PERFORMING NEW MATERIAL FOR LOWER CONTROL ARM PRODUCT VEHICLE USING FINITE ELEMENT ANALYSIS METHOD

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE TECHNOLOGY) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

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2022

DECLARATION

I declare that this Choose an item. entitled Performing new material for lower control arm product vehicle using Finite element analysis method is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	Anas
Name	:	*MUHAMMAD ANAS FARID BIN MASRI*
Date	:	JUNE 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature : Rosidah

Supervisor Name : *DR. ROSIDAH BINTI JAAFAR*

Date : JUNE 2022

DEDICATION

Let me begin by thanking to Allah SWT for providing me with the time, space, energy and resources necesssary to finish the work at hand. In addition, i must aknowledge the unwavering assistance of my loved once and fellow students. A special thanks goes out to DR Rosidah Binti Jaafar for allof his support and advice during this project. Students in this epidemic countries will undoubtedly find it difficult to deal with their studies because of the physical and emotional strain. As a result of their help, i was able to finish my Bachelor's degree project.

ABSTRACT

The vehicle's performance may be affected by the material used for the lower control arms. In the development of the lower control arm, the most important consideration is the material that can handle the force. A better material than what is now available for the lower control arm is needed to establish whether or not a better material can be employed. Steel is the most commonly utilised material because of its higher maximum stress and displacement capacity, according to a literature review. Drawing the lower control arm from the real lower control arm's measurements in SolidWorks is possible. There are also two alternative materials available for the lower control arm to test data results and analysis. It will display two unique forms of content. After all materials have been set up, a simulation may be conducted from the programme to analyse the lower control arm and offer data and analysis.

ABSTRAK

Prestasi kenderaan mungkin terjejas oleh bahan yang digunakan untuk lengan kawalan bawah. Dalam pembangunan lengan kawalan bawah, pertimbangan yang paling penting ialah bahan yang boleh mengendalikan daya. Bahan yang lebih baik daripada yang kini tersedia untuk bahagian kawalan bawah diperlukan untuk menentukan sama ada bahan yang lebih baik boleh digunakan atau tidak. Keluli ialah bahan yang paling biasa digunakan kerana tekanan maksimum dan kapasiti anjakannya yang lebih tinggi, menurut kajian literatur. Melukis lengan kawalan bawah daripada ukuran lengan kawalan bawah sebenar dalam SolidWorks adalah mungkin. Terdapat juga dua bahan alternatif yang tersedia untuk bahagian kawalan bawah untuk menguji keputusan dan analisis data. Ia akan memaparkan dua bentuk kandungan yang unik. Selepas semua bahan telah disediakan, simulasi boleh dijalankan daripada program untuk menganalisis bahagian kawalan bawah dan menawarkan data dan analisis

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My utmost appreciation goes to my supervisor, Dr. Rosidah Binti Jaafar, Faculty of Mechanical and Manufacturing Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM) for all her support, advice and inspiration. Her constant patience for guiding and providing priceless insights will forever be remembered who constantly supported my journey. My special thanks go to Prof. Madya Ts. Dr. Lau Kok Tee, the chairman of the PSM and his assistants for all the help and guide.

Last but not least, from the bottom of my heart a gratitude to my friend, Mohammad Haqeemee bin Mohd Hussein @ Unsein, a person who chose the same supervisor as me for his encouragement and who has been the pillar of strength in all my projects. He always explains and advised me about our work and compared each other since we get the same research concept but different topics. Finally, thank you to all the individuals who had provided me with the assistance, support, and inspiration to embark on my study

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LIST OF SYMBOLS AND ABBREVIATIONS

CAD	-	Computer-aided design
3D	-	3-Dimension
σ	-	Stress
P	-	Applied force
A	-	Area
ε	-	Strain
E	-	elongation
L	-	Length
N	-	Newton
m	-	Mass
g	-	gravity
M	-	Mega
Pa	-	Pascal

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CHAPTER 1

INTRODUCTION

1.1 Background

The lower control arm is a component of the vehicle that together with the steering knuckle, is attached to the frame. Its primary function is to maintain the vehicle's stability by enabling the chassis and the wheels to move in concert with one another when the vehicle is in motion. To put it simply, each front and rear wheel on every vehicle needs a set of lower control arms to function properly. These arms help the vehicle maintain a smooth movement while it is being driven on the road. Lower arm control is also one of the essential components of a suspension system. It is responsible for acting as the direction connection points between the front wheel assemblies and the frame of the vehicle. Another part of the lower control arm, the ball joints and bushings make up this part's construction.

However, the terms "lower control arm" and "vehicle's suspension system" may not be typical household terms for vehicle owners. This is because some vehicle owners truly do not care about this part. However, lower control arms are essential components of a vehicle's suspension system. If this component is missing, the car may experience difficulty when being driven, and the experience of driving will not be as pleasant or satisfying. In today's world, technological advancement can be seen in every aspect, product, and design. The lower control arm is another component that needs to be improved so that driving control can become more effective. It is necessary to adjust some of its qualities and redesign the lower arm control in order to provide the greatest products, which will assist riders in performing better.

There are many researchers and journals that comprise of suspension systems, various forms of suspension systems, and lower control arms. These systems can be found in vehicles. The lower control is subjected to a variety of stresses as a consequence of shifts in the gross weight of the vehicle, as well as impacts resulting from variations in the road surface and additional force. The current lower control arm is now heading in the correct direction thanks to the strength material that they have developed, but there is still room for improvement in terms of the material's strength so that it can produce more robust parts. It is made much simpler to carry out an analysis of the lower control arm by making use of the finite element approach. Combining two different kinds of material on the lower control arm is one way to boost the arm's strength, which is one of the strategies that can be used in the production of the design of the lower control to make it. Because of this, it is essential to carry out static.

1.2 Problem Statement

An advisory was given regarding the vehicle's lower control arm parts in the event that the vehicle's owner was unaware of the precautions and the root cause of the damaged lower control arm. There are a few different factors that contribute to the deterioration of the lower control arm. The driver of a certain vehicle who was going too fast will be responsible for any damage to the lower control arm. When the driver shifts into driving gear and then quickly presses the gas pedal, the lower control arm and the bushing elements of the vehicle will be subjected to a great deal of stress as a result. If this behaviour is carried out on a consistent basis, the system will be subjected to the knockabout effects of the consequences.

The damaged roads and uneven terrain were the next factor that contributed to the injury sustained by the lower arm. If the vehicles drive on this type of road regularly, the lower control arm is going to be subjected to a significant amount of wear and tear. Because of this, the lower control arm will become crooked, which could result in the steering becoming unstable. In the event that a rock or another substantial object strikes the lower control arm when it is located on the roadway, the metal will be fractured and bent as a result of the impact. The lower control arm is made of sturdy metal, but if it is struck with a significant impact like a serious accident, it might throw off the vehicle's alignment, causing it to be off-kilter.

Evidence from the lower control arm demonstrates that it is capable of withstanding any possible precaution due of the consequences of the functioning of the lower control arm. If the lower arm takes a substantial knock from something, such as the road or an object, you will need to replace it. The existing lower arm has solid findings and analysis based on the product analysis, but it is not functioning properly since it is under higher stress. It is necessary to mix it with additional materials in order for it to achieve outcomes that are superior to those of the current lower control arm.

1.3 Research Objective

The main aim of this research is to perform new material for lower control arm product vehicle using finite element method analysis. Specifically, the objectives are as follows:

a) To analyze of lower control arm material static analysis using simulation

b) To compare existing product with new product of static analysis lower control arm

1.4 Scope of Research

The scope of this research are as follows:

- To develop a comprehensive literature review of the lower control arm.
- Reseacrhes from literature review, this study proceeds to design the part using SOLIDWORK software. The parameters involving measurement, material selection and colour
- To come out with the results analysis for products with finite analysis method
- Comparison the lower control arm with two different material to see the improvement from existing material product to new material product

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter the aspect of literature review and the principle motive is to suggestively review and summaries prior research, numerous scientific works and determinations which have been enthusiastically carried out by different outstanding researchers in this field of study. Based on the literature review, the studies and process of studying will gather the desired information to produce the desired result of this project

2.2 Lower control arm mechanism

Because it provides a secure link between the wheel and the suspension, the lower control arm is an essential component in the suspension system of most automobiles. This enables the wheel and suspension to work in concert with one another. The lower control arm is a component of one of the suspension systems, and it can be found both in the front and in the back of the vehicle. It attach to the knuckle section, and the lower control arm is located in a similar fashion near the bottom of the vehicle, relatively close to the ground. The components contribute to the smooth operation of the vehicle, which is especially helpful when driving on an uneven surface. Two supplemental components have been added to the bottom control, and they contribute to the increased stability of that section. There are also ball joints and bushings to consider. Figure 2.1 shows the example of lower control arm

Figure 2.1 The example of lower control arm

Load measurements at component hardpoints are required to simulate vehicle durability when the vehicle is put through its paces on the proving site. When structural components, a lack of proving ground measurements or the high expense of creating them is a common issue.(Sharma et al., 2018) To satisfy the software's requirements for the lower control arm's durability, new materials will need to be designed. When determining how much the lower control arm can be enhanced, results and analysis play a very important role. In order to find out where the disparity is coming from, it is necessary to examine both the newly installed lower control arm and the one that was previously installed. After that, the project is finished by determining which approach was the most effective and then developing a strategy for how it can be improved in the future.

According to Kale AR, The lower control arm is subjected to a significant amount of stress as a result of variations in gross weight, collisions caused by changes in road surface, and extra forces. A potential increase in tension may be experienced by the lower control arm, in addition to the developments in technology. When running, there is a significant amount of strain placed on the arm. The lower control arm is susceptible to bending and breaking because of the complexity of the loads that it must support. Changes in the road's surface and other circumstances, such as braking and cornering, can cause loads such as this one to be carried by the vehicle. Because of this, the lower control arm is at a greater risk of bending and breaking as a result of its exposure to stress. (Kale AR*, 2018)

2.3 The Design of the lower control arm

Suspension system on most cars has two lower control arms at the front. For information, lower control arms come in two different shapes: "A" type or "L" type. According to Yu on the article, the lower control arm of the front suspension of the prototype vehicle was changed in order to cut down on the length of the design cycle and the costs associated with development. This design is based on the one that came first and has been improved in terms of both performance and weight. The analysis model for the lower control arm is initially developed to carry out free modal analysis. This construction is done using technology known as finite elements. (Yu et al., 2021)

2.3.1 "A" type design or "L" type design

One of the most prevalent designs for these kinds of automotive components, these have the appearance of a triangle and are used extensively. The lower control arms are shaped like a "A," with the boarder end attaching to the chassis of the vehicle and the narrow end connecting to the wheel assembly. In most cases, the narrow and will have a ball joint serving as the pivot point, and the border will have a bushing. Some of the control arms take the form of a "L." In a manner analogous to that of the "A" shaped design, they are attached to the steering knuckle at one end and have a ball joint at the other end on which they pivot. One alternative design for the control arm utilises a single shaft. It makes use of the same connections as the other control arms, which are a ball joint at one end and bushings at the other end of the control arm. According to Pachapuri, a steering arm and an A- or L-shaped wishbone are the most common configurations at the knuckle end of the wishbone. A greater balance between handling and comfort can be achieved with an L-shaped arm, which is why it is commonly found on cars. (Pachapuri et al., 2021). Figure 2.2 shows the assembly view of lower control arm from the Pachapuri's article.

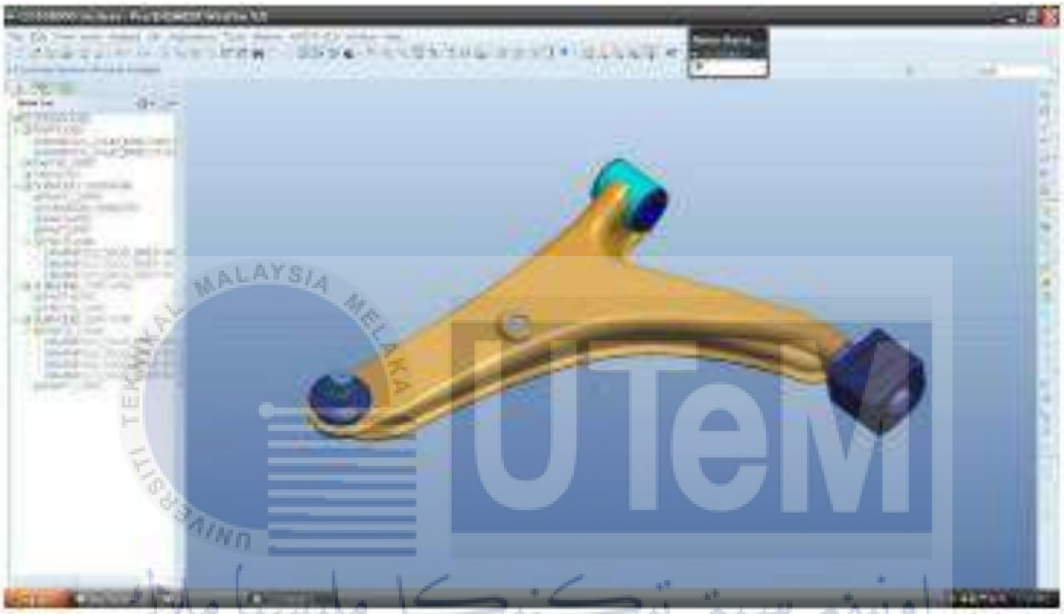

Figure 2.2 The assembly view of lower control arm (Pachapuri et al., 2021)

2.4 Material

The lower control arms of a vehicle are essential components of the vehicle. As has been demonstrated, these car parts make for a more comfortable ride for both the driver and the passengers. Because they attach the wheels to the frame, they are responsible for ensuring that the frame remains stable. When driving, having a control arm that is broken or bent is not ideal. This requires manufacturers to give careful consideration to the materials used for the lower control arm. Not only that, but they also follow the appropriate procedure for manufacturing. It is necessary to inspect the control arms in order to fulfil the various requirements. The making of control arms and the myriad of materials that go into their construction will be investigated.

2.4.1 Steel

Throughout the history of vehicles, this has been the primary material used for the lower control arms. Manufacturing lower control arms out of steel is less expensive. This indicates that they are capable of being produced in mass quantities, which is one of the reasons for the competitively low price that they command on the market. Steel lower control arms are more affordable than other materials, which is one of the reasons why car owners often choose to replace broken ones with steel versions. Because it can bend when subjected to pressure, steel is an excellent material for use in suspension parts. It means that there will be fewer instances of the lower control arm breaking or cracking when off-loading heavy loads or driving with heavy loads. The typical vehicle can also make use of lower control arms made of steel because they are strong enough. This can be shown in table 2.2, the structual steel's material properties. It can see the property from the material properties in steel such as ultimate strength, yield strenght, young's modulus, poisson ratio, bulk modulus and shear modulus.

Table 2.1 The structual steel's material properties

Property	Value
Tensile ultimate strength	400 MPa
Tensile yield strength	250 MPa

Young's modulus	2×10^{11} Pa
Poisson's ratio	0.3
Bulk modulus	1.6667×10^{11} Pa
Shear modulus	7.6923×10^{10} Pa

According to Patil, the double wishbone suspension arm used in modern automobiles is made of mild steel, and its presence might have an impact on the overall weight of the vehicle. As a result, in order to make fresh advancements and triumph over this challenge, a research pertaining to automobile suspensions has been carried out, and it involves the utilisation of composite materials.(Patil, 2013)

2.5 Composite material

A material known as a composite material is one that is made up of two different materials, each of which possesses distinct chemical and physical properties. The act of combining them results in the production of a substance that is uniquely suited to perform a particular function, such as being made more robust, lightweight, or resistant. They also have the potential to enhance one's strength and stiffness. When it comes to the production of automobiles, composite materials may one day offer significant advantages over steel. There has been some consideration given to the use of composites in the production of lighter, safer, and more fuel-efficient vehicles. When combined, the properties of the individual components that make up a composite are improved over those of the components that make up the composite on their own. High-performance fibres, such as carbon or glass, are embedded in a matrix material that is typically an epoxy polymer.

According to Papaczs, when modelling the composite control arm, the shape and dimensions of the steel control arm were kept as close to the original as possible. The criterion of maximum permitted stresses and strains was utilised in order to select the number of layers as well as the direction in which the reinforcement was placed. An MES approach was used in the SolidWorks software, and a composite module was utilised in the study that was carried out. The application provides the opportunity to conduct an independent analysis of the stresses and displacements experienced by each composite layer in addition to the overall structure. The research was carried out to determine the loads that operate on the control arm during braking, as well as the functioning of the most significant lateral forces and the simultaneous action of braking forces and lateral forces. (Papacz et al., 2013). Figure 2.3 shown the grid of the composite control arm model

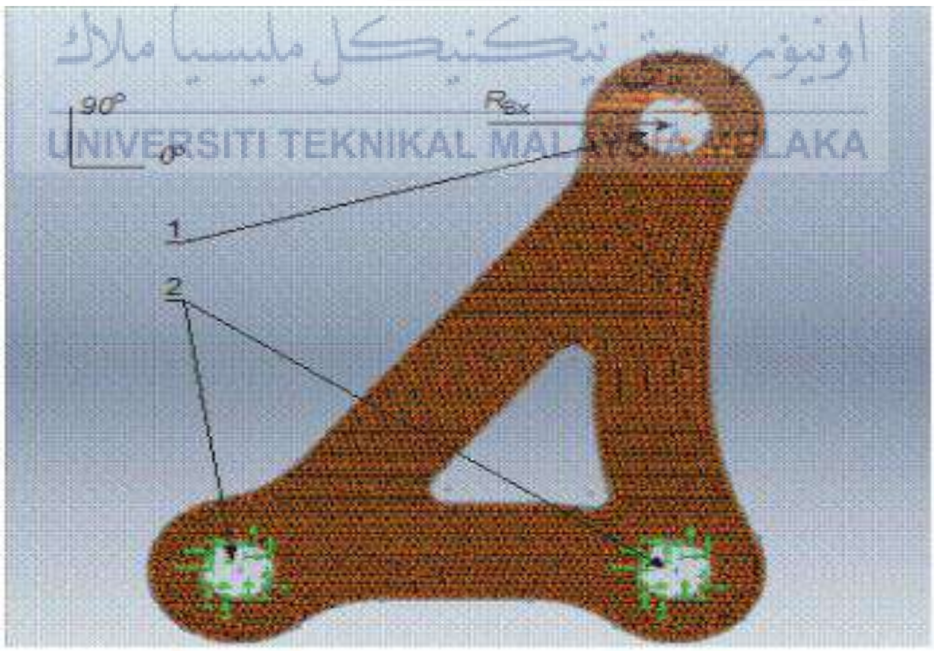

Figure 2.3 The grid of the composite control arm model (Papacz et al., 2013)

2.5.1 Carbon fibre

Carbon fibres are fibrous materials that range in diameter from around five to ten micrometres and are made up of predominantly carbon atoms. Carbon fibres offer a number of benefits, such as high stiffness and tensile strength, low weight, strong resistance to chemicals, high temperature tolerance, and minimal thermal expansion. Because of these qualities, carbon has found widespread use in a variety of industries, including civil engineering and the motorcycle industry. Creating a component out of carbon fibre presents a number of benefits for the manufacturing of automobiles. Since the precursor material must be drawn into long strands or fibres before being heated to a very high temperature without being allowed to come into contact with oxygen, carbon fibres are typically quite pricey in the industrial sector. This is due to the fact that the process used to produce carbon fibres is extremely costly. Due to use carbon fibre as a material to composite material to develop new material form for lower control arm, specification grade for carbon fibre is standard grade carbon fibre. Carbon fibre standard grade have a good combination of strength with stiffness. Table 2.3 shown the material properties for carbon fibre standard grade which can see it on table below.

Table 2.2 The material properties for carbon fibre standard grade

Property	Value
Tensile ultimate strength	110 MPa
Tensile modulus	92 GPa
Yield Strength	2.5 N/m2

Mass Density	1.6 (g/cm^3)
Poisson ratio	0.28
The coefficient of thermal expansion	$-0.56\propto\cdot\frac{10(-6)}{^{\circ}C}$

According to Messana, the only objective of the research is to enhance the damping characteristics of a multimaterial lightweight suspension arm that is constructed from steel and carbon fibre. Because of this, the global suspension system has been analysed to see whether or not there is a possibility that it can reduce vibrations. The primary focus of this research is on developing a novel low-density viscoelastic interface that can perform the functions of both a damper and an adhesive at the same time. In addition to this, the entire research was conducted on a component that has already been used in a production automobile. This is an advantage due to the fact that it makes it possible to integrate the multimaterial LCA on an actual automotive in a "ready-to-run" fashion.(Messana et al., 2020).

2.6 Software design

Before it can go into production, each and every automotive product must first go through the design phase. The development of the products and the conduct of analyses required for optimizing the products both require software design. According to the findings and the findings of the analysis, it has the potential to be a useful product for the automotive industry. Because it can display the results and the analysis, software design is a very important part to play in the design process. In order to design the lower control arm, you need to select the most appropriate software to design the part. In order to develop the component, there are several application software options from which to choose.

2.6.1 SOLIDWORK Software

Mechatronic systems are developed using SolidWork from start to finish. The software is used for planning, visual ideation, modelling, feasibility evaluation, prototyping, and project management at the beginning of the process. It is then utilised to create mechanical, electrical, and software components that are then put into action. Finally, the software can be used to manage devices, analyse data, automate data collection, and utilise cloud-based services and infrastructure. In this case, SolidWork is the good choice for design lower control arm because the software is easy to handle. SolidWork is a popular choice for teaching students how to utilise industry-standard software in engineering and product design. Its basic 3D form is simple enough for people in earlier years to understand, and its complexity can be gradually taught as lectures continue. SOLIDWORK is the choice to design the lower control arm.

2.6.2 CATIA Software

The measurement results are then used in the CATI**A V5** software to build a frame. Following the modelling, the three-dimensional design in solid form will be obtained. The truck's frame strength under static load was then determined using static analysis. The advancement of mathematics and the static world, aided by the discovery of integrated circuits and electrical materials, particularly electronics, has given rise to new products such as computers. Various technological tools can be readily completed using this tool planning. Computers are being created to tackle industry difficulties by providing facilities in the manufacturing process. The software built for this purpose makes the procedure considerably easier and replaces the manual manufacturing processes that were previously developed.(Supardjo et al., 2018)

2.7 Static Analysis

Using static analysis, which is often referred to as static code analysis, it is feasible to debug a computer programme without actually running the programme itself. By taking this technique, not only do it obtain a grasp of the structure of the code, but it also increase the likelihood that the code will comply with industry standards. Static analysis is utilised by members of the team throughout the stages of software development and quality assurance. Programmers and developers might benefit from using automated tools, which could make static analysis more straightforward for them to perform. The software will examine all of the project's code to determine whether or not it should be used in the project. As long as it is automated, static analysis is an easy operation. In the early stages of software development, static analysis usually comes before actual software testing.

Static analysis can be done in a variety of ways, including in a calling structure's control analysis, the focus is on the flow of control. A process, function, method, or subroutine might all be examples of control flows. Data analysis ensures that defined data is used correctly and that data objects are functioning appropriately. Analyzes model component faults and failures using fault or failure analysis software. Interface analysis analyses simulations to ensure that the code is correct and that the interface is properly integrated into the model and simulation.

In automotive industry, the static analysis is very important things to deal with the issues of verifying and validating more sophisticated software using automated testing. Transition to and promote agile development and continuous integration practise. According to Ramana Reddy, the researchers considered using Radioss software to do static and torsion analysis on the control arm in order to improve the control arm's stiffness while simultaneously decreasing its weight. In order to evaluate how well the upgraded analysis performs in comparison to the basic run analysis, this design was created using topology optimization. (Viqaruddin & Ramana Reddy, 2017)

2.7.1 Finite Element Analysis

Finite element analysis is a numerical approach that may be used to simulate a physical process is known as the Finite Element Method. This method is used in mechanical engineering, as well as in various other domains that are related. Additionally, it is a fundamental idea in the process of developing computer simulations. Using Finite elemet method technologies, engineers may conduct virtual experiments to develop their ideas rather than manufacturing real prototypes. This saves them time and money. Simulating a design using special software allows engineers to identify possible issues, such as regions of strain and weak points, before they are included in the final product. Figure 2.4 shows the example of finite element analysis of lower control arm using ANSYS software.

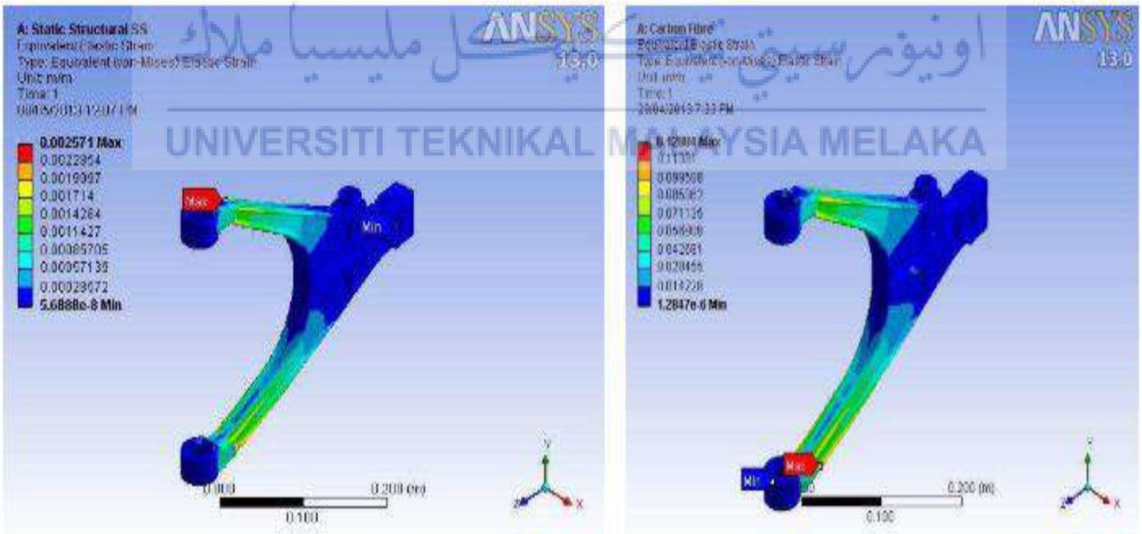

Figure 2.4 The example of finite element analysis of lower control arm using ANSYS software. (Kale AR*, 2018)

2.7.2 Classical method

Classical method is craftsmanship, uniqueness, use of materials, beauty, and functionality are all essential elements to consider during the design process. The practise of designing things with a particular attention to detail is an old-school method that incorporates the advantages of both modern and traditional design. There are many classidal method can be reach to observe the results and analysis using formula and calculation.

2.7.2.1 Formula

When solving a static problem, all finite element solvers will solve the following equation:

$$\{f\} = [K] \cdot \{u\}$$

K represented the global stiffness matrix

u represented displacement vector responce

f represented the external force vector

From the equation above, it generate the develop equation from general equation

Equation Stress

$$\sigma = \frac{P}{A}$$

Equation Strain

$$\varepsilon = \frac{\delta}{L}$$

From two equation above

$$\sigma = E\varepsilon$$

$$\frac{P}{A} = E\frac{\delta}{L}$$

So the final equation

$$P = \frac{EA}{L}\delta$$

From the final equation. It can be assume equation:

$$\{f\} = [K] \cdot \{u\}$$

$$=$$

$$P = \frac{EA}{L}\delta$$

- Displacement

  Created linear static and normal modes analysis. For general analysis, it is essential to verify displacements.

$$d = v \cdot t.$$

- Factor Safety

  By analysing the stress levels in each component..

$$Factor\ safety\ = \frac{yield\ stress}{calculated\ stress}$$

- Von Mises Stress

  a test method for determining the structural strength of ductile materials.

$$\sigma_v = \sqrt{\frac{1}{2}[(\sigma_{11}-\sigma_{12})^2+(\sigma_{22}-\sigma_{33})^2+(\sigma_{33}-\sigma_{11})^2+6({\sigma^2}_{12}+{\sigma^2}_{23}+{\sigma_{31}}^2)\,]}$$

2.7.3 Comparison between Finite element analysis and Classical method

According to Pidaparti and Ramana, finite element analysis affords approximate answers, but classical approaches produce accurate equations and precise solutions for such problems. Few common examples can be solved using conventional methods, however finite element analysis can solve any issue. This approach makes extreme assumptions and seeks for solutions that are shaped, bounding conditions and loading figure when faced with the following complications. For the preceding scenarios, the same boundary condition along a side and regular equivalent loads must be assumed in order to derive the answer. These kinds of assumptions are not made in a Finite element method model. When something goes wrong, it is dealt with head-on. (Pidaparti, 2017)

2.8 Summary

There is a possibility that the material used in the lower control arm will affect how well the vehicle performs. When designing the lower control arm, the selection of a material that is strong enough to withstand the force that will be applied to it was the most important consideration. To evaluate if a better material could be utilised than what is currently on the market, it is necessary to examine the material as well as the physical characteristics of the lower control arm. Steel is the material that is utilised the most on the market, as indicated by the results of a literature review, because it is capable of withstanding higher levels of stress and displacement.

The measurements of the real lower control arm can be entered into the Solidwork application, and a schematic of the lower control arm can be generated from those measurements. In addition, the lower control arm can be utilised with two distinct materials derived by the programme in order to investigate the data findings and conduct analysis. It will present two different varieties of content at the same time. After all of the materials have been prepared, a simulation can be run from the programme to analyse the lower control arm. This will allow for the collection of data and analysis to be performed.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The chapter be responsible for the description and explanation for the methodology of the project. Methodology will execute with the method of understanding and satisfying the analysis in order to reach the project's objectives that have been anticipated. This chapter contain the process which is how the flow process to make this project done. Following with all the element that is required in this project was enlightened in the chapter.

3.2 Overview the project work plan

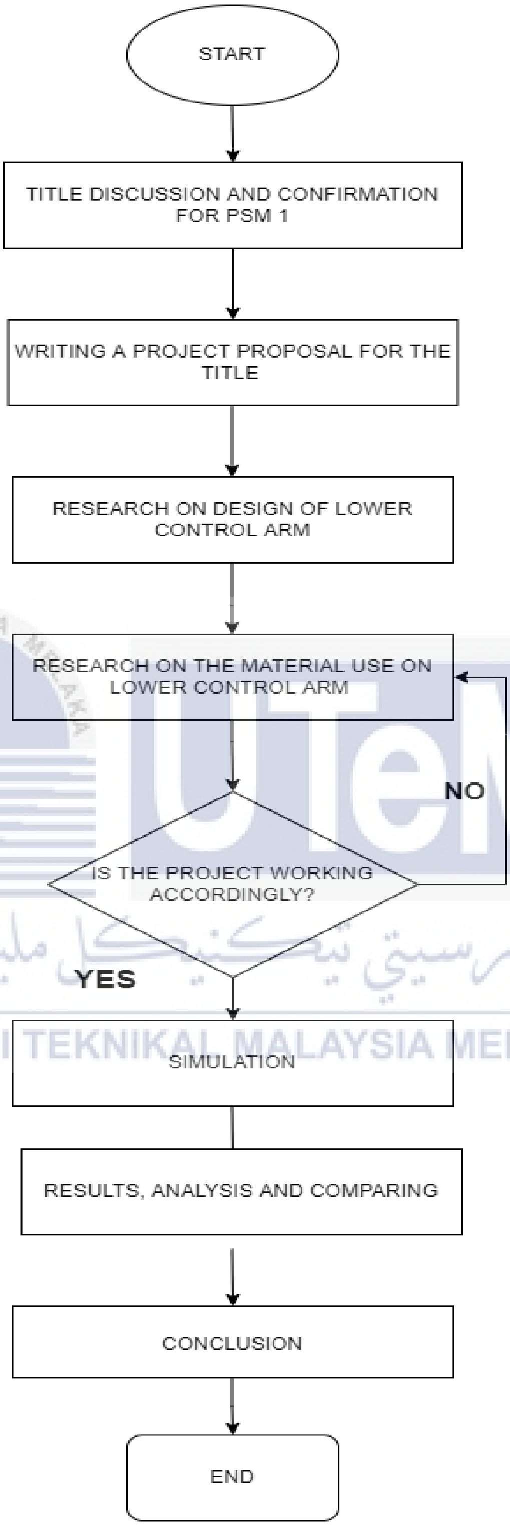

Figure 3.1 Overview the project work plan

3.3 Proposed Model Design

To develop a lower control arm design, the researcher will take a example of lower control arm drawing (Figure 3.2). Reconstructing the drawing by changing the new dimension on diameter to make a hole through the lower arm.

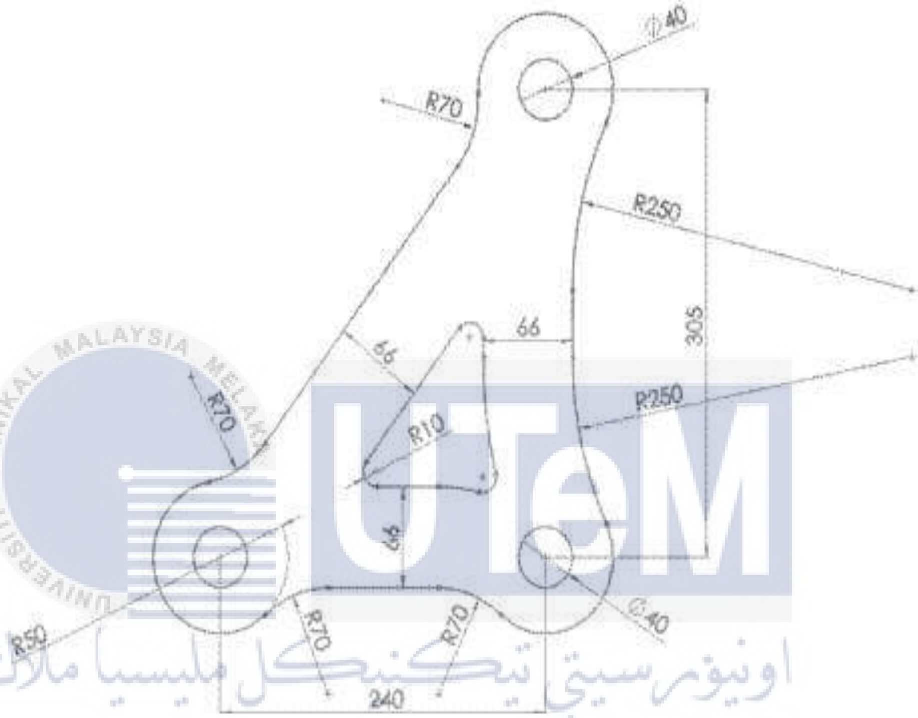

Figure 3.2 Drawing lower control arm

Then, .this is a new dimension that applied on the drawing (Figure 3.3) by changing the dimension diameter because logically the size of hole on the lower arm is bigger than the drawing (Figure 3.2).

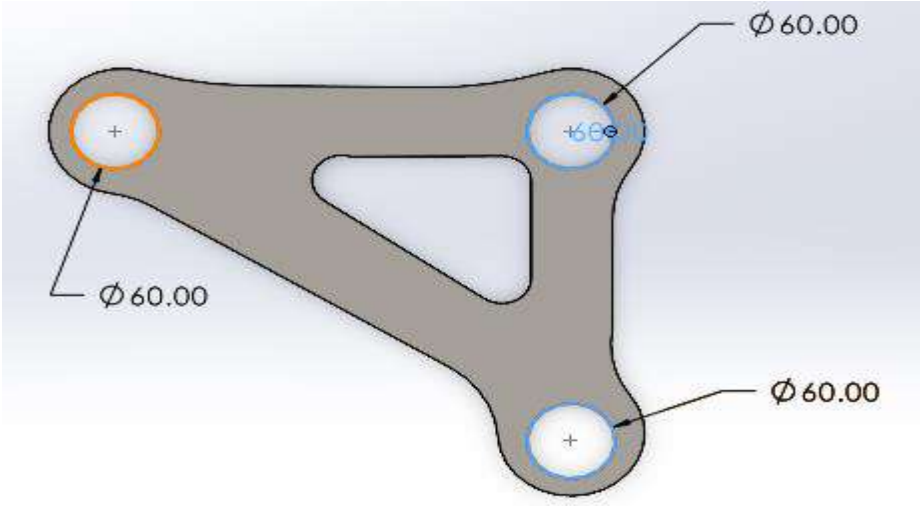

Figure 3.3 New Diameter of lower arm

After the reconstructing the drawing, sketch the lower control arm using SOLIDWORK software for the first step then provide two products of lower control arm. First, design a existing lower control arm with set the material is steel and the other design set the material with material which is carbon fibre. The first step must sketch the technical drawing on SOLIDWORK software (Figure 3.4)

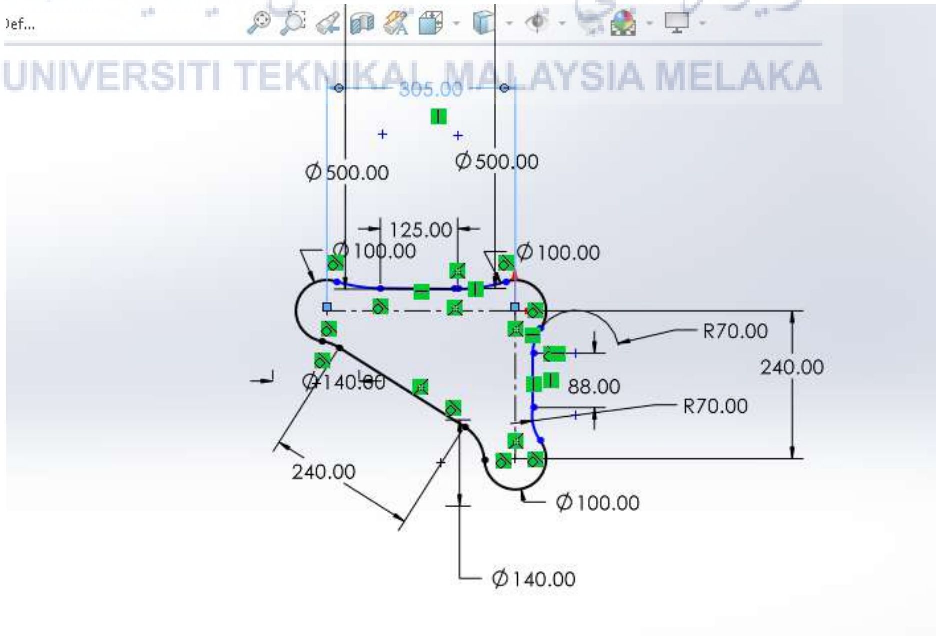

Figure 3.4 The Technical drawing on SOLIDWORK

3.3.1 Boss Extrude and Cut Extrude

From the technical drawing from the Figure 3.4, apply the boss extrude on the features to form a solid part (Figure 3.5). After the boss extrude was applied, move to the next step to cut extrude. To form the cut extrude, it must edit the sketch by click on the top plane then drawing the hole that want to be cut on the lower arm solid part. Finally, apply the cut extrude on features then make cuts to form a solid part lower arm.

Figure 3.5 The Final drawing of lower arm solid part.

3.3.2 Apply Material and Add Material

Move to the next part of applying the material on solid part lower arm by clicking on the display the shortcut menu. Right-click material in the Features Manager design tree. Next, select the part component and select the material. (Figure 3.6). The AISI 4350 Steel Normalized is used on the solid part lower arm.

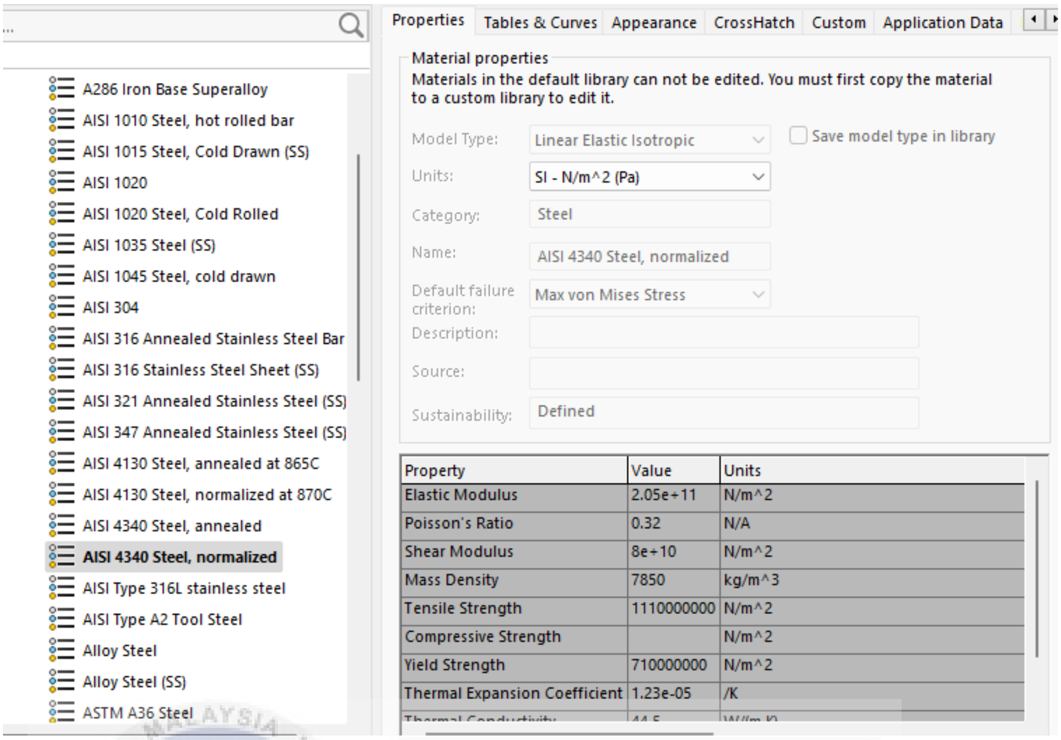

Figure 3.6 Applying the material on solid part lower arm

For the carbon fiber’s material properties, it should to be add first before apply the material on solid part lower arm. First need to do, click edit material select a custom material in the material tree. Next, select add material then put the properties of carbon fiber that want to appy on the solid part lower arm. Final step, save the material then apply the carbon fiber material to the solid part lower arm then make the solid part lower arm is fully carbon fiber. (Figure 3.7)

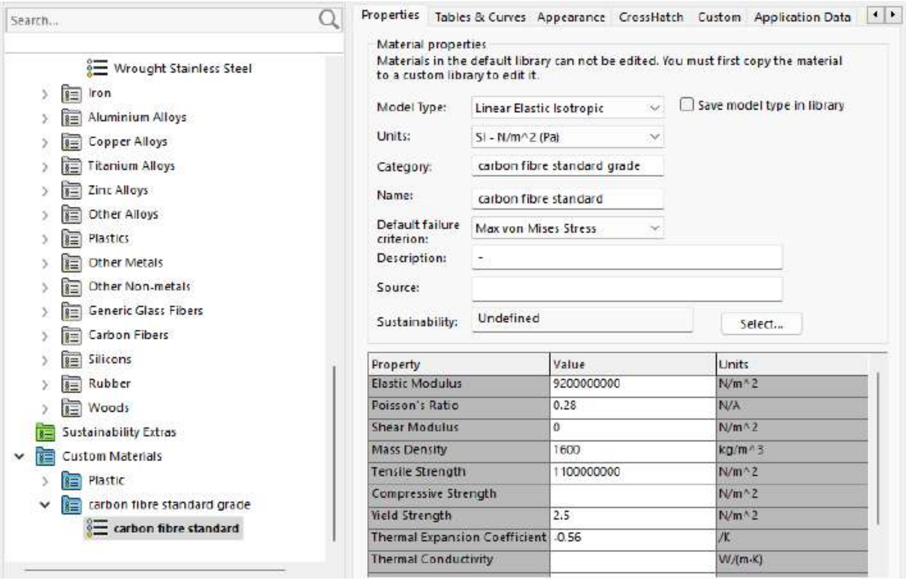

Figure 3.7 How to add and custom new material on the SOLIDWORK software

3.3.3 Mass Properties

To shown the mass properties on the software it must be done after apply the material on solid part lower arm. Then, it will be appear the mass properties on each part material. Select the Evaluate and click the Mass Properties. (Figure 3.8 and Figure 3.9)

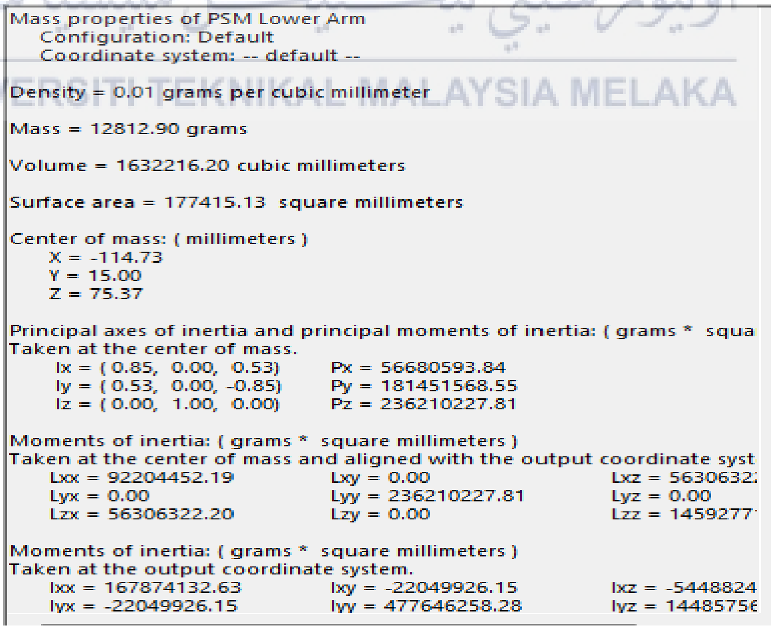

Figure 3.8 The Mass Properties for Solid part lower arm AISI 4350 Steel Normalized

```
Mass properties of PSM Lower Arm
    Configuration: Default
    Coordinate system: -- default --

Density = 0.00 grams per cubic millimeter

Mass = 2611.55 grams

Volume = 1632216.20 cubic millimeters

Surface area = 177415.13  square millimeters

Center of mass: ( millimeters )
     X = -114.73
     Y = 15.00
     Z = 75.37

Principal axes of inertia and principal moments of inertia: ( grams *  squa
Taken at the center of mass.
      Ix = ( 0.85,  0.00,  0.53)       Px = 11552732.50
      Iy = ( 0.53,  0.00, -0.85)       Py = 36983759.19
      Iz = ( 0.00,  1.00,  0.00)       Pz = 48144759.81

Moments of inertia: ( grams *  square millimeters )
Taken at the center of mass and aligned with the output coordinate syst
     Lxx = 18793264.14            Lxy = 0.00                  Lxz = 1147644
     Lyx = 0.00                   Lyy = 48144759.81           Lyz = 0.00
     Lzx = 11476447.84            Lzy = 0.00                  Lzz = 2974322

Moments of inertia: ( grams *  square millimeters )
Taken at the output coordinate system.
     Ixx = 34216383.72            Ixy = -4494252.46           Ixz = -1110588
     Iyx = -4494252.46            Iyy = 97354651.37           Iyz = 2952510.
```

Figure 3.9 The Mass Properties for Solid part lower arm AISI 4350 Steel Normalized

3.4 Simulation

When the product design was done, It can be run the analysis on SOLIDWORK analysis and simulate the product that can show the result and analysis. From the software also, it can produce results based on the analysis that can be apply on lower control arm design.

3.4.1 Analyze

To access the Finite element analysis on lower control arm, it must be done by analyze in SOLIDWORK. The purposes to analyze the lower control arm are to evaluate the performance of existing lower control arm to support in target setting and evaluate new concepts on lower control arm developed from results simulation. Lower control arm must inputs the requirements before run the simulation. There are:

1. Materials
2. Loads
3. Fixtures
4. Mesh

After the data inputs all be set, it can be analyze the simulation based on Figure 3.6 the flow process analyze simulation on lower control arm.

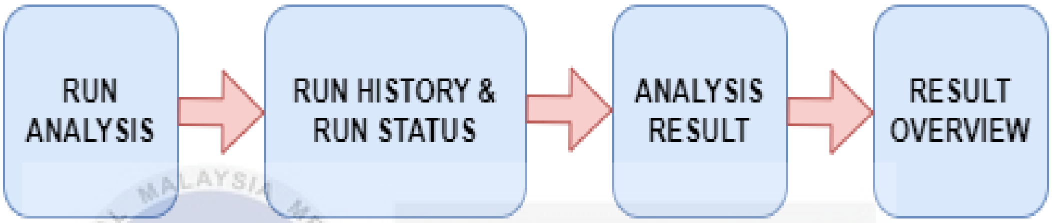

Figure 3.10 The flow process Analyze simulation on lower control arm

3.4.1.1 Run analysis

On run analysis, it must set the lauch run submission dialog where the details of the run can be defined on lower control arm. Table 3.1 details on run submission dialog with explanation. From the dialog below, its show the criteria needed before run the simulation. This can be seen at the simulation tree setup for run the analysis (Figure 3.11)

Table 3.1 Details on run submission dialog with explanation.

Dialog	Explanation
New Study	To conduct the solid part studies stressess. Diplacments, Strains and Factor of Safety with general simulation.
Apply Material	Defines material to selevted items.

External loads	Applaying the loads. Loads can simulate interactions caused by external bodies or phenoemenon excluded from the analysis
Fixtures	Describe how the model is supported.
Run the Study	To run a simulation analysis and overview the results analysis

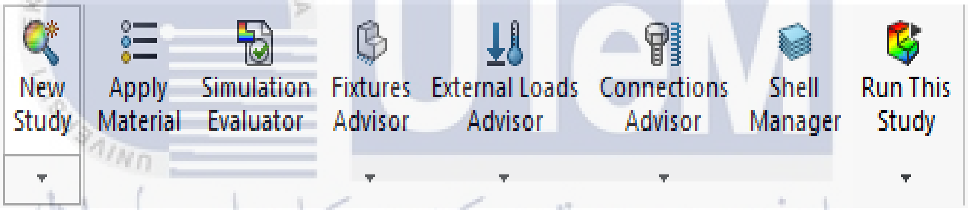

Figure 3.11 the simulation tree setup for run the analysis

3.4.1.2 Run History and Run Status

After the run analysis process is done, it can be show on the run history to show previously run on lower control arm model. It contains the history of analysis and optimization results which it can be open anytime

3.4.1.3 Analysis Results

In analysis results, it can compare different analysis results on lower control arm. Then, it can show analysis results at a point of interest in the lower control arm. All can be desplayed minimum and maximum callouts

3.4.1.4 Analysis Overview

From this analysis overview, lower control arm model can be displayed the results which are:

- Displacement
- Factor safety
- Resultant Reaction Force
- Von Mises stress
- Strain

3.5 Result Data Comparison

After the process of analysis and optimization, the infromation of displacement, factor safety, percent of yield, max shear stress, von Mises stress and two products lower control arm are collected. The data will be compare on Table 3.2 to see the differents between two products lower control arm and if the new material products have a better improvement than existing product.

Table 3.2 Sample data results

Material	Displacement	Factor Safety	Strain	von Mises stress
Steel				
Carbon Fibre				

3.6 Summary

This methodolgy provides the material of lower control arm from steel to carbon fibre. This is begis from modelling the example lower control arm and sketch the lower control arm using SOLIDWORK software. After the sketch two materials lower control arm, it will be test the design by simulation using SOLIDWORK to get the results of displacement, factor safety, strain, max shear stress and von Mises stress. Finally, these results will be compared between the existing lower control arm with the new material lower control arm.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter enlightened the description and explanation for all the results obtained from the project made. Starting from the sketch design lower arm that have been researched for the material properties, the results analysis were compared. This chapter also responsible for proving whether the objectives were archieved or not.

4.2 Results and analysis

The software has modules for performing many types of analysis. Displacement, Factor safety, Von Mises stress, and Strain are all part of the analysis. The outcomes of all the analyses that desire to be compared are provided by the two lower arms. Each value will be placed on a table to demonstrate the differences between steel and carbon fibre lower arms. Before the run simulation on the solid part lower arm, load and boundary condition and the calculation for the lower arm load must be calculate first before applied the force on the lower arm. Assume one of the car which is Myvi car was selected to be subject test on the lower arm analysis.

4.2.1 Load and Boundary condition

End A is attached to the ball joint, which moves in a vertical manner with a vertical load from the ground. It is fixed in the X and Y directions, thus there is no movement in those directions. Where end B and end C are fixed in the z direction and cannot move in the vertical direction. And it can only rotate in the x direction; rotation in the y and z directions is fixed. Due to side force components, the loads on ends B and C are obtained while turning.

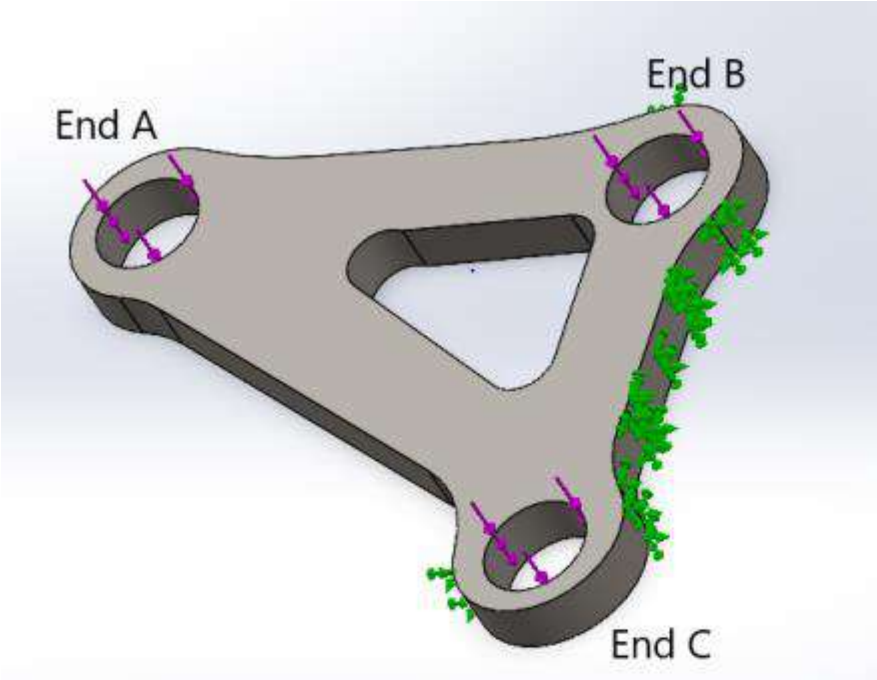

Figure 4.1 Applied boundary conditions

4.2.2 Calculation

For the calculation to get load case, it must be done to find the mass car, lenght car and center gravity. For this, Perodua Myvi was choose to do the simulation on lower arm. Here table 4.1 the data of Perodua Myvi specification:

Table 4.1 the data of Perodua Myvi specification

Type of car	Mass car	Length of car	Center of gravity
Perodua Myvi	985	3.895	1.9475

From the data, calculation can be forrm from the equation:

$$vertical\ Force = \frac{m \times 2 \times g}{2}$$

Where , mass is the mass of the car

2 is the number of wheels on which max load acting

g is the gravity.

So, the final answer from the equation above is 4831.25 N. This answer is for the end A load which is connected to the ball joint. Consider the car as it turns, with two forces acting on it. One is calculated vertical force, while the other represents rotating force. From equation,

$$momentum = force \times perpendicular\ distance$$

So the final answer will get for both End B and End C because two ends connected to the frame. The value is 7350.94 MPa

4.2.3 Von Mises Stress

Von Mises Stress is a value used to determine if a given material will yield or fracture. It is mostly used for ductile materials. Von Mises also is used to predict yielding of materials under complex loading from the results of uniaxial tensile tests. From the analysis results for both materials, steel and carbon fiber, Figure 4.2 and Figure 4.3 shows results for both materials, steel and carbon fiber.

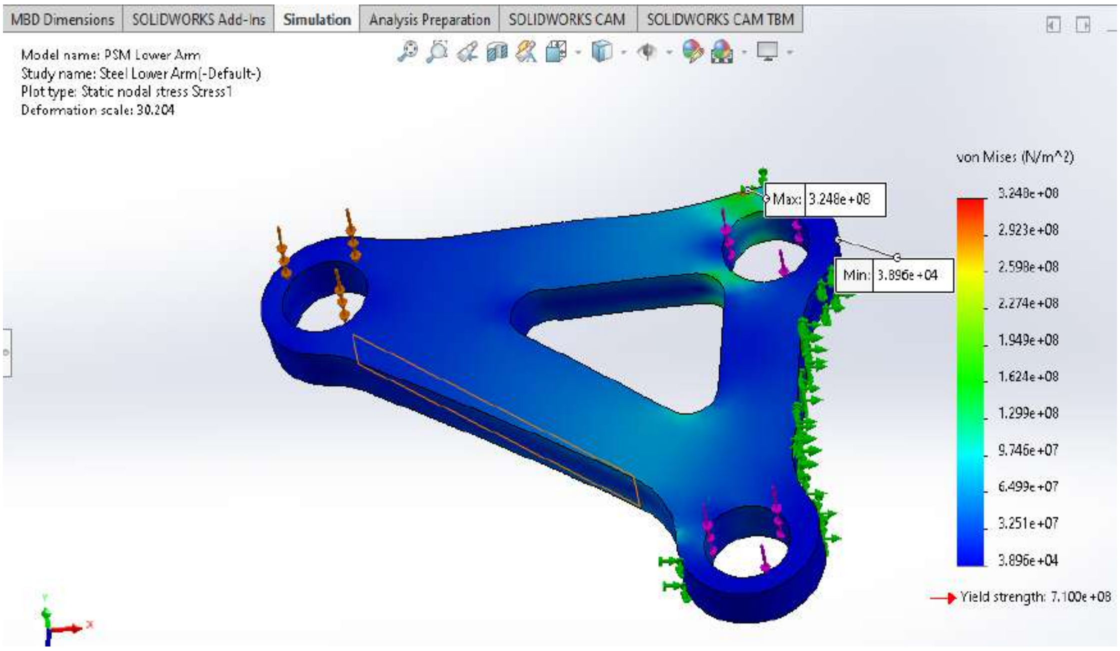

Figure 4.2 The results Von Mises Stress for AISI 4350 Steel Normalized

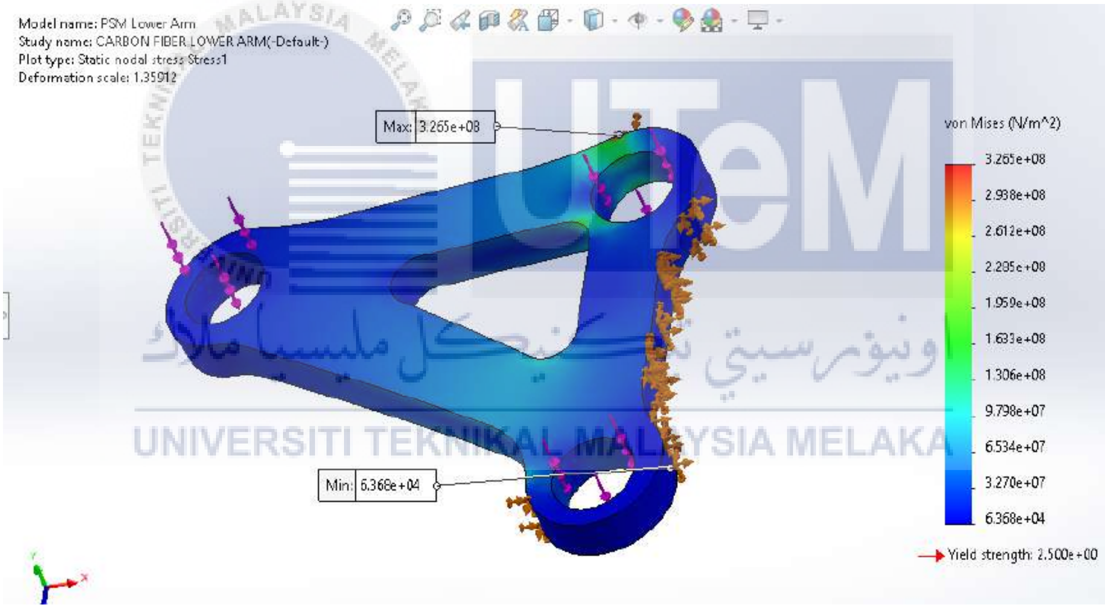

Figure 4.3 The results Von Mises Stress for standard Carbon Fiber

Observation for the both materials on Von Mises Stress results, AISI 4350 Steel Normalized solid part lower arm have values of 324.8 MPa meanwhile the standard carbon fiber solid part lower arm have values of 326.5 MPa. There is mean no effect on performance because of the value is not too significant for bothe materials.

4.2.4 Displacements

Displacement refers to the process of moving something from a location. In simulation results, it can be observed the movements of the solid part lower arm by playing the animation. Figure 4.4 and Figure 4.5 shows the results of displacements values for both materials.

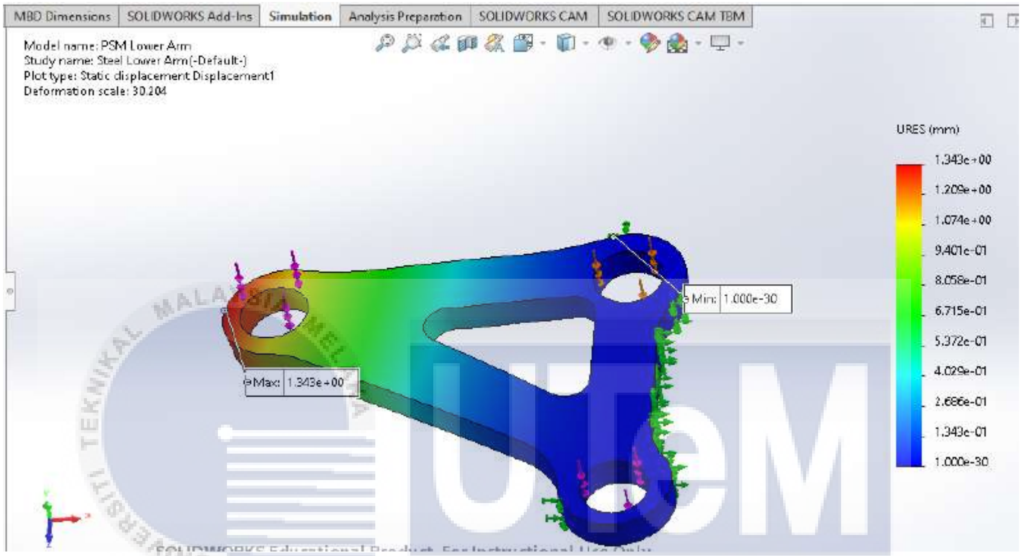

Figure 4.4 The results Displacements of AISI 4350 Steel Normalized

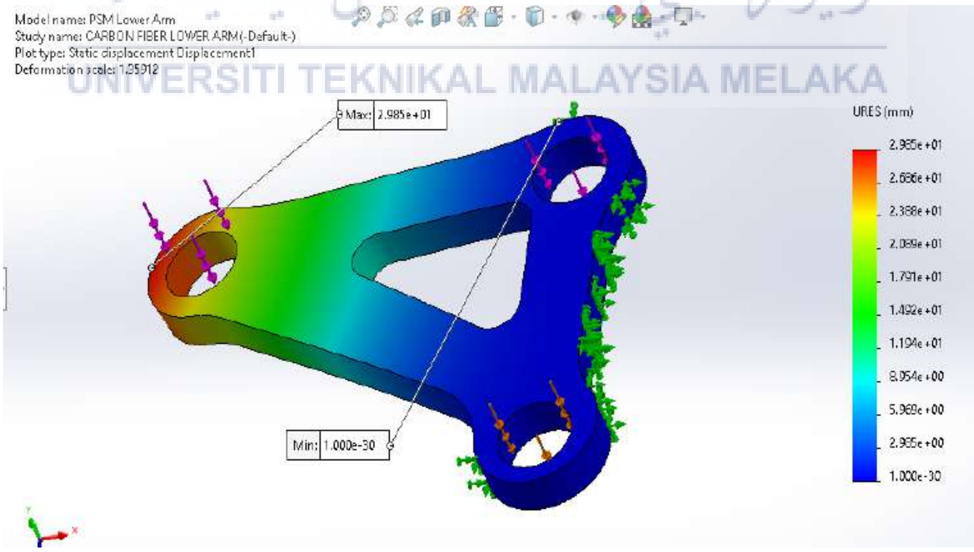

Figure 4.5 The results Displacements of Standard Carbon Fiber

From the results of diplacements for both materials, the AISI 4350 Steel Normalized is 0.1343 cm meanwhile the standard carbon fiber is 2.985 cm. This can be obeserve that the solid part lower arm standard carbon fiber is greater movement than the AISI 4350 Steel Normalized. So, the higher the displacements values, it can be form aa damage to the part.

4.2.5 Strain

Strain is a material's distortion caused by stress. It is just the ratio of the length change to the original length. Normal strains are deformations that are applied perpendicular to the cross section, whereas shear strains are deformations that are applied parallel to the cross section. For both materials, Figure 4.6 and Figure 4.7 shown the value of strain for both materials.

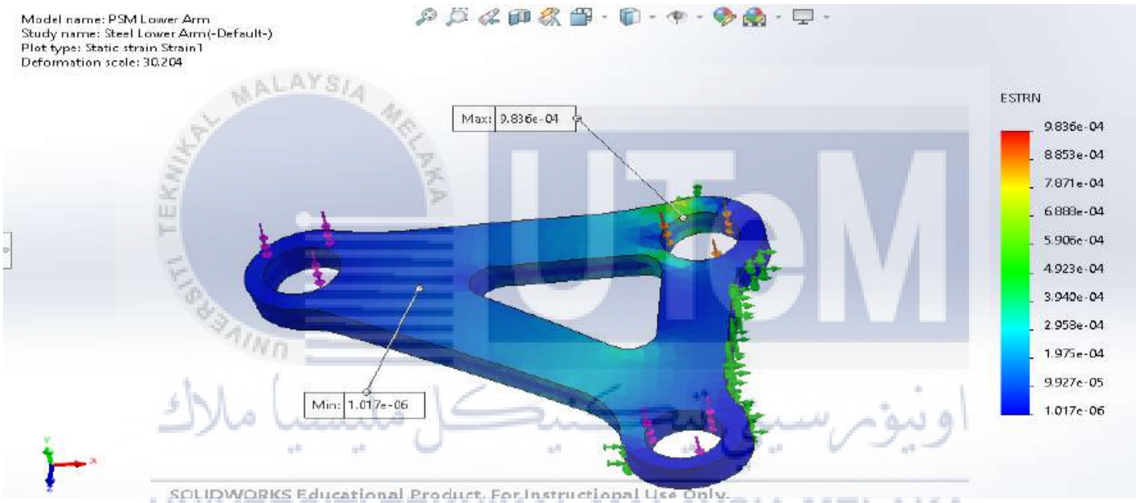

Figure 4.6 The value of strain AISI 4350 Steel Normalized

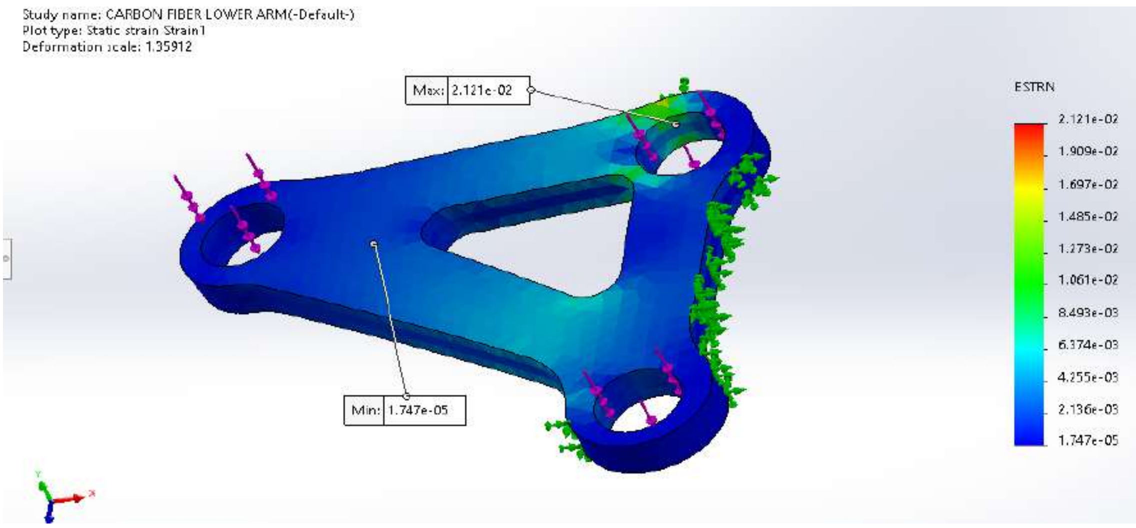

Figure 4.7 The value of strain Standard Carbon Fiber

The results strain from both materials, the AISI 4350 Steel Normalized has a value of 9.836 e-8 meanwhile the standard carbon fiber has a value of 2.121 e-2.

4.2.6 Factor of Safety

Factor of Safety is the ratio of a member's or piece of material's ultimate strength to its actual working stress or maximum allowable stress when in use. Figure 4.8 and Figure 4.9 shown the results of Factor of Safety for both materials

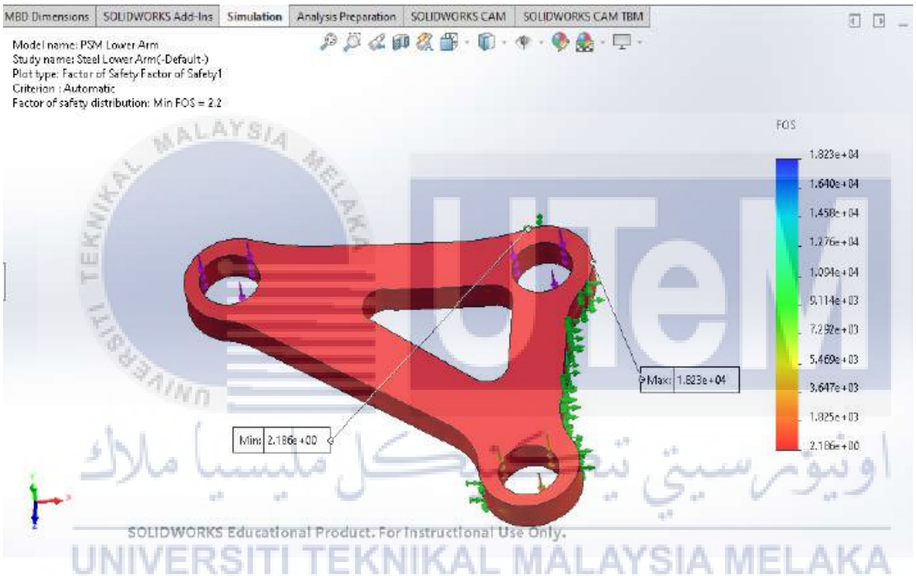

Figure 4.8 The results Factor of Safety AISI 4350 Steel Normalized

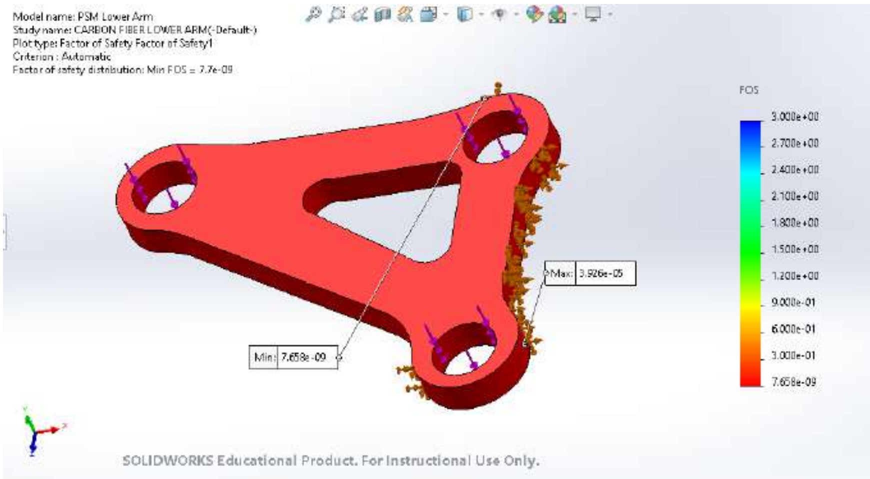

Figure 4.9 The results Factor of Safety Standard Carbon Fiber

From the results Factor of Safety for both materials, AISI 4359 Steel Normalized has a value of 1.823 e 4 of factor of safety meanwhile the standard carbon fiber has a value of 7.658 e -8 which are the solid part lower arm steel is more suitable for the part than solid part lower arm carbon fiber. The value from solid part lower arm carbon fiber is not logical because the characteritics of carbon fiber is ductile that main to the value of factor of safety is too far from the solid part lower arm carbon fiber.

4.2.7 Comparison material analysis.

The results for the data analysis were collected to the table 4.2 to observe the value of each analysis and comparing both materials solid part lower arm.

Table 4.2 Comparison Material Analysis

Material	Displacement	Factor Safety	Strain	Von Mises stress
AISI 4350 Steel Normalized	0.1343 cm	1.823 e 4	9.836 e-8	324.8 MPa
Standard Carbon Fibre	2.985 cm	7.658 e -8	2.121 e-2	326.5 MPa

The data table above, the solid part lower arm AISI 4350 Steel Normalized still the best material for suitable lower arm because each value from the analysis results shown the best solution to be form a material can be used on lower arm. Although new material, carbon fiber is applied to form a new lower arm material cannot be suitbae because lack of data value that is not logicaly and suitable for lower arm. The value for solid part lower arm carbon fiber can be observed from the data table, each analysis results definitely not accuired to add perform new material. This is because the characteristic of carbon fiber is not enough or suitable to be part of automative product.

4.3 Summary

The material for carbon fiber is not suitable for automotive products when it is made fully carbon fiber because the characteristics of carbon fiber still lack of durability but the carbon fiber achieve the mass reduction from previous material AISI 4350 Steel Normalized that reduce the mass higher. The value data analysis such as displacement, Factor of safety, strain and Von Mises Stress, the solid part lower arm steel definitely is the best requirement for automotive product and can be used to other products. In addition, carbon fiber still can be used in another way to proceed the best solution performing new material by combining other material.

CHAPTER 5

CONCLUSION

5.1 Conclusion

As a conclusion, this project has brought more knowledge and studies on the accuracy and sensitivity of various design of lower control arm by performing new material. Next, there are many applications for design lower control arm has been implemented in the automotive industries to achieve a good product. The material of lower arm is taken into consideration during analysis that is carried out. It was found many lacks of mistakes during this project to form new design lower arm. The carbon fiber is not a solution to form new material for lower control arm because the results analysis is not suitable for this products. So, for the next future for analysis material lower arm, it can be prove that carbon fiber can be used in automotive products to attach the durability by performing combine materials.

5.2 Recommendation

For future research and improvement , estimation results could be enhance as follows:

I. This research can be studied even more by applying suitable material

II. Studies more about carbon fiber material properties and caharcteristcs to apply the material into the products by combining with other materials.

III. Specific in design and load cases to make sure the results analysis is more accurate.

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APPENDIX

APPENDIX A GANTT CHART

PROJECT ACTIVITY	ACADEMIC WEEK SEMESTER 2													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PSM 2 meeting with super visor (DR. Rosidah Binti Jaafar)								S						
Design the lower control arm in SOLIDWORK								E						
Apply material and custom material carbon fiber								M						
Apply a load case on software														
Run simulation for both materials								B						
Progress on chapter 4								R						
Collect data results on SOLIDWORK ANALYSIS								E						
Comparison the data for both material								A						
Proposed the results and finishing chapter 4								K						
Progress on Chapter 5 Conclusion														
Review on report PSM 2 and 4 pages summary														
Seminar Presentation of PSM 2 with panel														

Rujukan Kami (Our Ref):
Rujukan Tuan (Your Ref):
Tarikh (Date): 31 Januari 2021

Chief Information Officer
Perpustakaan Laman Hikmah
Universiti Teknikal Malaysia Melaka

Melalui

Dekan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Tuan

PENGKELASAN TESIS SEBAGAI TERHAD BAGI TESIS PROJEK SARJANA MUDA

Dengan segala hormatnya merujuk kepada perkara di atas.

2. Dengan ini, dimaklumkan permohonan pengkelasan tesis yang dilampirkan sebagai TERHAD untuk tempoh **LIMA** tahun dari tarikh surat ini. Butiran lanjut laporan PSM tersebut adalah seperti berikut:

Nama pelajar: MUHAMMAD ANAS FARID BIN MASRI

Tajuk Tesis: PERFORMING NEW MATERIAL FOR LOWER CONTROL ARM PRODUCT VEHICLE USING FINITE ELEMENT ANALYSIS METHOD

3. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"
"KOMPETENSI TERAS KEGEMILANGAN"

Saya yang menjalankan amanah,

NAMA
Penyelia Utama/ Pensyarah Kanan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka