

DESIGN AND FABRICATION OF PEDAL COMPONENTS FOR UTEM
FORMULA STYLE RACE CAR

MOHD ZAINI BIN JAMALUDIN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

‘I have read this thesis
and from my opinion this thesis
is sufficient in aspects of scope and quality for awarding
Bachelor of Mechanical Engineering (Automotive)’

Signatures :

Name of Supervisor :

Date :

DESIGN AND FABRICATION OF PEDAL COMPONENTS FOR UTEM FORMULA
STYLE RACE CAR.

MOHD ZAINI BIN JAMALUDIN

This report is presented in
Partial fulfillment of the requirements for the
Bachelor of Mechanical Engineering (Automotive)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

MAY 2011

“I declare this report is on my own work except for summary and quotes that I have mentioned its sources”

Signature :

Name of Author :

Date :

For my beloved mum, Mrs. Rokiyah bt Abdullah and my caring dad,
Mr. Jamaludin bin Awang

ACKNOWLEDGEMENT

Alhamdulillah, I want to thank to Allah S.W.T for giving me good health to do the necessary research work for PSM. First of all I would like to express my gratitude to all those who gave me the possibility to complete this project report (PSM). I am deeply indebted to my supervisor, Mr. Muhd Ridzuan bin Mansor from the Faculty of Mechanical Engineering Department whose help, stimulating suggestions and encouragement helped me in all the time of research and writing of this project for this semester.

I have furthermore to thank my fellow friends (Hafizullah, Sabirin and Amar Ridzuan) who encouraged me to go ahead with my project and also want to thanks, for all his assistance on generating the use of Catia Programming, CES Edupack programming and fabrication processes. Especially, I would like to give my special thanks to my parents whose patient love enabled me to complete this work, and given me encouragement and inspiration to excel. Thank you.

ABSTRACT

These thesis are about the design and fabricate a new brake pedal and fuel pedal for UTeM formula varsity style race car. The project design has been produced using CATIA software such as drawing design, structure analysis and weight measuring. This project also studied about the materials properties of Aluminium Alloy 6061 T6 and Low Carbon Steel AISI 1010 using CES EduPack 2010 software. Moreover, the pedals components have been generated using Milling machine process. The new pedals design had reduced weight about 0.245 kg. From the calculation done, the safety factor for both brake and accelerator pedals are 3.31 and 22.72 respectively. From the research done on the pedals components, the measurement, material studies, ergonomic factors, and material selection method were explained.

ABSTRAK

Tesis ini adalah tentang rekabentuk dan fabrikasi pemijak brek dan pemijak minyak yang baru untuk kereta lumba Formula Varsity UTeM. Reka bentuk projek ini telah dihasilkan dengan menggunakan perisian CATIA seperti menghasilkan lukisan rekaan, analisis rekaan dan pengukuran berat rekaan tersebut. Projek ini juga mempelajari mengenai sifat bahan seperti *Aluminium Alloy 6061 T6* dan *Low Carbon Steel AISI 1010* dengan menggunakan pengisian CES EduPack 2010. Selain itu, bahagian-bahagian pemijak telah dihasilkan menggunakan proses mesin Pengilling. Rekabentuk pemijak baru telah mengurangkan berat sekitar 0,245 kg. Dari perhitungan yang dilakukan, faktor keselamatan untuk kedua-dua pemijak brek dan pemijak minyak masing-masing 3.31 dan 22.72. Dari kajian yang dilakukan pada bahagian pemijak, saiz, bahan kajian, faktor ergonomik, dan kaedah pemilahan bahan telah dijelaskan.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	<i>ABSTRAK</i>	vi
	TABLE OF CONTENT	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF SYMBOLS	xiv
	LIST OF ABBREVIATIONS	xv
	LIST OF APPENDICES	xvi
1	INTRODUCTION	1
	1.1 Introduction	1
	1.2 Objective of project	2
	1.3 Scope of study	2
	1.4 Problem statement	2
	1.5 Summary	3
2	LITERATURE REVIEW	4
	2.1 Introduction	4

2.2	Accelerator pedal concept	5
2.3	Brake pedal concept	5
2.4	Interdependencies with other system	6
2.5	Ergonomic considerations in pedal design	6
2.6	Design guideline of brake pedal on seat height	8
2.7	Pedal design consideration	9
2.8	Material selection	11
2.8.1	CES Edupack	13
2.8.2	Element in Aluminium Alloy 6061 T6	14
2.8.3	Element in Low Carbon Steel AISI 1010	16
2.9	Manufacturing process	18
3	METHODOLOGY	20
3.1	Introduction	20
3.2	Design concept	21
3.3	Design concept selection	22
3.4	Materials selection	23
3.5	The flow chart for pedal design processes	25
3.6	Finite Element Analysis	27
3.7	Conclusion	29
4	DESIGN SELECTION	30
4.1	Introduction	30
4.2	Accelerator Pedal Concept	31
4.3	Brake Pedal Concept	31
4.4	Mounting Bracket Arrangement Concept	32
4.5	Product Design Specification (PDS)	33
4.6	Current Pedals Design	35
4.7	Concept Generation	36
4.8	Evaluation and Selection of Concept	39
4.9	Design Selection	43
4.10	Final Design	44
4.11	Total Design Method	45

5	MATERIALS SELECTION	46
	5.1 Introduction	46
	5.2 Aluminum Alloy 6061 T6	47
	5.3 Material Selection Process Using CesEdupack	49
	5.4 Conclusion	55
6	STRUCTURE ANALYSIS	56
	6.1 Introduction	56
	6.2 Pedal Structural Analysis	57
	6.3 Calculation for Brake Pedal (Al 6061-T6)	58
	6.4 Calculation for Accelerator Pedal (Al 6061-T6)	59
	6.5 Calculation for Brake Pedal (AISI 1010)	60
	6.6 Calculation for Accelerator Pedal (AISI 1010)	61
	6.7 Conclusion	62
7	FABRICATION	63
	7.1 Introduction	63
	7.2 Stage 1	65
	7.3 Stage 2	68
	7.4 Stage 3	71
	7.5 Final Product	72
8	RESULT AND DISCUSSION	73
	8.1 Introduction	73
	8.2 Weight and cost	74
	8.3 Fabrication problem	75
	8.4 Ergonomic consideration	76
	8.5 Conclusion	77
9	CONCLUSION AND RECOMMENDATION	78
	9.1 Conclusion	78
	9.2 Recommendation	79

REFERENCES	80
APPENDICES	86

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Ergonomic Consideration in Pedal Design	7
2.2	Anthropometric Data	9
2.3	Comparison of Mechanical Properties	12
3.1	Design Concept Selection	22
4.1	Current Pedals Design	35
4.2	Application of Digital Logic Method to Criteria of Pedal	40
4.3	Ergonomic Factor for Criteria of Pedal Design	41
4.4	Evaluation Process of The Generated Concepts	42
5.1	Advantages and Disadvantage Of Materials	50
5.2	Design Requirement For The Pedal	53
5.3	Materials Properties for Aluminum Alloy and Low Carbon Steel	54
6.1	Result of Analysis	62
8.1	Result Data of Pedals Weight	74
8.2	Previous and New Pedal Components	75

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	Design Guideline of Brake Pedal on Seat Height	8
2.2	The Distance Between Seat Position and Pedal	9
2.3	Manikin from 95 th Percentile Japanese	10
2.4	Phase Diagram for Aluminum Alloy	15
2.5	Phase Diagram for Low Carbon Steel	17
2.6	Bubble Chart of Mechanical Properties	17
2.7	Bar Chart of Mechanical Properties	18
2.8	Laser-Sculpting Machine	19
2.9	Rapid Prototyping Machine	19
3.1	Design Concept	21
3.2	Price Per Unit Mass of Materials	23
3.3	Graph on Young`S Modulus and Density for Different Type of materials	24
3.4	Graph on Young`S Modulus for Different Type of Materials	24
3.5	The Overview of work carried out	26
3.6	Clamp Process	27
3.7	Applied Force	28
3.8	FEA Produces for Pedals Design	29
4.1	Morphological Chart of Accelerator Pedal	36

4.2	Morphological Chart of Brake Pedal	37
4.3	Concept Design 1	38
4.4	Concept Design 2	38
4.5	Concept Design 3	39
4.6	Ergonomic Factor Based on Sixth Criteria	41
4.7	The Final Design	44
5.1	Bubble Chart of Mechanical Properties	48
5.2	Bar Chart of Mechanical Properties	48
5.3	The strategy for material selected	52
5.1	Phase Diagram For aluminium alloy	45
5.2	Phase Diagram For low carbon steel	46
6.2	FEA for brake pedal Aluminum Alloy 6061 T6	58
6.3	FEA for accelerator pedal Aluminum Alloy 6061 T6	59
6.4	FEA for Brake Pedal Low Carbon steel AISI 1010	60
6.5	FEA for accelerator Pedal Low Carbon steel AISI 1010	61
7.1	Flow Chart of Pedals Manufacturing Process	64
7.2	Milling Spindle Cutter	65
7.3	Manual Conventional Milling Machine	66
7.4	Manual Milling Process	67
7.5	HAAS CNC Machine	68
7.6	Band Saw Machine	69
7.7	CNC Machining Process	70
7.8	Assemble and Fitting Process	71
7.9	Overview The 3D Model and Actual Model of Pedal Box	72
8.1	The Location of Pedal Box Inside The Chassis	76
8.2	Ergonomic	77

LIST OF SYMBOLS

σ_y = Yield Strength
 σ' = Von Mises Stress

LIST OF ABBREVIATIONS

CAD	= Computer Aided Design
CAE	= Computer Aided Engineering
CATIA	= Computer Aided Three-dimensional Interactive Application
CES	= Cambridge Engineering Selector
CNC	= Computer Numerical Control
FEA	= Finite Element Analysis
FOS	= Factor of Safety
MSDS	= Material Safety Data Sheet
PDS	= Product Design Specification
SAE	= Society of Automotive Engineering
UK	= United of Kingdom
UTeM	= Universiti Teknikal Malaysia Melaka

LIST OF APPENDICES

NO	TITLE	PAGE
A	Gantt Chart for PSM 1	86
B	Gantt Chart for PSM 2	87
C	Flow Chart for PSM 1 and PSM 2	88
D	Dimension For The Design Selected.	89
E	The Assemble Components of Pedal	90
F	The Exploded Components of Pedal	91
G	The Assemble Components of Pedal Design 2	92
H	The Assemble Components of Pedal Design 3	93
I	Overview about Properties for Low Carbon Steel	94
J	Formula Varsity Technical Specifications	95

CHAPTER 1

INTRODUCTION

1.1 Introduction

Brake pedal and accelerator pedal for UTeM formula style race car are an important part for a vehicle and more specific in this project. Pedal is one of mechanical design and the shape is depending on the material choosing. So, in this project we need to understand the material properties that use in nowadays industry. In choosing the pedal design, sketching and material properties are considered in this research. In future study, we need to compare this material to the alternative material and considering the new design of pedal if needed.

Formula Varsity is a national student competition organized by Faculty of Mechanical Engineering UTeM where participants compete in a challenge to design, built and race a working prototype of a single seater open wheel formula style racing car in real track condition.

1.2 Objective of Project

To design and fabricate a new pedal components (fuel and brake pedal) for UTeM formula style race car 2010.

1.3 Scope of Study

Scopes for this project are:

- i. To produce detail and 3D design of the pedal components using CAD software based on 2010 UTeM Formula Varsity specification and regulation.
- ii. To perform material selection and load analysis on the components.
- iii. To fabricate the pedal components.
- iv. To measure the overall weight of the pedal components.

1.4 Problem Statement

- i. The pedal positions not suit/appropriate to the driver's legs because the position of pedal distance not appropriate with the driver's foot.
- ii. The pedal design not suitable to the driver because the distance ratio between pedal lever and fulcrum inaccurate.

1.5 Summary

This technical report is basically described about how to design and fabricate new components pedals for UTeM Formula varsity race car. This report has ninth chapters which are the first section is Introduction. In the chapter of Introduction, there are stated about objective, problems and scope of the project. Second chapter is Literature Review which explains about the study that has been done in order to get the information about this project. The third chapter is Methodology which explains in basic about the step is needed in order to achieve the project objective. The fourth chapter is the chapter Design Selection. This chapter explain detail about the step and method used in term of deciding the most suitable design for the pedal components of style race car. Fifth chapter is chapter of Materials Selection. This Materials Selection chapter explain in detail about the method and comparison used in selected materials. Sixth chapter is chapter of Structure Analysis. This analysis of structural chapter explains in detail about method to get the suitable design for this project. The seventh chapter is Manufacturing Process which will explain the step of manufacturing the pedal components. The eighth chapter is Result and Discussion where stated the reason for outcome result and also all the problem arise during project. The last chapter is Conclusion and Recommendation which will conclude all of the project activities that has already been done and also recommendation that can be done in further study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Design is the most important word that means everything to all people. In designing process, the materials choose is also important (Budynas et. al. 2008). Materials are physical substances used as inputs to production or manufacturing that derive from or composed matter. Some material have limited design based on that material properties, but the process to shape the material nowadays are more faster than at any previous time. The pedal components on conventional vehicles are actuated by the foot or both feet of the driver (Brad 2007). For this reason it is important to know the foot force capabilities of individuals comprising the driving population. Pedal function to control the amount of braking required on each axle to achieve that perfect balance in braking (Earl 1976). Besides that, the pedal box is set-up to use either a hydraulic clutch or a cable clutch (Ingerslev 2007)

2.2 Accelerator Pedal Concept

A pedal controlled by an extension return spring hooked to the carburettor. The pedal is mounted in bulkhead by mean a small shaft enclosed by a pair of anchorage (Finken et. al. 1970). The throttle cable is used to link the pedal and the carburettor. The pedal profile has been carefully engineered to deliver the optimum pedal ratio (Tilton Engineering Inc. 2010).

2.3 Brake Pedal Concept

Pedal connection to brakes disc and access to hydraulic cylinder, pivot shaft and the type of brakes signal. The common pivot shaft is located at the far end of pedal. The brake pedal light switch is situated on top of pedal (Higginbotham et. al. 1972). The operation performed in braking is the reverse of the carried out in accelerating (Hamid 2007).

2.4 Interdependencies with Other Systems

- i. Frame- need to accommodate the full length of the pedal box plus room for adjustability.
- ii. Ergonomic- it determines the initial pedal angle as there exists a foot angle that gives the maximum amount of force transfer from the driver.
- iii. Brakes- the brake system has the most interdependencies with pedal box. .
- iv. Intake- the accelerator interacts with the carburetor/throttle body on the intake system.

2.5 Ergonomic considerations in Pedal Design

The distance between steering wheel and brake pedal must be kept to approximately 600 mm. The pedal design must not cause fatigue to the feet of the driver. The design must not provide comfort and enough space installing and removal of the pedal box system (Jack E. Gibas et. al. 1970). Besides that, tool feature that adjusts the anthropometric data for secular trends so that the manikin sizes are likely to correspond to the driver' sizes when the car is eventually introduced on the race and throughout the car platform's market life cycle (Lars et. al. 2006). Table 2.1 had shown the ergonomic consideration in pedal design. Moreover, Figure 2.1 also has shown the guideline design for the pedal on a seat height. Besides that, for the pedal ratio is the overall pedal length or distance from the pedal pivot called the fulcrum to centre of the pad that foot will push by the distance from to the fulcrum to the master cylinder push rod attachment point (Ruiz 2005).