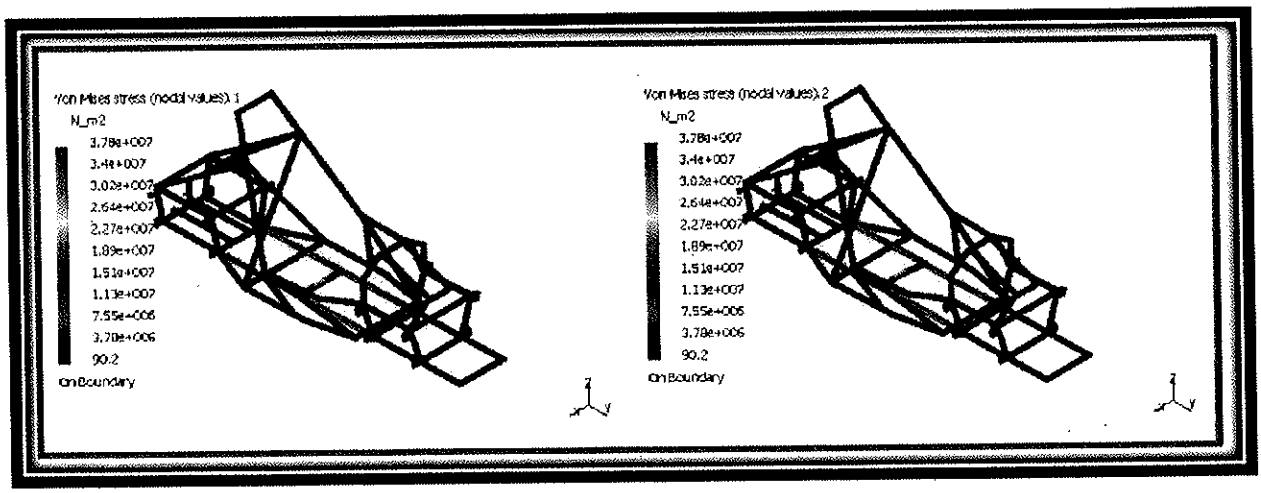

Figure 2.2: The result of the chassis after undergo acceleration with a force of 6000 N at the middle

2.2.2. Bending

In engineering mechanics, bending (also known as flexure) characterizes the behavior of a slender structural element subjected to an external load applied perpendicularly to a longitudinal axis of the element. From the value shown by the Von Mises stress and the color of the potential bending region, I could say that the chassis will undergo a very small bending effect at extreme condition like during cornering, accident or car crash. The rate of bending will change based of which part of the chassis receive the pressure. For Figure 2.3, Figure 2.4 and Figure 2.5, the rate of bending only applies for the driver's seat.

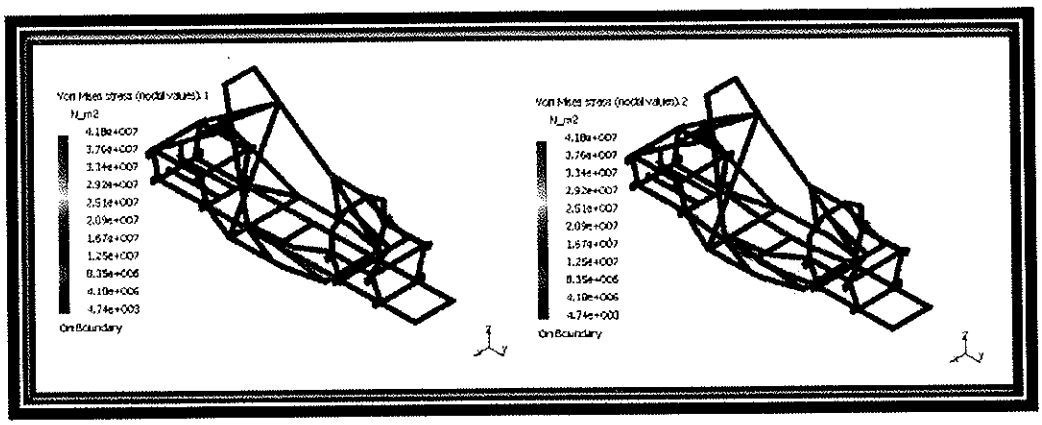

Figure 2.3: The rate for the chassis to undergo serious bending during a race while carrying a weight of 6000 N

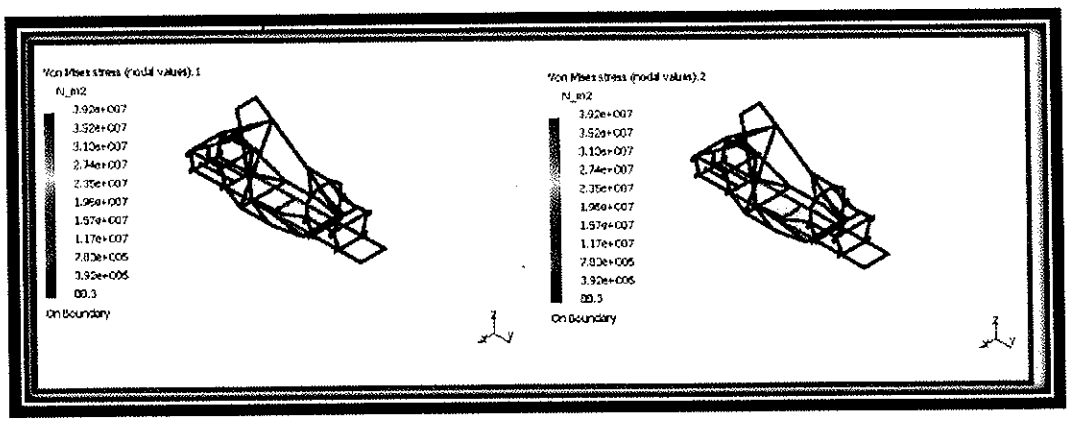

Figure 2.4: The result for the chassis to bend during emergency braking

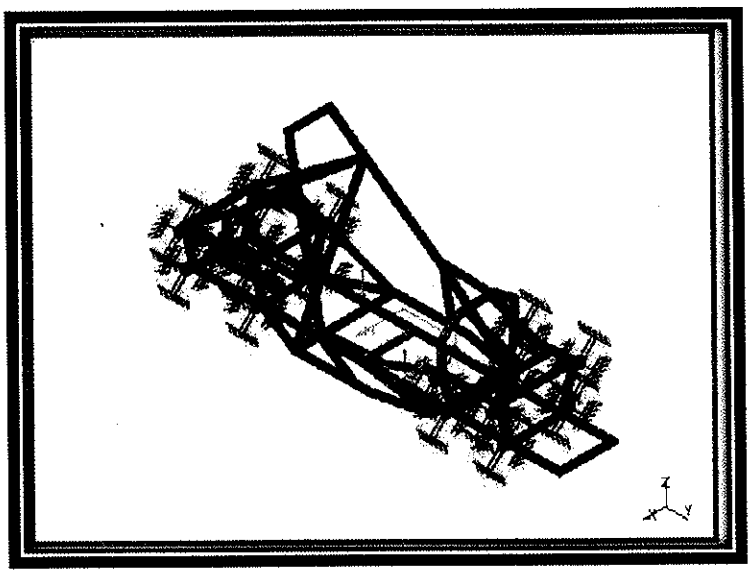

Figure 2.5: How the chassis is held. Each of the blue line represent where the A – arm of the vehicle will be situated.

2.2.3. Torsion

Torsion is the twisting of an object due to an applied torque, therefore is expressed in N·m or ft·lbf. In sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius. Based on Figure 2.6 and Figure 2.7, it can say that my team's chassis will not undergo serious torsion even though a stress of 6000 N is present in the middle of the chassis. This proves and shows how safe the chassis is to be used.

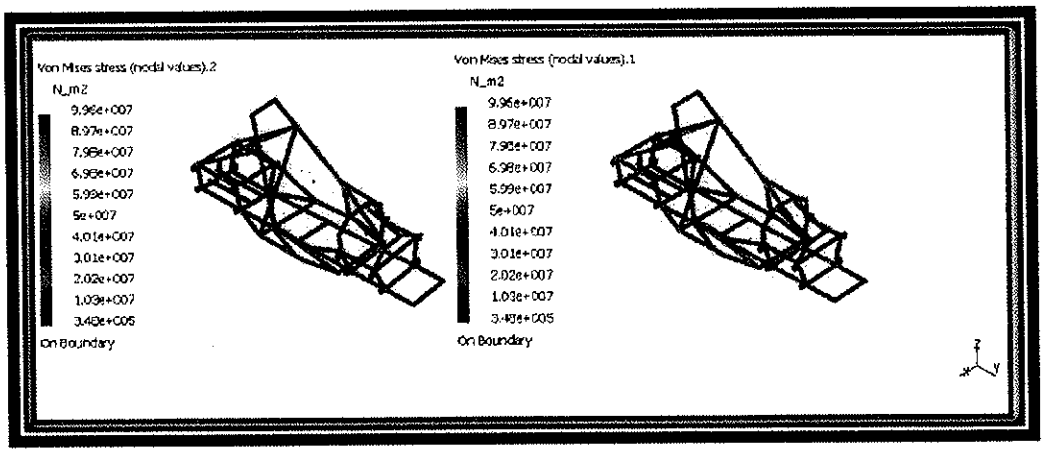

Figure 2.6 : The result for front torsion of the chassis

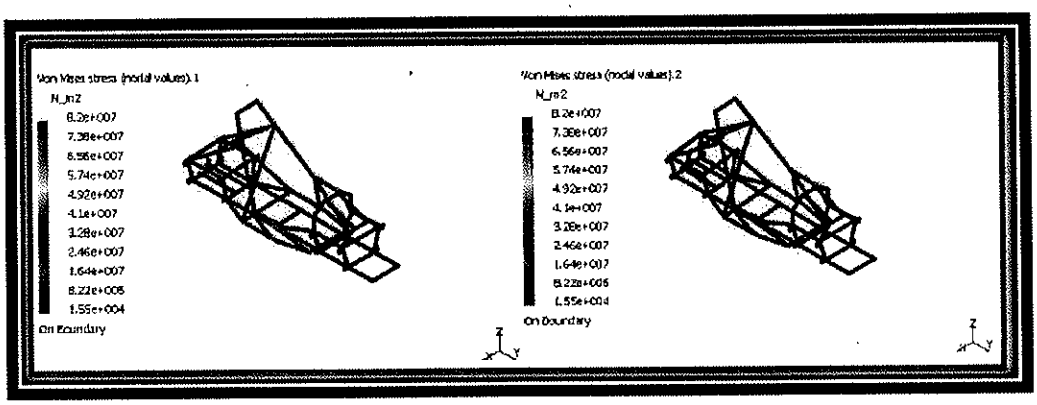

Figure 2.7: The result for rear torsion of the chassis

The process of making the chassis required precision and accuracy and mistake in calculation for the length of the metal used for producing the chassis will greatly affect the weight and also the reliability of the chassis.

2.3. Department Chassis & Bodywork

Department chassis & bodywork their work focus to analyze and finish build structure chassis and design chassis cover body. The first step to build chassis student must design it by using solid work or catia software, by using this software student can analyze their structure strength, turning and so on, the analyze must do because to make sure that chassis can have long life or can endure during accident. The chassis design had been design before student enter engineering practical.

2.4. Build Car Chassis

We start build chassis begin with build base where it length is 240 m and it width is 140 m , material use it square hole steel and it thick is 1.6 mm. After that continue add box in front and back, where box at back is place for differential. The measure box at back length is 34 cm and it height is 14 cm, for box in front the length is 36 cm and height is 16 cm. figure below is the box that add in base chassis. After finished welding box for front and back chassis, we continue to install cockpit base in the middle chassis. After done cockpit base we can image how to setting or add part at base chassis for more strength. The chassis have 70 percent done for basic structure and for another 30 percent for support mounting part and protect part, such protect brake pump and support for mounting steering rack, engine, radiator, and fire wall. Figure 2.8 side shown the structure chassis have been add.

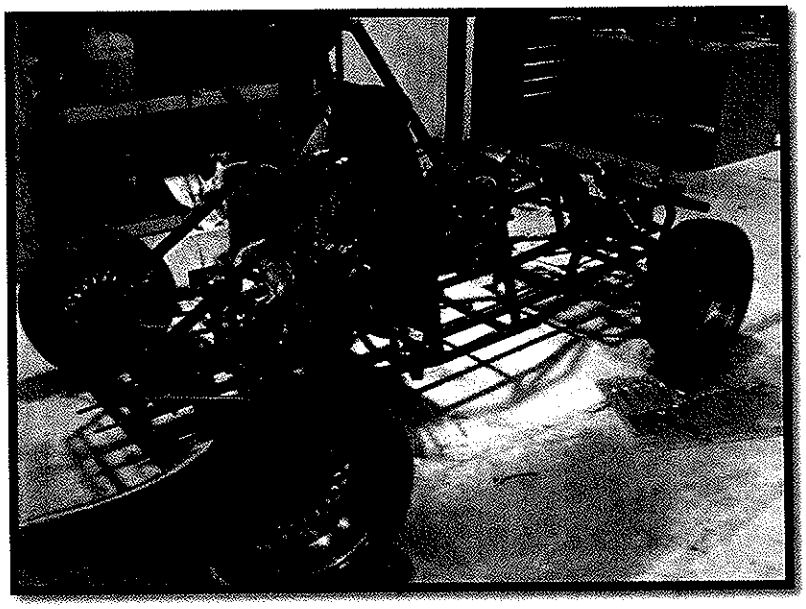

Figure 2.8: The chassis car has done assemble with another component

With chassis done it have use for while to do mounting for many part that must use chassis measure. After done all the part must disengage from chassis, because chassis will be paint undercoat so that the chassis not rust and it will make chassis harsh condition. Figure 2.9 shows that chassis have been painted with white undercoat color and black color.

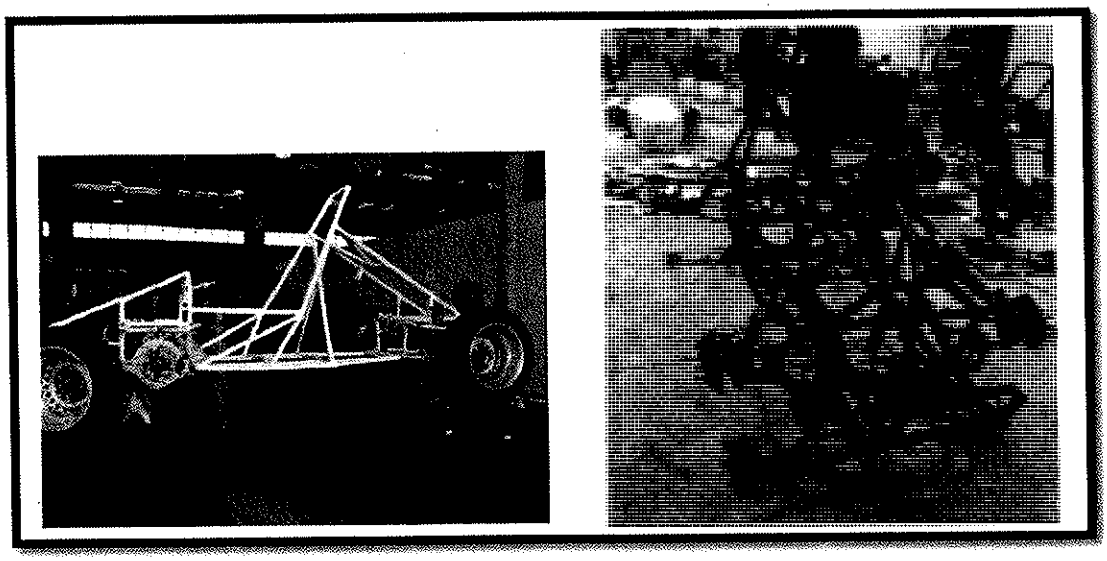

Figure 2.9: The chassis have done white undercoat and black color

3.0 DRIVE SHAFT & ARM

3.1. Drive shaft

Drive shaft is an important component in a car to move. Early in our assembly of the car, we have been adjusting the drive shaft to make it suitable with the chassis. A drive shaft is a mechanical component for transmitting torque and rotation. Usually, it is used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. Drive shafts are also known as carriers of torque. They are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, whilst avoiding too much additional weight as that would in turn increase their inertia. In this Formula Varsity, we have to installed the drive shafts on the chassis and configure it. It is the second step after we build the chassis and installed the differential. This progress has been noted to Engineering Practice logbook.

3.2. Fitting Work

Some fitting work that has been done are grinding, drilling, cutting and marking. Those all are the process involve producing components such as bracket, A-arms, spacer, adjusting knuckle, cleaning the rust on the chassis and etc. this work has been performed by all members. Among of the operations that can be performed at the laboratory are marking, cutting, filling, chiseling, drilling, sawing and fitting. This requires all the hard work from all team members in order to finish assemble the car.

3.3. Create A – arm

A – arm one of suspension system in race car, it use to hold knuckle, absorber, and tire. There are many type of A – arm that we can use but our team decides to use standard A – arm. It

build by using material cylinder role steel with thick is 1.6 mm. Before chassis build we have do a – arm for front and rear car but after chassis done the – arm cannot install to the chassis because dimension a – arm not accurate as the dimension chassis design in catia. Only a – arm lower in front that can install into car for another cannot install, so we must do a new a – arm for rear and upper front car, a – arm connect to the chassis and knuckle by using ball joint. Figure 3.1 shown the old a – arm;

Figure 3.1: The old a-arm for lower front car

When we start to do new a – arm our team come up a few type a – arm that we can use or test with the most suitable with our car. We start do a – arm with type A as shown in Figure 3.2, after done we install it into car so that we can test it if car can do a balance.

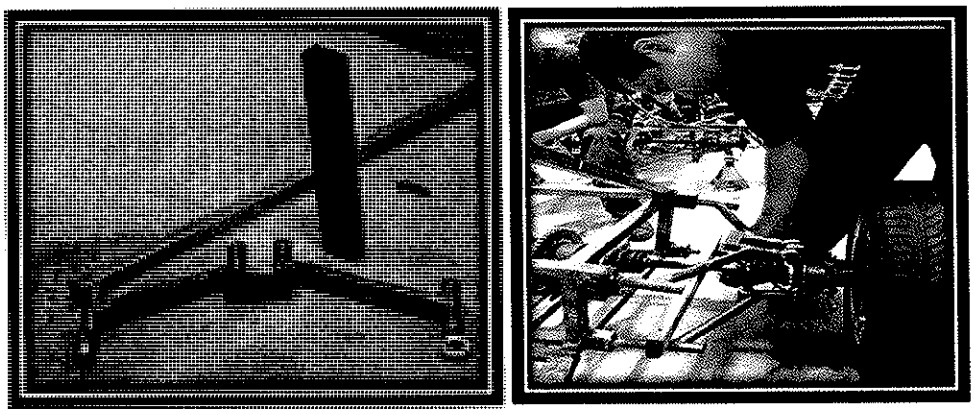

Figure 3.2: A-arm Type A

After install a – arm type A we try to setting car so that it balance, but a – arm for left side cannot do the balance, so we start to create an A – arm type B. when it done we try to install it into car and do the balance for the car, when we setting it the car in position balance so we use a – arm type B. The different a –arm type A & B is their angle. Angle for type A is 45

degree but for type B is 40 degree. When a- arm type A have been use the position knuckle not stable but using a-arm type B the position knuckle became stable. When A – arm for rear car done another group will do A – arm for front car. The shape for A- arm is different for upper and lower A- arm. Because upper a –arm shape not same as the lower it will make tire became chafer. Final work for do A-arm is paint it to make it hold for long time and also became good looking.

3.4. Custom Drive Shaft

A driveshaft, driveshaft, driving shaft, or propeller shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. Drive shafts are carriers of torque: they are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, whilst avoiding too much additional weight as that would in turn increase their inertia. Drive shafts frequently incorporate one or more universal joints or jaw couplings, and sometimes a splined joint or prismatic joint to allow for variations in the alignment and distance between the driving and driven components. Drive shaft we use is kancil car drive shaft. We use for both left drive shaft, what we do is custom it to became suitable to the differential and head for drive shaft column can trough knuckle. The completed drive shaft is shown in Figure 3.3

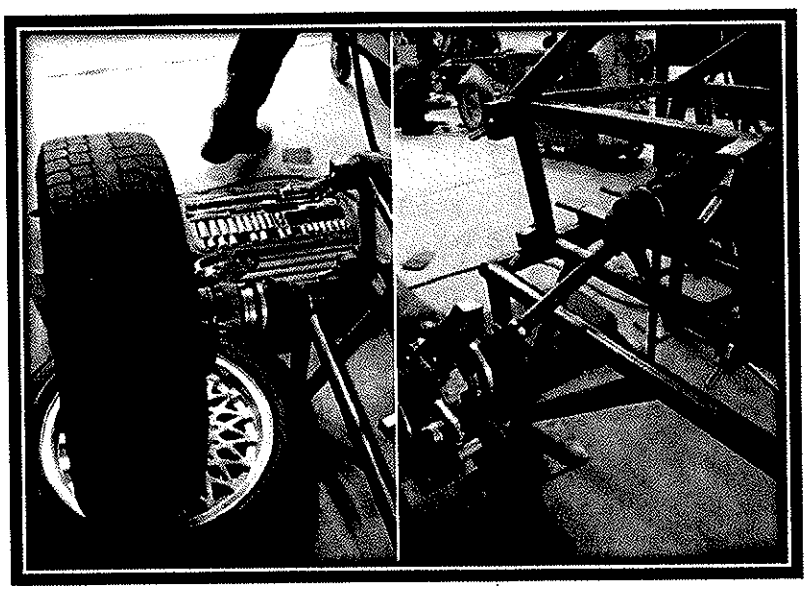

Figure 3.3: Drive shaft

4.0 ENGINE MODIFICATION

4.1.Engine and wiring

We use LC motorcycle engine, to take measurement we replace it from motorcycle into behind car chassis to do mounting. There are three places for mounting engine, first mounting in above engine, second below engine, and third behind engine. This mounting to make sure that position engine static and no movement when the car brakes. When place engine in car chassis we must take measurement about position engine gear chain and differential gear chain became parallel. When mounting engine done we can start to service engine and setting anything to make sure that engine in good condition. We continue to install radiator and do simple wiring by using their own CDI. After that we make test to start engine and make test drive in Fasa B in two laps. When it done test, we see that engine in good condition and continue to make full wiring system for the car. The wiring has done by student that expert in wiring system. Wiring system is one of most important in our car, because our car use paddle shift system for shift gear. So in our car have more electric and electronic system, for this we can see that many box at the back car content component electric and electronic. In our car, wiring system for switch start, switch fan radiator, switch compressor, and paddle shift. During to emergency problem in our engine, we try repair for old engine in old race car. Because during emergency we can use old engine for spare part, for another part in old car also we repair and use as spare part for our car later. For engine and brake part we finish due to date that have been equable, just add paddle shift and engine start.