FRONT AND REAR SUSPENSION DESIGN FOR SOLAR CAR

MOH DZOHAIRY BIN MOHAMMAD MOHSAN

Report submitted in partial fulfillment of the
requirements for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering
University Malaysia Pahang

DECEMBER 2010

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "Front and Rear Suspension Design for Solar Car" is written by Mohd Dzohairy Bin Mohammad Mohsan. I have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

DR. RIZALMAN BIN MAMAT
Examiner Signature

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project report and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

Signature :
Name of Supervisor : ZAMRI BIN MOHAMED
Position : LECTURER
Date : 06 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :

Name : MOHD DZOHAIRY BIN MOHAMMAD MOHSAN

ID Number : MH08011

Date : 06 DECEMBER 2010

ACKNOWLEDGEMENT

First I would like to express my grateful to ALLAH S.W.T. as for the blessing given that I can complete my final year project. In preparing this paper, I have engaged with many people in helping me completing this project.

I am grateful and would like to express my sincere gratitude to my supervisor Mr. Zamri Bin Mohamed for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. I appreciate his consistent support from the first day I applied to graduate program to these concluding moments. I am truly grateful for his progressive vision about my training in science, his tolerance of my naïve mistakes, and his commitment to my future career.

My sincere thanks go to all my labmates and members of the staff of the Mechanical Engineering Department, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable. Many special thanks go to member engine research group for their excellent co-operation, inspirations and supports during this study.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I acknowledge the sincerity of my parents-in-law, who consistently encouraged me to carry on my higher studies. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Special thanks should be given to my committee members. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

The next category people who help me to grow further and influence in my project are my colleagues who always help me in order to finish this project. I really appreciate the idea and information given.

ABSTRACT

Suspension is a necessary system for solar cars because it protects the frame and other on-board components from large jolts encountered along highways. If the suspension is too soft, energy is wasted by absorbing the motion of a car as it travels over bumps. For increased efficiency, most solar cars use a suspension that is stiffer than normal. For this project, the solar car has two front wheels and one rear wheel. The front wheels provide turning, so the front suspension needs to let the wheels turn. The suspension also allows the wheels to move up and down as the car runs over bumps. The type of front suspension for this project is a double wishbone system. It has a pair of an A-frames, one above the other, mounted to the top and bottom of the wheel hub. A separate spring until then sits between either the hub itself or one of the wishbones and the body to control the wheel movement. Lastly, this car uses a trailing arm on rear suspension. This kind of suspension has only one link (arm) on each side which puts greater structural requirements on it. Strong bending forces in all directions (especially during cornering) must be withstood by this suspension and as well as breaking, camber and steer torques. Nevertheless trailing arm suspension has been used in many vehicles as a rear linkage, because it requires little space to be accommodated.

ABSTRAK

Suspensi adalah sistem yang diperlukan untuk kereta solar kerana melindungi frame dan bahagian-bahagian on-board lain dari goncangan besar ditemui di sepanjang jalan raya. Jika suspensi terlalu lembut, tenaga terbuang dengan menyerap gerakan mobil saat dihantar melalui benjolan. Untuk meningkatkan kecekapan, kebanyakan kereta solar menggunakan suspensi yang lebih kaku dari biasanya. Untuk projek ini, kereta suria mempunyai dua roda depan dan satu roda belakang. Roda depan memberikan berputar, sehingga suspensi depan perlu membiarkan roda putar.Suspensi juga membolehkan roda bergerak naik dan turun ketika kereta berjalan di atas benjolan. Jenis suspensi depan untuk projek ini adalah sistem wishbone ganda. Ia memiliki sepasang A-frame, satu di atas yang lain, mount ke atas dan bawah dari hub roda. Sebuah pegas berasingan sampai kemudian duduk antara baik hub sendiri atau salah satu wishbones dan tubuh untuk mengawal gerakan roda. Terkini, kereta ini menggunakan lengan sisa pada suspensi belakang. Suspensi semacam ini hanya memiliki satu link (lengan) di setiap sisi yang menempatkan keperluan struktur yang lebih besar di atasnya. kekuatan bending yang kuat di segala penjuru (khususnya saat menikung) harus bertahan dengan suspensi ini dan juga melanggar, camber dan mengarahkan torsi. Namun demikian trailing suspensi lengan telah digunakan dalam banyak kenderaan sebagai penghubung belakang, kerana memerlukan sedikit ruang untuk diakomodasi.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CAD	Computer Aided Design
CAE	Computer Aided Education
FEA	Finite Element Analysis
FYP	Final Year Project

CHAPTER 1

INTRODUCTION

1.1 PROJECT SYNOPSIS

Suspension is a necessary system for solar cars because it protects the frame and other on-board components from large jolts encountered along highways. If the suspension is too soft, energy is wasted by absorbing the motion of a car as it travels over bumps. For increased efficiency, most solar cars use a suspension that is stiffer than normal.

For this project, the solar car has two front wheels and one rear wheel. The front wheels provide turning, so the front suspension needs to let the wheels turn. The suspension also allows the wheels to move up and down as the car runs over bumps.

The type of front suspension for this project is a double wishbone system. It has a pair of an A-frames, one above the other, mounted to the top and bottom of the wheel hub. A separate spring until then sits between either the hub itself or one of the wishbones and the body to control the wheel movement.

Lastly, this car uses a trailing arm on rear suspension. This kind of suspension has only one link (arm) on each side which puts greater structural requirements on it. Strong bending forces in all directions (especially during cornering) must be withstood by this suspension and as well as breaking, camber and steer torques. Nevertheless trailing arm suspension has been used in many vehicles as a rear linkage, because it requires little space to be accommodated.

1.2 PROBLEM STATEMENT

If the suspension is too soft, energy is wasted by absorbing the motion of a car as it travels over bumps. For increase efficiency, most solar cars use a suspension that is stiffer than normal.

1.3 OBJECTIVE

There are two main objectives to achieve in this research which are to design front and rear suspension of solar car and for analysis a suspension of solar car.

1.4 PROJECT SCOPE

In order to reach the objectives, there is the scope of project which is a benchmarking, a concept generation, to design of suspension structure using force balance calculation and CAD, to analysis of suspension parts and a lastly, to make a fabrication availability of components.

1.5 PROJECT PLANNING

This project started with made a research and literature review. It is from internet, books and my supervisor that related to my project title. All of this literature review takes about three week. I also do my schedule management for my project. This is done by using Microsoft Excel Worksheet using Gantt chart system. The next week I have been submit my project title acceptance form and continue detail research on suspension and it takes a week to be done.

After all of literature review done, I must find out what is the suitable type of suspension that matching with solar car's body. After that, I sketch a design of the suspension. The sketching of the suspension takes about 2 weeks to be done. The sketching done using manual sketched at A4 size paper. Lastly, I transfer the design into SolidWorks software because I want to analyze it by using ALGOR software.

The fabrication process is started on next semester. For the first fabrication is must fabricate the part of suspension using a CNC machining. After done the fabrication process, next process is assembly, testing, correction and finishing. This task scheduled takes several weeks to finish. The next task is preparation of progress presentation and progress report writing, both of these tasks takes one week to be done. After that, the progress presentation week and progress report submission. On this week I have to prepare the speech for the presentation and double checked the report that has to be submitted.

Lastly, the final report has been written and prepared for presentation. This will take about one week to prepared and accomplish. A report is guided by UMP thesis format and also guidance from supervisor. Due to any problems that student face, the management has agreed to extend the time of submission of the report and presentation. All task scheduled takes around 28 weeks to complete.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to give the reader necessary background information to understand the research presented in this paper. There are a few very important fundamentals such as wheel alignment, weight transfer and suspension configuration, which influence the design of vehicle suspension. This chapter gives current knowledge which will introduce the reader to comprehensive suspension design and development.

2.2 MECHANICAL SYSTEMS OF SOLAR CAR

The mechanical systems are designed to keep friction and weight to a minimum while maintaining strength and stiffness. Designers normally use aluminum, titanium and composites to provide a structure that meets strength and stiffness requirements whilst being fairly light. Steel is used for some suspension parts on many cars.

Solar cars usually have three wheels, but some have four. Three wheelers usually have two front wheels and one rear wheel: the front wheels steer and the rear wheel follows. Four wheel vehicles are set up like normal cars or similarly to three wheeled vehicles with the two rear wheels close together (see Figure 2.1).

Solar cars have a wide range of suspensions because of varying bodies and chassis. The most common front suspension is the double wishbone suspension. The rear suspension is often a trailing-arm suspension as found in motor cycles.

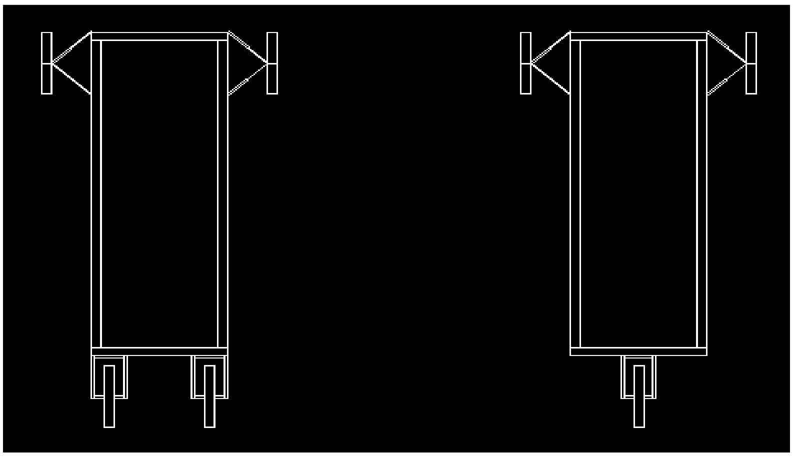

Figure 2.1: Four wheel versus three wheel

2.3 SUSPENSION ALIGNMENT

2.3.1 Toe Setting

Toe setting strongly affects the handling characteristics and transitional cornering of the vehicle. It is the difference between the front and rear edges of the wheels as shown in Figure 2.2. Toe-in means the front edges are closer together than the rear edges and the wheels point inward. Toe-out means the front edges are farther apart than the rear edges and the wheels point outward. Extreme toe-in or toe-out will cause excessive tire wear and steering instability, especially at high speeds. Most vehicles need a small amount of toe in for strait-line steering stability. Toe setting is adjusted by lengthening or shortening the steering system's tie-rods and it usually varies between ± 3 mm. An example of this is the Daihatsu Charade, model G100, where the toe setting specification is between 1 mm toe out-3 mm toe in (Gregory' s Automotive 1991, p 196).

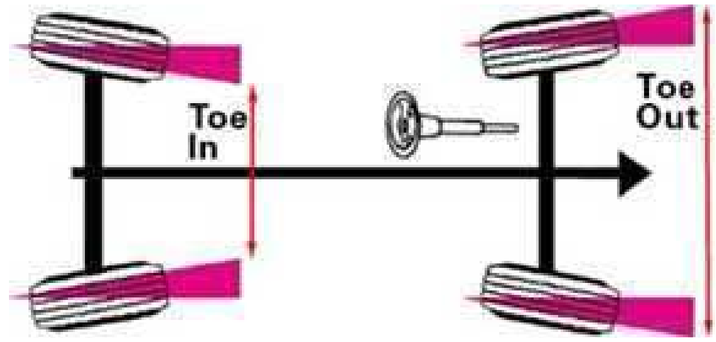

Figure 1.2: Toe setting

Source: http://www.specprod.com

2.3.2 Camber Angle

Camber angle is measured in degrees. It is the angle at which the wheels are angled i.e. the angle between the centreline of the tyre and a vertical line. Extreme positive camber causes wear on the outside of the tyre. Extreme negative camber causes wear on the inside of the tyre. Excess negative camber will also tend to increase straight line stopping distances. The camber angle should be optimized to minimize dynamic side forces acting on the wheel and decreasing steering imbalance caused by lateral forces. The drawback of camber angle is increased rolling resistance and tyre wear. This explanation is visualized in Figure 2.3.

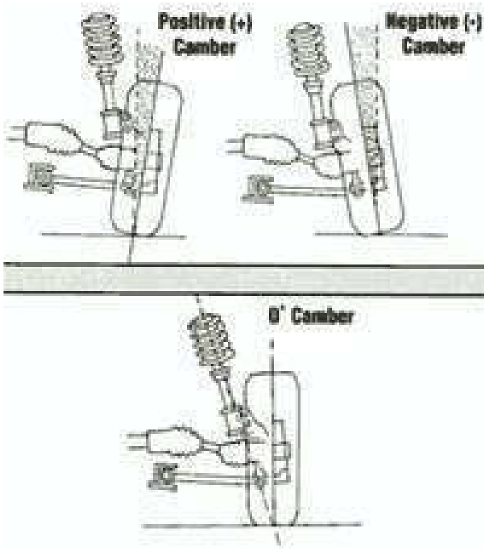

Figure 2.3: Camber angle

Source: http://www.allwheelalignment.com

2.3.3 Caster

Caster is the backward or forward slope of the steering axis when viewed from the side. Caster angles are used to alter the directional stability of the wheels. Hence caster angle is a very dynamic setting. It changes as the suspension moves. As a result the difference between caster angles of the left and right front wheels should be as small as possible to avoid steering imbalance. Proper caster angle provides the self-centre action to pull the front wheels back to a straight ahead position after coming out of a corner. Proper caster will also help to keep the vehicle in a straight line at high speeds. Caster angle is mostly adjustable on suspensions arms for normal wear in suspension and steering. Negative caster can cause hard steering when returning out of a turn and reduced straight line stability. Also vehicles with a negative caster tend to pull from side to side. Most cars are designed with a positive caster setting which is from + ½ degree to + 4 degrees, but there are some cars such as Mercedes which have specified caster angle up to +10 degrees (Kerr 2003). The caster angle is shown in Figure 2.4.

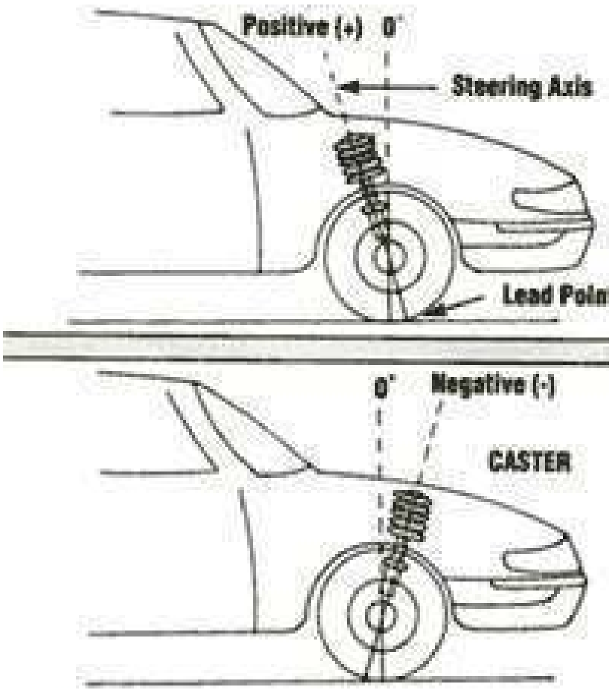

Figure 2.4: Caster angle

Source: http://www.allwheelalignment.com

2.3.4 Thrust Line

Thrust line is defined by the rear suspension's relationship to the centreline of the car i.e. direction in which the rear wheels are pointed. Thrust angle refers to the relationship of all four wheels to each other with respect to the centre line. If the thrust line is to the right of the centreline, the angle is said to be positive. If the thrust line is to the left of centreline, the angle is negative. Excessive thrust angle can cause tyre wear, steering wheel misalignment, or pulling to one side. Figure 2.5 displayed the relationship between the thrust line and the thrust angle.

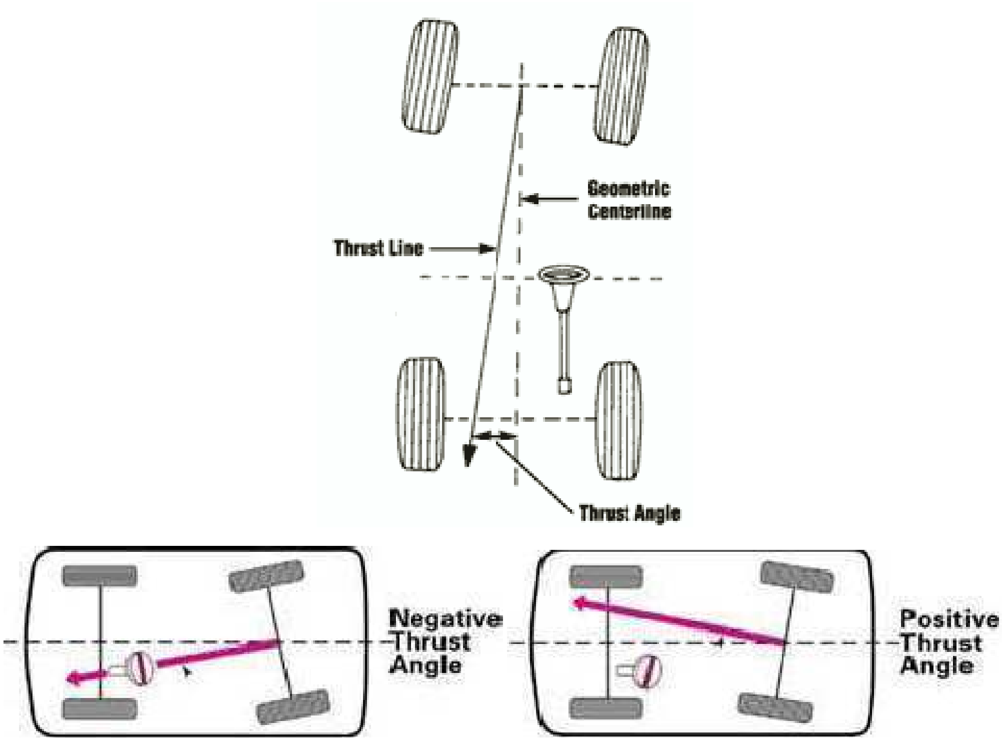

Figure 2.5: Thrust line and angle

Source: http://www.specprod.com

2.3.5 Scrub Radius

Scrub radius is the distance between the projected steering axis indication (SAI) and the tyre tread centreline at the road surface. This distance must be exactly the same from side to side or the vehicle will pull strongly to one side at high speeds. The Scrub Radius provides the driver with better driving stability. In conjunction with toe setting the correct scrub radius helps to bring the running toe to zero. Different wheels or tyres from side to side will cause differences in scrub radius as well as a tyre that is low on air. Scrub Radius is set by the designer and it is not adjustable. Figure 2.6 displays the scrub radius.

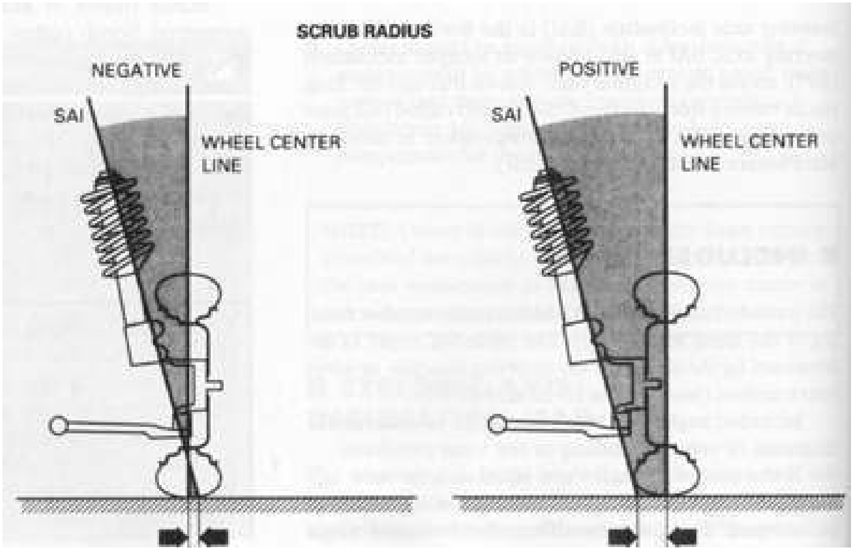

Figure 2.6: Scrub radius

Source: http://206.117.169.65/alignment.htm

2.3.6 Set-Back

Set-Back occurs when front and rear axles (which should be perpendicular to the centerline) are not parallel to each other. This means that one front wheel is set farther back than the other wheel. This is usually the result of a collision, different regulation of caster of the right and left wheels and sometimes by the car manufacture (sees Figure 2.7, Set Back by design). Positive setback means the right front wheel is set back further than the left. Excessive set back might affect steering system which can be indicated by pulling the vehicle to one side. However, small amounts of setback usually won't cause any problems.