UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A NEW DESIGN OPTIMIZATION OF LIGHTWEIGHT LOWER CONTROL ARM FOR B-SEGMENT PASSENGER CAR

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

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DECLARATION

I declare that this thesis entitled "A new design optimization of lighweight lower control arm for B-segment passenger car" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Mechanical Engineering Technology (Automotive Technology) With Honors

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Date:

ABSTRACT

Recent year automakers are concerned with the carbon dioxide that produce by the vehicle. To reduce this, some components of vehicle can be reduce their weight resulting in reducing the carbon dioxide that produce. Purpose for that, this study was conducted to reduce the weight of the lower control arm for the B-segment passenger car by reducing the weight about 30% percent of their weight by using the method of the optimization process. The lower control arm product was produced using the Catia V5 Software and had been optimize using the Solidthinking – Inspire software. Several parameter had been constrain such as the hard point for the lower control arm, the loadcase that been applied and the material that used to ensure the overall performance of the lower control arm meet the requirement. At the end of this project, the best design of the lower control arm will be recommended based on the analysis data that had been conducted where it can be used for future development.

ABSTRAK

Dalam era yang serba moden ini, peningkatan carbon dioksida yang dihasilkan oleh kenderaan amat membimbangkan para pembuatan perusahaan kenderan. Untuk mengatasi hal yang demikian, terdapat beberapa komponen pada kenderaan yang dapat dikurangkan berat komponen tersebut dan secara tidak langsung dapat mengurangkan penghasilan karbon dioksida. Tujuan utama projek ini dijalankan adalah bagi mengurangkan berat salah satu komponent sistem gantungan iaitu arm kontrol bawah untuk kereta segmen- B sebanyak 30% dengan mengunakan kaedah pengoptimuman. Penghasilan produk Arm kontrol bawah dihasilkan mengunnakan perisian Catia V5 dan proses pengoptimuman dijalankan menggunakan perisian Solidthinking – Inspire software. Beberapa faktor dalam penghasilan arm kontrol bawah telah ditetapkan seperti titik penting, daya yang dikenakan pada arm kontrol bawah dan jenis bahan yang digunakan bagi memastikan arm kontrol bawah dapat mengekalkan prestasi pada tahap optimum. Di akhir projek ini, persediaan rekabentuk arm kontrol bawah yang terbaik akan dipilih berdasarkan maklumat analisis yang telah diperoleh dimana ia boleh digunaklan untuk pembangunan masa hadapan.

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TABLE OF CONTENT

LIST OF FIGURE

LIST OF TABLE

CHAPTER 1

INTRODUCTION

1.0 Introduction

Recent years, automotive industry was growing rapidly this can see when automakers are investing their money in develop new system for automotive usage. Not only that, this also can be seen when automakers are concerned with the reducing of carbon dioxide produce by the vehicle. In achieving this, they are attempted to reduce the weight of the vehicle as much as possible in order to achieve the optimum weight of the vehicle that effected in reducing in the carbon dioxide produce and achieved the most ideal fuel consumption. As the weight of the car was reduced, it's enables the manufacturer to develop the same vehicle characteristic with smaller engine, smaller transmission and fuel tank. From this it's estimated that overall of 10% vehicle reduction resulting in 8-10% of fuel economy improvement (Liew, Hashim, & Rahman, 2017).

In this study, the development of the new design concept of Lightweight Lower control arm system for the Macpherson suspension system was produce. Lower control arm system is one of the vital component on the suspension system where the role of the system is to maintain the tire movement to make sure the tyre is always make contact with the road surface by force produced on the lateral and longitudinal force. A control arm connects the wheel centre point and guiding knuckle to the casing of the vehicle. The lower control arm could be shape of A or L geometry. The conventional Lower Control Arm (LCA) was produced by the usage of the SAPH 440 steel material. SAPH 440 steel is structural Hot Rolled steel in the form of plates, sheets & strip purpose for automobile. To produce light weight vehicle, recent study show that the development of lightweight material that used in car was increased.

The development of the AHSS had been begun science early 2000 where the automakers are finding to develop strong and lightweight of the automotive parts, body or other components. The development of the applying AHSS into the automotive is because of the increasing vehicle production, AHSS can be formed and joined in much the same way as milder steel, but with only half the thickness. Instead of getting into the parts that reduce the weight of the car and reduce the emission, the application of the Advance High-Strength steel (AHSS) into the automotive parts, body or other components help to improve the passenger safety. As the weight reduction measure, automakers are increasingly applying the high tensile strength steel to automobile (Giho, 2004). The AHSS is not like the timeworn mild steel that been used for ages the yield strength exceeds of 550 MPa. Other than the AHSS there is another metal that so-called Ultrahigh-strength steels where the tensile strength are over 780 MPa. These steels are also sometimes called "ultrahigh-strength steels" for tensile strengths exceeding 780 MPa.

Not only the material need to be in term of light weigh , the design also need to be as ideal as possible to reduce the weight of the material. This can be achieved by using the optimization process. Optimization process is process where to maximize or minimize the design restricted to the certain parameters. By combined the lightweight design and the lightweight material the objective to produce lightweight vehicle can be achieved by the help of Computer Aided Design (CAD) software such the CATIA and Hyperwork. For the product development process several method had been used starting from the designing process until the fabrication of part. The product prototype is made by using the 3d metal printing using DMLS 3D printing.

1.1 Problem statement

There is some components inside the car that can be reduce their weight in term of design or material that use, in order to produce a lightweight vehicle. There is slightly significant contribution of the lightweight components to the car weight, but small contribution will lead to improve in fuel efficiency and emissions. As one of the automotive

To solve the problem, this study is focusing in reducing the weight of the lower control arm from the design aspect and the material that use by using the design optimization process and resulting in analysis by using the linear analysis study.

1.2 Objective

I. To design new design concept of lower control arm system.
II. To develop a prototype of lightweight lower control arm system using 3D Printing.

1.3 Scope

1. Project primarily focus on the new design of lower control arm system for MacPherson Suspension system for front suspension only.
2. To achieve lightweight lower control arm by reduction over 30% of weight based on the previous study by help of the Optimization Process.
3. Study restricted to new design by constrain on the manufacturing stamping process & Additive Manufacturing process.
4. Analysis result refer to the material mechanical properties for the conventional metal & Metal 3D printing

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this modern era the automotive industry is growing rapidly, this we can see when the biggest automotive industry company is investing their money to develop a new system for future. Not only that, they also develop in making a light weight components for automotive application. The term of light weight components for automotive application is purpose for reduction of the weight of transport vehicles. Instead reduce the weight of the vehicle the main reason to produce light weight components for the automotive application to reduce the energy consumption by resulting reduce the (CO2) emissions. The application of lightweight material for vehicle components, well known as "light weighting" resulting in automobile weight reduce and directly improve the vehicle fuel economy (Cole & Sherman, 2002). As a result of vehicle is one the largest contribution to the greenhouse effect since its release the carbon dioxide (CO2) it's important to reduce the emissions that produce by them. The essential driver of transportation-related emanations was (CO2) from non-renewable energy source ignition (Sims et al., 2014). In this study the development of the new design concept of Lightweight Lower control arm system for the Macpherson suspension system was produced. Lower Control arm is one of key components in the suspension system, more about the suspension system will be discuss in this chapter.

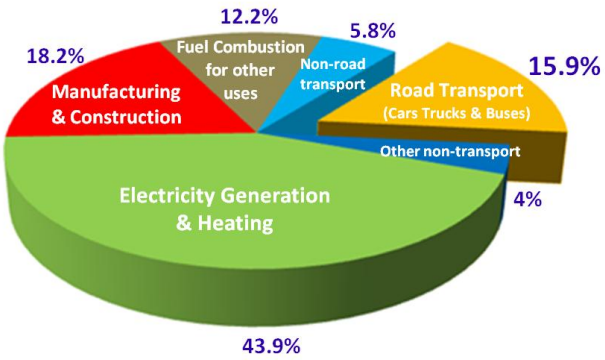

Figure 1: CO2 Contribution by sector.

2.1 Introduction of Suspension System

Suspension system is one of the key to achieve riding comfort, handling qualities and safety for the car user. The key to achieve riding comfort and handling qualities in the automotive industry was greatly affected by the suspension system (Gadade, 2015). The purpose of the system is to maintain the stability, safety and manoeuvrability. Besides, suspension system also provide various role such as control the tyre to make sure tyres is always make contact to the road surface , protecting vehicle chassis from shocks excited when driving on the rough road surface. If the vehicle body isolate from uneven road and inertial disturbances corresponding during the circumstance of cornering , braking , and speeding up the suspension system will consider ideal system (Gadade, 2015).

There are several components in the suspension system such as spring, wheels and tires, shock absorber and struts, linkage, bushings, bearings and joints. These components are design to make sure the system run smoothly, several fault in the minor components can cause abnormal behaviour of the suspension system for the worst case it might place the driver into risk. The design of a suspension system was significant influence the system performance. At the point when the vehicle move along the road, the vehicle will exhibits the impact loads. It's very uncomfortable for passenger, if the passenger experience unexpected motion along with the vehicle (Khode, 2017).

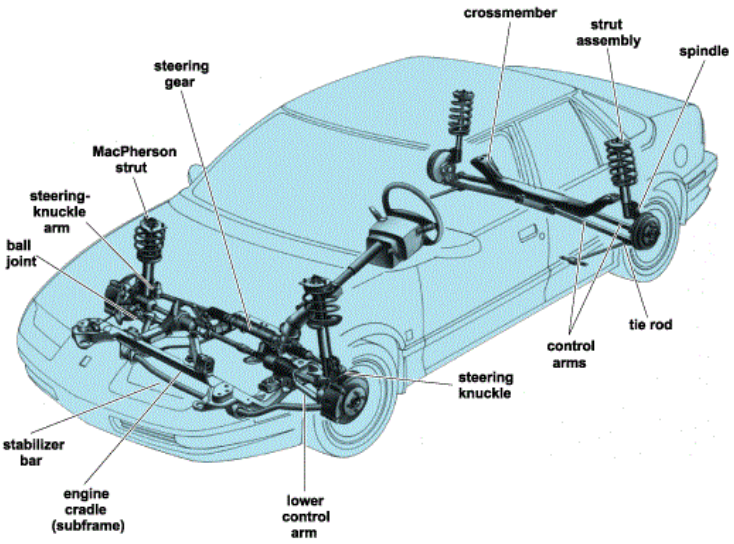

Figure 2: Suspension System Overview

2.2 Category of Suspension System

There is two diverse class of suspension namely, Dependent suspension system and the Independent Suspension system. For purpose for this study the focus are on the Independent Suspension type the MacPherson Strut Suspension.

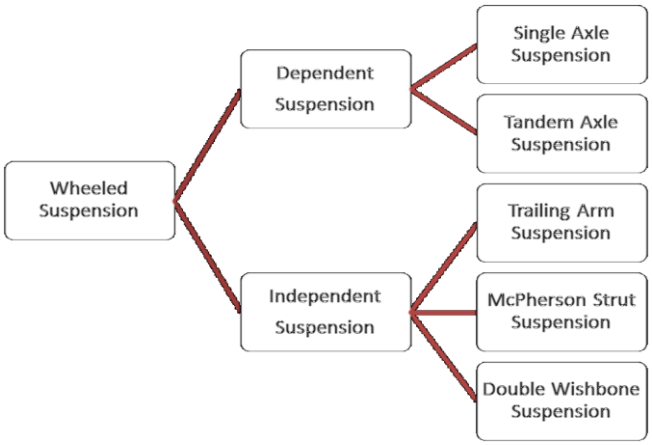

Figure 3: Type of Suspension System

2.2.1 Dependent suspension.

In this system there is a solid axle that connect both wheel together that goes across the width of frame. This cause when one wheel are on the bump its transfer the motion to the opposite wheel. There were solid connection between two wheels that located on same axle on the dependent suspension system. If the motion occurred at one wheel, the motion will be transfer to the other wheel while moving along surface irregularities (Khode, 2017).

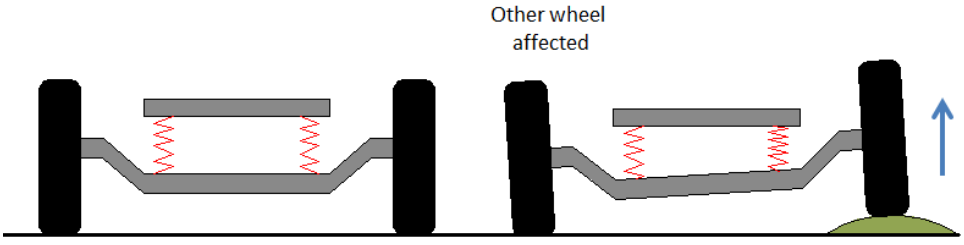

Figure 4 : Dependent Suspension System

2.2.2 Independent suspension

For this system, it allow the suspension to work independently for each wheel since there is no connecting axle between the one wheel to the other opposite wheel. This cause the motion for the one wheel will no transfer to the other wheel during riding on the uneven road condition such as bump and other. The rise and fall of the wheel on their own are allowed in independent suspension without affecting the other wheel on same shaft(M.Sridharan & Dr.S.Balamurugan, 2016).

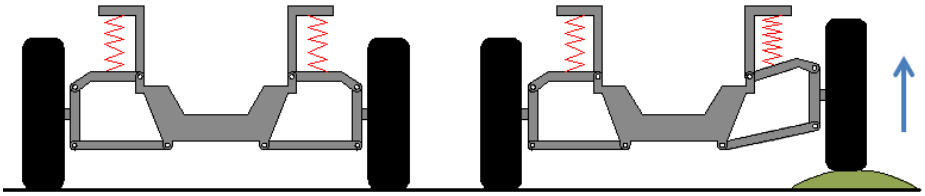

Figure 5: Independent Suspension System

2.3 MacPherson Suspension System

McPherson suspension system had been develop since 90's by the Earl MacPherson it has been design for the Ford Company. There is several basic components for the system, the upper mounting point, shock absorber, spring, spring leg and only one lower control arm used. The Macpherson only contains one lower control arm, they also well known as single wishbone system (Verma & Raza, 2016). This suspension system is commonly use for the front suspension but it's also can be found for the rear suspension system. Besides, this system is also use for the small and medium car due to its light weight, compact size and less cost. As the system are more light weight and size compatibility the system is widely used in different car manufacturer (Fallah, Bhat, & Xie, 2008).

McPherson suspension system is design with more simplicity system where the suspension upper bolt is directly connected to the upper part of body while the lower end suspension bolt is bolted to the steering knuckle. The typical Macpherson system , the upper bolt are positively attached to top of the body structure and bottom bolt connected to the knuckle (Craig, n.d.).

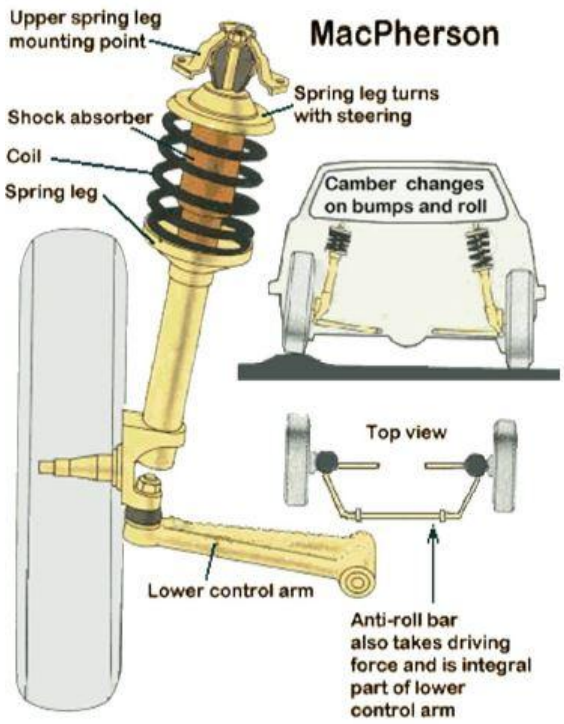

Figure 6: Schematic Diagram of Macpherson Suspension System

2.3.1 Advantage and Disadvantage of Macpherson System

Every system had their own pro & Cons, this what make the system are unique then the other's system.

2.3.1.1 Advantage of Macpherson Suspension System.

There are few advantage for the system:

1) Takes up a bit space horizontally, that permits for a lot of space for the front drive shaft to have the front hub.
2) Grant for further passenger section space.
3) The Macpherson strut are low-cost in contrast to any of the other independent suspension system.
4) Increase the ride comfort exhibited by the car.

2.3.1.2 Disadvantage of Macpherson Suspension System.

1) Since the shock absorber are almost in vertical position the Centre gravity is increase because of the ride height.

2) The variation of the chamber position because of the body rolling and cornering.

2.4 Lower Control Arm

Lower Control arm (LCA) is part of the suspension system where it provide the connection to the wheel hub and steering knuckle to the frame of the vehicle. Suspension arm or well known as the lower control arm are one of key components in the suspension system (Khode, 2017). The role of the lower control arm is to manage the movement of the tyre either to move up or down during drive. The lower control arm enable the up and down motion of wheel (M.Sridharan & Dr.S.Balamurugan, 2016). There is end support at the lower arm that call lower ball joint system that connect the knuckle and control arm and bushing support that connect between the control arm and chassis.

The lower ball joint system is to connect and holds the front suspension of vehicle together and it's allow the wheel and suspension to move synchronise. Ball joint was one the influence components for the car suspension system. The system act as pivot point between two parts: the suspension and tires (Shinde & Kadam, 2016).

Next for the bushing system, this system is typically consist of and outer metal sleeve, durable rubber and inner metal sleeve. The bushing support is offer the cushion to the system where they control the vibration and noise that occur in the system. This system play important role in the system. To achieve riding comfort and better handling of vehicle, the design of the suspension bushing also influence the both two factor (S. R. Kumbhar, Subhasis Maji, 2013) .

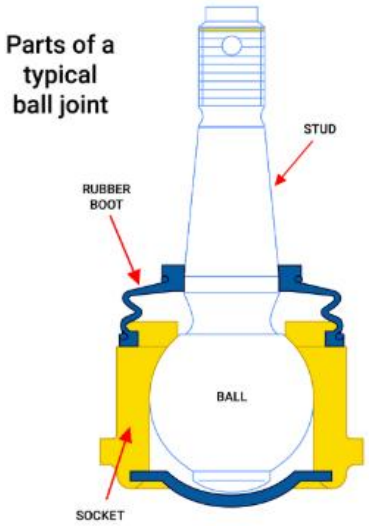

Figure 7: Ball Joint System

Figure 8 : Lower Control Arm Bushing

2.4.1 Shape of Lower Control Arm

There is some designed of lower control arm that had been produce, each shape is design to meet the usage of the control arm for their application. There is an A-type shaped, U-typed shaped and L-typed shaped, H- typed shaped or single bar linkage. This is the basic shape design of the lower control arm. There are so many shapes of control arm like L-shape, and U-shape (Dahanu & Prof.r.s.kattimani, 2016). In this study, we are focusing only for the L-typed shaped design

The L-typed shaped are usually produce for the usage of the passenger vehicle. This is because of the design is more simple that can easily reduce the cost of the manufacturing process. Other, than that the L-typed shaped are improved in performing for the handling and comfort in drive. The L-shaped design are more preferable for the passenger vehicle as it's allow greater handling and comfort to be tuned in (M.Sridharan & Dr.S.Balamurugan, 2016).

Next for the A-type shaped, this shaped can be used in various type of suspension structure for example for the usage in the Double wishbone suspension system. For this type of lower control arm shaped are useful for lowering the profile hood and provide package space for the engine in longitudinal direction. The system well known as A-type control arm and provide linkage between the wheel hub and vehicle frame. The system offer variety of motion while maintaining proper suspension alignment (Gadade, 2015).

Figure 9 : L-Typed Shaped Design

Figure 10 : A-Typed Shaped Design

2.5 Design

Design new product basically to improve the actual design of product that had been develop or improve the functionality of the product. Engineering designs so called as invention-devices or something that created by human power and did not exist previously or an enhancements over existing product or system (Khandani, 2005). Design process include several step from the beginning where the process of identify the problem until the product development. This step must be followed to achieve desire new product that can solve the problem. The good solution to design problem need several step and process. The solution to the design problem doesn't suddenly appear (Khandani, 2005).

There is 5 basic step that must be followed but the process may be backtracking and iteration because of several situation that can't be achieved during the development of the product.

1) State the problem.
2) Look after the background research and Constrain
3) Generate Multiple Solution.
4) Analyse and select a solution.
5) Test and implement the solution.

In implement the new design the design must concerned with an ideal product architecture. The product architecture was obtain by observe the physical configuration and connection of the main components to other components or other interconnection of sub-components and main components in turn. By focusing on the product architecture the overall product specification can be obtained such the product dimension, tolerance, surface goods and materials. Design process need to be determined the overall products detailed instantaneously while running other design activities in corresponding (Murthy, D. N. Prabhakar, Rausand, Marvin, Øster ås, 2011)