Faculty of Mechanical and Manufacturing Engineering Technology

SENSITIVITY STUDY ON FRONT SUSPENSION HARDPOINT OF FORMULA SAE RACE CAR TOWARDS VEHICLE DYNAMICS CHARACTERISTICS

Parthiban A/L Bala Subramaniam

Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

2018

SENSITIVITY STUDY ON FRONT SUSPENSION HARDPOINT OF FORMULA SAE RACE CAR TOWARDS VEHICLE DYNAMICS CHARACTERISTICS

PARTHIBAN A/L BALA SUBRAMANIAM

A thesis submitted in fulfilment of the requirements for the Bachelor of Mechanical Engineering Technology (automotive technology) with honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: Sensitivity Study on Front Suspension Hardpoint of Formula Sae Race Car Towards Vehicle Dynamics Characteristics

Sesi Pengajian: 2019

Saya **PARTHIBAN A/L BALA SUBRAMANIAM** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (X)

☐ SULIT* Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.

☐ TERHAD* Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.

☒ TIDAK TERHAD

Yang benar,

.....

PARTHIBAN A/L BALA SUBRAMANIAM

Alamat Tetap:

D-12-02, IMPIAN BAIDURI

JALAN 224/51A

46100, PETALING JAYA

SELANGOR

Tarikh:

Disahkan oleh penyelia:

.....

MOHD HAFIZI BIN ABDUL RAHMAN

Cop Rasmi Penyelia

Tarikh:

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report Entitled Sensitivity Study on Front Suspension Hardpoint of Formula Sae Race Car Towards Vehicle Dynamics Characteristics is the results of my own research except as cited in references.

Signature: ……

Author : PARTHIBAN A/L BALA SUBRAMANIAM

Date:

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

Signature: ..…….

Supervisor: MOHD HAFIZI BIN ABDUL RAHMAN

ABSTRAK

Matlamat projek ini adalah untuk menentukan sensitiviti 'hardpoint' sistem penggantungan depan kereta perlumbaan Formula SAE ke arah Ciri-ciri Dinamik Kenderaan. Analisis dalam projek telah disimulasikan secara virtual mengunakan perisian CAE MSC ADAMS. Masalah yang dihadapi projek ini adalah sumber seperti masa, wang tenaga untuk mensimulasikan dan menganalisis sifat dinamik kenderaan secara fizikal. Analisis yang dijalankan adalah Kinematics & Compliance dan "FULL VEHICLE". Tujuan projek ini dijalankan adalah untuk mengurangkan masa dan tenaga yang akan dibelanjakan untuk mengenal pasti prestasi dinamik kenderaan kereta perlumbaan dengan simulasi fizikal. Objektif projek ini adalah untuk melaksanakan analisis dinamik kenderaan untuk penggantungan depan dan kenderaan Kendaraan Formula SAE Formula Penuh dan untuk melaksanakan Design of Experiment (DOE) hardpoint penggantungan depan untuk analisis kepekaan hardpoint. Simulasi dan analisis akan dijalankan menggunakan MSC ADAMS / CAR dan selanjutnya diproses dan dilihat dalam ADAMS / POSTPROCESSOR. DOE akan dijalankan pada ADAMS / INSIGHT. Hasil simulasi untuk Kinematik dan Pematuhan dan Kendaraan penuh disusun menjadi jadual dan diplotkan kepada graf untuk melihat dengan jelas prestasi dan juga untuk menganalisis secara sistematik. Projek ini merupakan usaha awal untuk penyertaan UTeM dalam perlumbaan Formula SAE. Hasil projek ini akan menjadi rujukan untuk penalaan dan penetapan kereta perlumbaan Formula SAE UTeM berdasarkan susun atur landasan (track layout).

ABSTRACT

The aim of this project is to determine the sensitivity of front suspension hardpoints of Formula SAE race car towards the Vehicle Dynamics Characteristics. The analysis in this project was simulated virtually via the means of a CAE software MSC ADAMS. The problem that this project overcomes is the resources such as time, energy money to physically simulate and analyze the vehicle dynamics characteristics. The analysis carried were Kinematics & Compliance and Full Vehicle. The reason for this project being conducted is to reduce the time and energy that will be spent to identify the vehicle dynamics performance of the race car with physical simulations. The objectives of this project are to perform the vehicle dynamics analysis for front suspension and Full Vehicle of Formula SAE race car and to perform Design of Experiment (DOE) of front suspension hardpoint for hardpoint sensitivity analysis. The simulations and analysis were carried using the MSC ADAMS/CAR and the further processed and viewed in ADAMS/POSTPROCESSOR. The DOE was conducted on ADAMS/INSIGHT. The results of the simulation for Kinematics and Compliance and Full vehicle are tabulated into tables and plotted into graph to clearly see the performance and also to analyze systematically. This project is a preliminary effort for the participation of UTeM in the Formula SAE race. The outcome of this project will be a reference for tuning and setting up the Formula SAE race car of UTeM for according to the race track layout.

DEDICATION

To my beloved late father, Bala Subramaniam and my beloved mother, Sandi.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my gratitude to my supervisor, MR Mohd Hafizi Bin Abdul Rahman from the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) for allowing me to carry out this project under his supervision. Without his guidance and help this project wouldn't have been a reality. I would also like to thank my fellow peers and friends for always motivating and providing support whenever needed which certainly helped in completing this project. Lastly, thank you to everyone who had been to the crucial parts of realization of this project. Not forgetting, my humble apology as it is beyond my reach personally mentioned those who involved directly or indirectly one to one.

TABLE OF CONTENT

List of Figures

List of Tables

List of abbreviation

SAE	-	Society of Automotive Engineers
UCA	-	Upper Control Arm
LCA	-	Lower Control Arm
BC	-	Bell Crank
PROD	-	Push Rod
OB	-	Outboard
IB	-	Inboard
TR	-	Tie Rod
K&C	-	Kinematics and Compliance
DOE	-	Design of Experiment
RWD	-	Rear Wheel Drive
FWD	-	Front Wheel Drive
AWD	-	All Wheel Drive
CAE	-	Computer Aided Engineering

CAD	-	Computer Aided Design
CG	-	Centre of Gravity
WC	-	Wheel Centre
TCP	-	Tyre Contact Patch
Deg	-	Degree
m	-	Meter
mm	-	millimetre
Hz	-	Hertz
FEA	-	Finite Element Analysis

CHAPTER 1

INTRODUCTION

1.1 Project Background

Formula SAE by SAE international is competition of student design. Its main purpose is to allow students from various institute to fabricate an open wheel race car on the asphalt. Institutes from various countries take part in this competition. As a stepping stone in enabling Universiti Teknikal Malaysia Melaka (UTeM) to participate in Formula SAE in the near future, this project is being carried out.

As there are many aspects and elements in constructing a race car for Formula SAE, the project needs to be broken down into smaller topics. The title that this project and report will discuss on will be the front suspension. There are many rules and regulations in the Formula SAE, however in terms of suspension there aren't many rules or regulations to adhere to.

The main aim of this project is to develop a front suspension system for a Formula SAE car that has excellent vehicle dynamics performance according to the formula SAE terms. The vehicle dynamics properties of the race car will provide great cornering ability, steering ability, handling performance hence shorter lap time which will eventually win races.

In the automotive sector, power is nothing without control. This means having a high output engine with a bad suspension will only be a waste as all that power will not be utilized.

In order to put all the power made by the engine, the suspension system and handling of the race car should be at top notch.

In order to develop the front suspension system of a race car with all the characteristics stated above, several steps were taken which are;

1. Research on suspension system available within the automotive industry especially for open wheel race car.
2. Study on the function and characteristics of each front suspension geometry and components of an open wheel race car.
3. Study on the suspension parameters that are crucial for race cars.
4. Research on vehicle dynamics analysis.
5. Designing and analysis of the front suspension geometry.

As the important parameters and elements that play key role in the race car are identified, the scope now will be smaller and become more focused. When these elements are taken care of, it eventually makes the race car better in terms of handling as desired.

Figure 1.1 open wheel race car

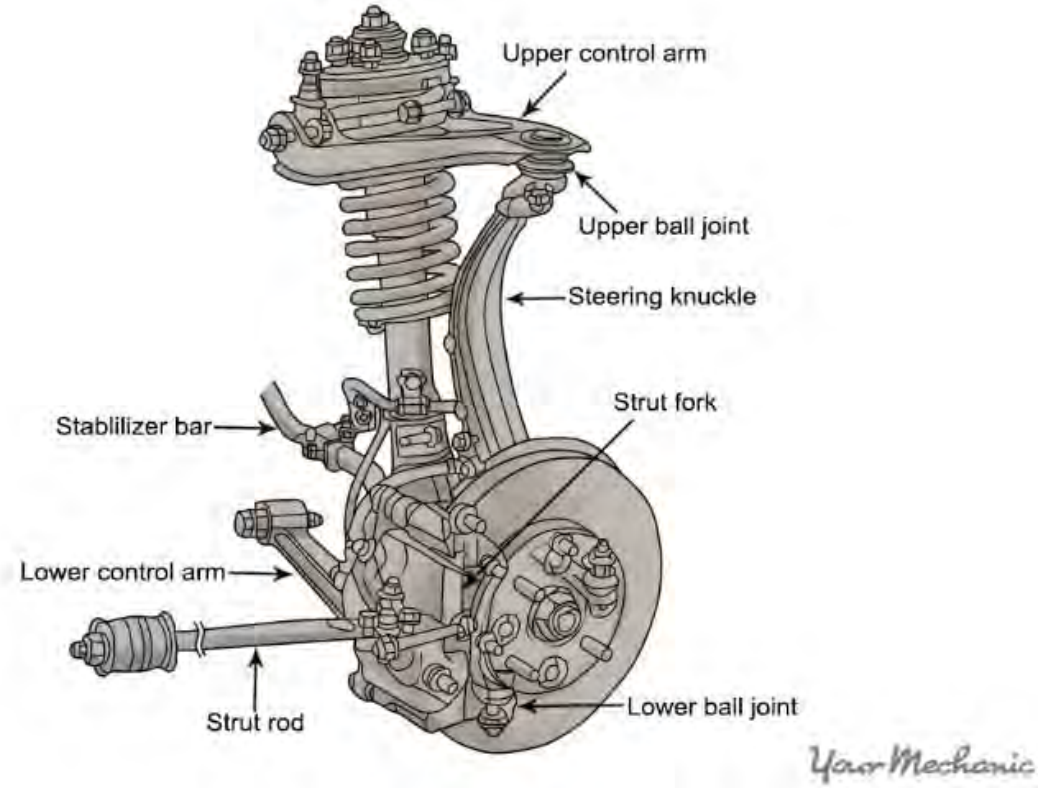

Figure 1.2 components of suspension system