UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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OPTIMIZATION OF CAR FRONT SUSPENSION FOR DYNAMIC PERFORMANCE IN VIRTUAL FORMULA

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

by

RONALD VALERIANO
B071310022
881017-12-5583

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APPROVAL

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

16/1/2017

(Mr. Mohd Hafizi B. Abdul Rahman)

ABSTRACT

Virtual Formula or virtual championship is organised by VI-Grade in order to let the student to learn vehicle dynamics and to understand how to use the software used by leading motorsports team and automotive OEM. Vi-Grade is a software that has been develop for more than 20 years with a team that has great experience with multibody system-level simulation and software development. The championship has expanded around the world thus is the best way to promote UTeM globally. The purpose of this project is to study and optimize the front suspension system of a formula race car using VI-Grade software or VI Car Real Time. Several parameters are tuned to achieve the best lap time and reduce fuel consumption. Design of Experiment (DOE) will be performed using Altair Hyperstudy to get the best suspension parameters to suit with maximum speed, final lap time and fuel consumption. The suspension setup are based on the rules and regulation given by Vi-grade to compete with other virtual race car around the world. At the end of this project, the best design of the suspension system will be recommended based on the analysis data gathered in each simulation where it can be used for future development.

ABSTRAK

Kejohanan formula maya dianjurkan oleh VI-Grade untuk membolehkan pelajar belajar mengenai dinamik kenderaan dan untuk memahami bagaimana menggunakan perisian yang digunakan oleh pasukan sukan permotoran terkemuka dan automotif OEM. VI-Grade adalah sebuah perisian yang telah dibangunkan lebih 20 tahun dengan pasukan yang berpengalaman dengan simulasi multibody system dan pembangunan perisian. Kejohanan tersebut telah berkembang ke seluruh dunia justeru merupakan cara yang terbaik untuk mempromosikan UteM secara global.

Tujuan projek ini dilaksanakan adalah untuk mempelajari dan mengoptimumkan sistem penggantungan depan sebuah kereta lumba formula menggunakan perisian VI-Grade atau VI Car Real Time. Beberapa parameter diubah untuk mendapat masa pusingan yang terbaik dan mengurangkan penggunaan bahan api. Reka bentuk eksperiment (DOE) akan dilakukan menggunakan Altair Hyperstudy untuk mendapatkan parameter system penggantungan yang sesuai dengan kelajuan maksima, masa pusingan dan penggunaan bahan api. Persediaan Sistem penggantungan adalah berdasarkan kaedah-kaedah dan peraturan yang diberi oleh VI-Grade untuk bersaing dengan pelumba maya yang lain di seluruh dunia. Di akhir projek ini, persediaan rekabentuk sistem penggantungan yang terbaik akan dipilih berdasarkan maklumat analisis yang dikumpul dari setiap simulasi dimana ia boleh digunakan untuk pembangunan masa hadapan.

DEDICATION

This report is dedicated to my family for their endless support and encouragement.

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I owe a huge debt of gratitude to the Dean of our Faculty of Engineering Technology, Prof. Mohd Rahimi Bin Yusof for giving me space to grow intellectually and to both of my supervisor Mr. Mohd Hafizi Bin Abdul Rahman and Mr. Saiful Naim Bin Sulaiman for the guidance, support and constant encouragement during my research.

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LIST OF SYMBOLS AND ABBREVIATIONS

DOE	Design of Experiment
DWB PR	Double Wish Bone with Push Rod
LUCA	Lower Upper Control Arm
KM	Kilometre
V	Velocity
VI	Virtual Instrument
VS	Versus
OEM	Original Equipment Manufacturer

CHAPTER 1

INTRODUCTION

1.0 Introduction

This project focused on optimizing the front suspension system of a formula race car using VI grade software / VI Car Real Time. Using VI-CarRealTime in Vi-Grade, we can quickly and easily perform large Design of Experiments (DOE) and multi-objective optimization studies. It provides a real-time vehicle simulation environment where the same simplified vehicle model can be used by vehicle dynamics to optimize vehicle and control system performance.

Several front suspension parameters will be tune such as the spring stiffness, Jounce start, Jounce end, Camber angle and also Torsion stiffness of anti roll bar (ARB) in order to get the best lap time and fuel consumption in virtual formula racing event. Design of Experiment (DOE) will be performed using Altair Hyperstudy to get the best suspension parameters to suit with max. speed, final lap time and fuel consumption.

1.1 Problem statement

During race car event, suspension tuning is very crucial in order to get the best max speed, lap time and lower fuel consumption. Current race car has a lot of parameter to tune in order to get optimum performance. Commonly used racing suspension system parameters are usually difficult to tune and might be far from its optimum setting. To test the suspension system physically would take much time and cost.

To solve this problem, the front suspension setting are to be analyze using a package of Altair Hyperworks called Hyperstudy and using real time simulation software VI Car Real time to compare the result. Design of Experiment (DOE) analysis is performed on the front suspension to get the optimum value of max speed, lap time and fuel consumption.

1.2 Objective

I. To optimize the virtual race car dynamic and performance using VI-Grade.

II. To achieve the best lap time on racing track in VI-Grade track.

1.3 Scope

This project will focus primarily on the study of the characteristic of the front suspension system and its effect towards maximum speed and minimum lap time and proposed the optimum setting for race event in Virtual Formula. Other aspect such as production of the suspension system and applying these setting to a real car and real life environment will not be covered in this project.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction of Suspension System

Suspension system are important in automotive industry. It additionally give a vital part to security and the solace of driving. The suspension system is responsible for driving comfort and safety as the suspension caries the vehicle body and transmit all forces between the body and the road. When vehicle is in motion, the vibration from the road surface factors negatively impacts on the ride comfort, handling stability and auto speed, and consequently can also damage vehicle parts and components. The purpose of suspension system is to isolate the vehicle from the uncomfortable vibration transmitted from the road through the tires and to transmit the control forces back to the tires so that the driver can keep the vehicle under control. The suspension system will help the tires to remain constant contact with the ground so that the tires can be used to the limit of their capacity. The suspension system will improve the vehicle dynamics during acceleration and braking, turning or cornering (J. Cent. South Univ., 2013).

Suspension system basically referred to the springs, shock absorbers and the linkage that connects to the vehicle wheel to allow relative motion between the wheel and the vehicle's body. All of the dynamics parameter are to be considered while designing the suspension system, especially the behaviour of the suspension for various loading cases (Pimpri Chinchwad, 2014).

A lot of high performance sports car today use double wishbone type suspension system design. This design is considered to be suitable for race track because it allow for greater adjustment and can be set to achieve negative camber to accommodate the body roll that the vehicle encounter during cornering(Karthik.s ed al.,2016).

2.1 Type of Suspension

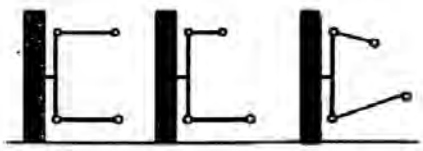
The type of suspension system used for this literature review is double wishbone. The function of double wishbone will be discuss in details in this chapter

2.1.1 Double wishbone

The double wishbone usually have two lateral control arms of an unequal length with a coil over spring and shock absorber in a shape of a double wishbone. The two control arms are connected to the body of the car and mounted on the wheel. It is widely used as a front suspension system and mostly used in a rear wheel drive vehicle. This type of suspension system will induce negative camber when going along the corner. The Double wishbone suspension system has good dynamic characteristic as well as capable of handling high load (Vivekanandan et al., 2014).

In the United States, they are called 'A-arms' and while in Britain, they are called wishbones. The length of the upper and lower arm are usually different, hence get its name short-long arm (SLA). It provide package space for the engine in a longitudinal direction. The unequal-arm length can improve the handling by reducing body roll by counteracting with the camber of the outside wheel (GÜLER, 2006).

The double wishbone have three type of arm. They are (a) parallel and equal (b) parallel and unequal and finally (c) Nonparallel and Unequal as shown in figure 2.1 Double wishbone suspension design. More examples are shown in for Parallel and equal arm in figure 2.2, parallel and unequal arm in figure 2.3 and Nonparallel and unequal arm in figure 2.4 (Ünlüsoy, 2000).



(a) Parallel and equal (b) Parallel and unequal (c) Nonparallel and unequal
Figure 2.1 Double wishbone suspension designs
(Source: Ünlüsoy 2000)

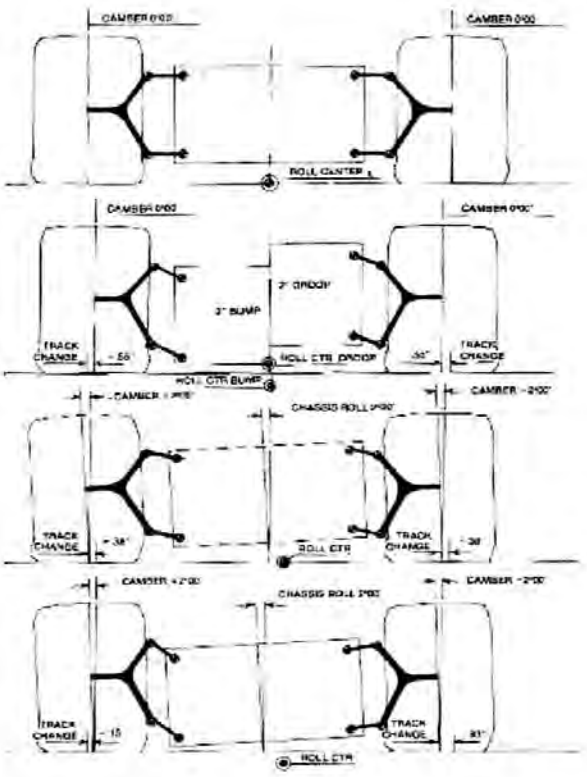


Figure 2.2 Parallel and equal link suspension system (http://www.mechanics.iei.liu.se/edu_ug)

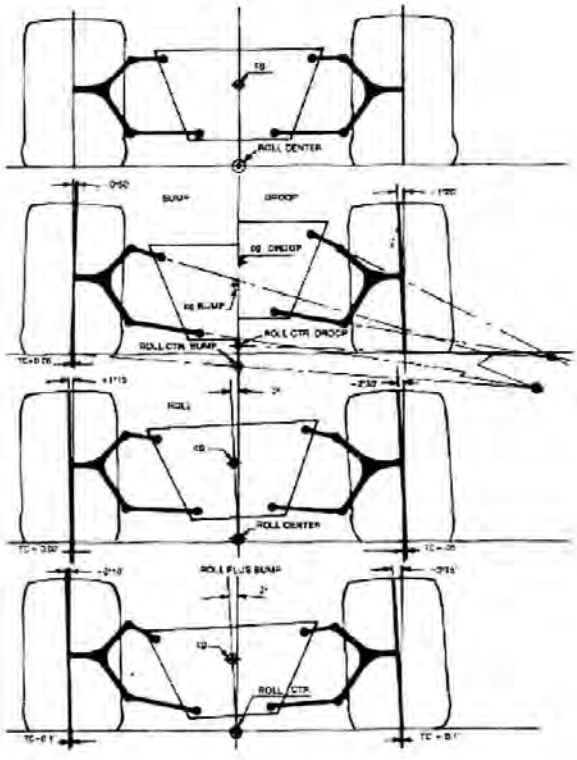


Figure 2.3 Parallel and unequal link suspension system (http://www.mechanics.iei.liu.se/edu_ug)

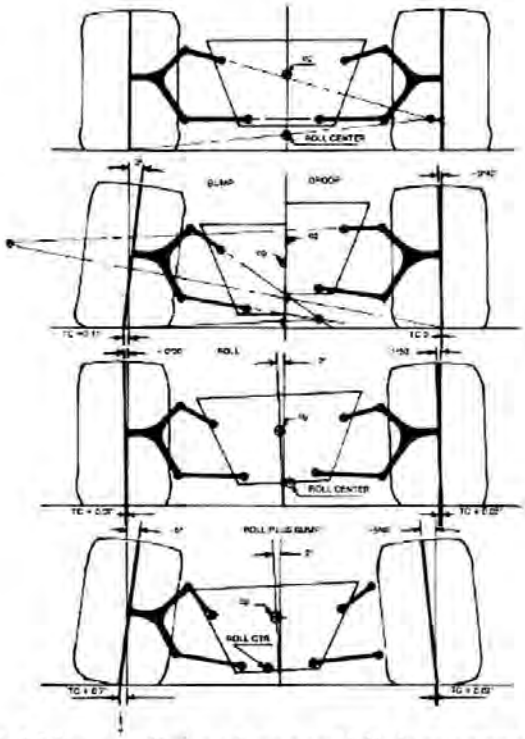


Figure 2.4 Nonparallel and unequal link suspension system (http://www.mechanics.iei.liu.se/edu_ug)