UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPROVEMENT OF ANTI ROLL BAR FOR ROLLOVER PREVENTION IN AUTOMOTIVE APPLICATION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) (Hons.)

by

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I hereby, declared this report entitled " Improvement of Anti Roll Bar for Rollover Prevention in Automotive Application" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) (Hons.). The member of the supervisory is as follow :

.....

(Encik Nur Rashid bin Mat Nuri @ Mat Din)

ABSTRAK

Merekabentuk sistem penggantungan kenderaan untuk sejenis jalan tertentu atau mentakrifkan manuver bukan satu cabaran lagi. Ini adalah kerana, aplikasi profil menjadi lebih luas, dan juga menjadi lebih sukar untuk mencari sebuah spring yang sesuai dan ciri-ciri peredam bagi mencapai kompromi yang boleh diterima antara keselesaan pemanduan dan pengendalian. *Anti-roll bar* kenderaan merupakan komponen penggantungan yang digunakan untuk menghadkan sudut gulingan badan kenderaan. Ia mempunyai kesan langsung ke atas ciri-ciri pengendaliaan kenderaan. Perubahan dalam reka bentuk *anti-roll bar* adalah perkara biasa dalam pelbagai aliran pengeluaran kenderaan, dan analisis reka bentuk mesti dilakukan untuk semua perubahan.

Dalam kajian ini, *anti-roll bar* aktif dan separa aktif dihasilkan untuk membandingkan reka bentuk dan analisis *anti-roll bar* pasif sebagai satu cara untuk meningkatkan pengendalian kenderaan tanpa mengorbankan keselesaan perjalanan. Penyelesaian yang dicadangkan direka, dan dianalisis untuk mengukur keberkesanan *anti-roll bar* aktif dan separa aktif berbanding *anti-roll bar* pasif di kedua-dua pengendalian dan keselesaan kenderaan ketika menunggang pada keadaan perubahan dua lorong.

ABSTRACT

Design the suspension system of the vehicle for a type of defines certain road or manoeuver is not a challenge anymore. This is because, the road profile applications become wider, and also becomes more difficult to find a suitable spring and damper characteristics to achieve an acceptable compromise between ride comfort and handling. Vehicle anti-roll bar is one of the suspension component use to limit vehicle body roll angle. It has a direct effect on the handling characteristics of the vehicle. Changes in the design of anti-roll bar is common in multi-step production of vehicles, and the design analysis must be performed for all changes.

In this study, active and semi-active anti-roll bars are developed to compare the design and the analysis of passive anti-roll bar as a way to improve vehicle handling without sacrificing ride comfort. The proposed solution is designed, and analyzed to measure the effectiveness of the active and semi-active anti-roll bars towards passive anti-roll bar on both handling and ride comfort for double lane change condition.

DEDICATION

Every challenging work needs self efforts as well as guidance of elders especially those who were very close to our heart. My humble effort I dedicate to my sweet and loving parents, whose affection, love, encouragement and prays of day and night make me able to completing this project succesfully.

ACKNOWLEDGEMENT

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Besides that, I would like to express an appreciation on all the help and concerned during completing this report. All the guidance is very helpful in the success of completing this report. I appreciate on his concern to share all the knowledge and experiences that he had. With all the patience, focus on the readings, interest on this research and also a convince feedback from him are very helpful to complete this report.

Then, in this opportunity, I would like to express my special gratitude and thanks to my family because of all their blessed on me. My thanks and appreciations also go to my colleagues in developing this report and people who have willingly helped me out with their abilities.

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LIST OF ABBREVIATIONS, SYMBOLS, AND NOMENCLATURE

K&C - Kinematic and Compliance

DLC - Double Lane Change

MR - Magnetorheological

TVA - Tuned Vibration Absorber

NATO - North Atlantic Treaty Organization

ISO - International Organization for Standardization

PCL - Path-Corrected Limit

LC - Lane Change

NHTSA - National Highway Safety Administration

CAE - Computer Aided Engineering

FEA - Finite Element Analysis

LCA - Lower Control Arm

UCA - Upper Control Arm

CG - Centre of Gravity

R - Right

L - Left

CHAPTER 1

INTRODUCTION

1.1 Background

For the automotive industry, a major consideration is to provide passenger safety, through optimal road holding and comfort, for a large variety of road conditions and vehicle maneuvers. By providing an optimal road contact for tires while minimizing or preventing the roll and heave of the vehicle body, the passenger comfort and safety can be improved. The system responsible for this action is the vehicle suspension, which is a complex system incorporating various arms, springs, and dampers that separate the vehicle body in two aspects such as the sprung mass, from the tires and axle and the unsprung mass.

Many vehicles are equipped with fully passive suspension systems, incorporating springs, dampers and anti-roll bars with fixed characteristics due to their low cost and simple construction. Noting that optimal handling and passenger comfort are conflicting objectives, these passive systems can only obtain a compromise between safety and comfort. However, with the introduction of semi-active anti roll bar, this compromise has been significantly reduced.

Anti roll bars are fitted as one of the key components in the vehicle's suspension system. They can be fitted at the front and the rear of the vehicle and their purpose is, as the name suggests, to reduce body roll from the vehicle under cornering conditions. For vehicle, when everything leans to the outside of the turn, it pushes down on that side of the vehicle. As this happens, there is less loading on the side of the vehicle on the inside of the turn and it lifts up slightly. When this scenario occurs it is referred to as body roll and is something we try to avoid. Roll transfers the load to the outside of the turn which means considerably harder work for the tire, which will lead to excessive wear, a reduction in traction as the inside wheels will not have as much weight on them and will require the driver to work harder to adjust the steering wheel to compensate.

1.2 Problem Statement

Nowadays, typical vehicle behavior is pitching during braking and acceleration, and rolling in the corners. Additionally, road irregularities can cause vibration in the vehicle. The body-roll during cornering is demanding aspect of the vehicle, which can reduced comfort, and unstable the vehicle. The passive anti roll bar is not so effective, thus vehicle needs another type of an anti roll bar that can interact with both right and left suspensions. Depending of this problem, the active and semi active anti roll bar is invented to improve the vehicle anti roll bar system.

1.3 Objectives

The objective of this project is:

a) To design the active and semi active anti roll bar system using CATIA V5 software
b) To analyze the anti roll bar using the HyperWork MotionView software

1.4 Scopes

The scope of this project is:

a) Design the anti roll bar using the CATIA V5 software
b) Do the roll test which is Kinematic and Compliance (K&C) analysis, and Double Lane Change (DLC) analysis of anti-roll bar by using the parameter in HyperWork MotionView
c) Compare the passive, semi-active, and active anti roll bar based on the result that provided in the analysis

CHAPTER 2

LITERATURE REVIEW

2.1 Anti Roll Bar

2.1.1 Anti Roll Bars and Vehicle Performance

Three aspects that a vehicle suspension system has to provide compromise solutions such as ride comfort, handling, and road holding. Ride comfort requires insulating the vehicle and its occupants from vibrations and shocks caused by the road surface. Handling requires providing safety in maneuvers and in ease in steering. The tires must be kept in contact with the road surface in order to ensure directional control and stability with adequate traction and braking capabilities for good road holding (Ünlüsoy, 2000). As has been a suspension component, anti roll bar is used to improve the vehicle performance with respect to these three aspects (Kemal, 2003).

2.1.2 Function of Anti Roll Bar

During cornering, anti roll bar or stabilizer bars in motor vehicles are functioning to reduce the body roll. Wheel load shift and the change of camber angle influenced by body roll is influenced by the occur. Steering performance, which may be purposefully adjusted towards understeer or oversteer when designing the stabilization is important. So the travelling comfort and the driving safety of stabilizer bars increases the to a considerable amount. Stabilizer bars are non-bearing spring elements in vehicles. The stabilizer bars are normally loaded during the driving phases only in contrast to all bearing springs, which are loaded by the static forces also in resting condition.

2.1.3 Position of Anti-Roll Bar

The position of stabilizer bars is selected according to the way that the anti-roll suspension stiffens, the rotation of the body about the vehicle's longitudinal axis is made difficult, without simultaneously hindering the vertical suspension, which is the motion of the body towards the vertical axis. The stabilizer bar is arranged in the axle in such a way that the back comes to rest approximately at the level of the wheel centers across the driving direction for this purpose. The bearings of the stabilizer bar support themselves against the body.

The anti-roll bar is usually connected to the front, lower edge of the bottom suspension joint. It passes through two pivot points under the chassis, usually on the subframe and is attached to the same point on the opposite suspension setup. Effectively, it joins the bottom of the suspension parts together.

In the case of rear suspension, the fittings will probably already be there even if the anti-roll bar isn't. Typical anti-roll bar kits include the up rated bar, a set of new mounting clamps with polyurethane bushes, rose joints for the ends which connect to the suspension components, and all the bolts etc that will be needed (Chris, 2010).

The anti-roll bar is a rod or tube that connects the right and left suspension members. It can be used in front suspension, rear suspension or in both suspensions, no matter the suspensions are rigid axle type or independent type. A typical anti-roll bar is shown in Figure 2.1.

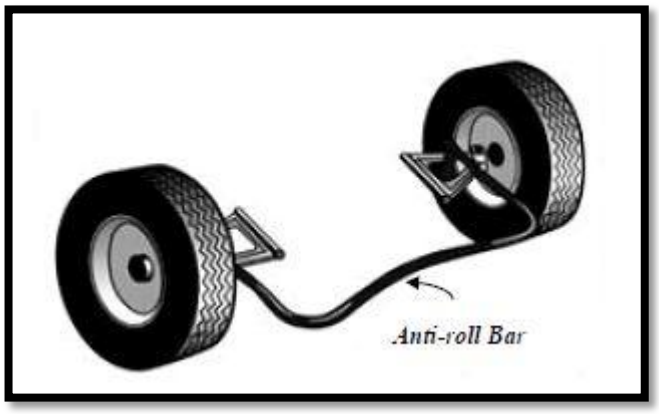

Figure 2.1 : Typical anti roll bar in automotive industry (www.motorera.com,2009)

The ends of the anti-roll bar connect to the suspension links while the center of the bar is connected to the frame of the car such that it is free to rotate. The ends of the arms are attached to the suspension as close to the wheels as possible. If the both ends of the bar move equally, the bar rotates in its bushing and provides no torsion resistance. But it resists relative movement between the bar ends, such as shown in Figure 2.2. The bar's torsion stiffness-or resistance to twist-determines its ability to reduce such relative movement and it's called as "roll stiffness".

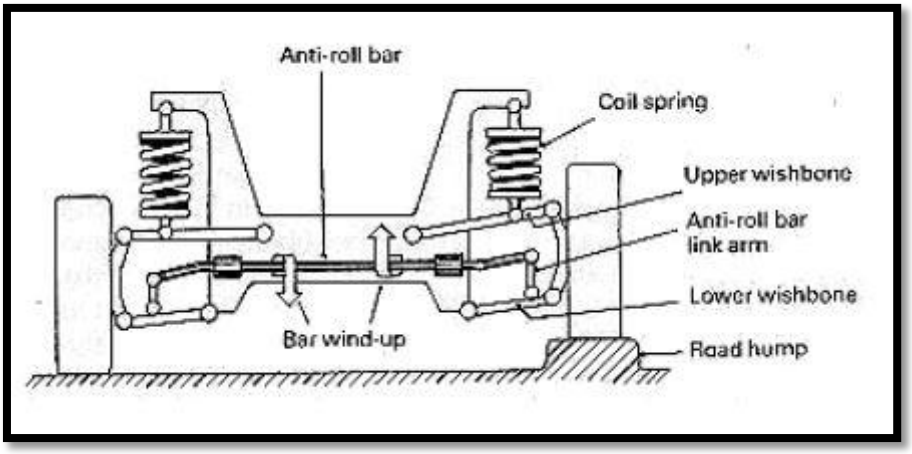

Figure 2.2 : An anti roll bar that attached to the suspension (The vehicle is crossing over a road bump on one side). (www.reddit.com, 2005)

2.1.4 Anti Roll Bar Working Principles

The car begins to roll out of the corner when the car head into a corner. For example, the car body rolls to the right when cornering to the left. The result, anti-roll bar on the right side suspension are compressible. As the lower part of the suspension moves upward relative to the car chassis, it transfers some of that movement of the same component on the other side with a good anti-roll bar. In effect, it tries to lift the left suspension component by the same amount. Because this isn't physically possible, the left suspension effectively becomes a fixed point and the anti-roll bar twists along its length because the other end is effectively anchored in place. It's this twisting that provides the resistance to the suspension movement.

Nowadays, the expensive car is provided with active anti-roll technology. These senses the roll of the car into a corner and deflate the relevant suspension leg accordingly by pumping fluid in and out of the shock absorber. It is a high-tech, super expensive version of the good old mechanical anti-roll bar. Body roll during cornering can be reduced also by selection of the vertical suspension is more difficult, but it will have a negative impact on the ride comfort. Stabilizer bars that significantly contribute to an increase in motor vehicle comfort (Carlson, Catazarite, and Clair, 2010).

2.1.5 Anti Roll Bar for Rollover Prevention

The main target of using anti-roll bar is to reduce the body roll. When a vehicle deviates from straight-line motion, body roll occurs. The line connecting the roll centers of front and rear suspensions forms the roll axis of a vehicle. Center of gravity of a vehicle is normally above this roll axis. Thus, while cornering the centrifugal force creates a roll moment about the roll axis, which is equal to the product of centrifugal force with the distance between the roll axis and the center of gravity. This moment causes the inner suspension to extend and the outer suspension to compress, thus the body roll occurs as shown in Figure 2.3. Body roll also occurs when a wheel crosses a bump on one side only, which was the case in Figure 2.2.

Figure 2.3 : A vehicle body roll during cornering (www.reddit.com, 2005)

Actually, body roll is an unwanted motion. The first reason for this is the fact that, too much roll disturbs the driver and gives a feeling of rollover risk, even in safe

cornering. Therefore, the driver cannot drive the vehicle with confidence. The second reason is its effect on the camber angle of the tires, which is the angle between the central plane of symmetry of the wheel and the vertical plane at the center of the contact patch. The purpose of camber angle is to align the wheel load with the point of contact of the tire on the road surface. When the camber angle is changed due to body roll, this alignment is lost and also the tire contact patch gets smaller. The smaller the contact patch of the tire, the less traction exists against the road surface (Comesky, J., 2002). Thus, body roll should be prevented.

The first way to prevent body roll is to eliminate its source, roll moment. By increasing the roll center heights of the front and rear suspensions, this moment can be reduced. But, this will cause considerable lateral wheel displacements during bump and rebound with track variations during operation. Another negative effect is the higher camber angle change. Another method for preventing excessive body roll is to use stiffer suspension springs, thus making it harder for the suspensions to move in opposite directions at the same time. This, however, reduces the ride comfort. A compromise solution is to use softer suspension springs to provide ride comfort, lower roll centers to avoid lateral wheel displacement and anti-roll bar to reduce body roll.

Anti-roll bars serve two key functions. First, as explained above, they reduce body roll, and second provide a way to redistribute cornering loads between the front and rear wheels, which in turns, gives the capability of modifying handling characteristics of the vehicle. By arranging the roll stiffnesses of the anti-roll bars at the front and rear suspensions, it can be done. If a firmer anti-roll bar is installed at the front, then the distribution of lateral load transmits increases toward the front tires, since a firmer anti-roll bar allows less deflection, thus transfers lateral loads at a faster rate. And the overall result is an additional understeer effect. Adversely, increasing roll stiffness at the rear by using firmer anti-roll bar will create an oversteer effect. Thus, anti-roll bars are also used to improve directional control and stability.

One negative effect of anti-roll bars is that, too stiff bars can reduce the adhesion on slick surfaces. This is especially true on snow and ice. They can also be a disadvantage for serious off-road driving (Domingues, R., 2002).