



**UNIVERSITI PUTRA MALAYSIA**

**FATIGUE CHARACTERISTIC OF AUTOMOTIVE JOUNCE BUMPER**

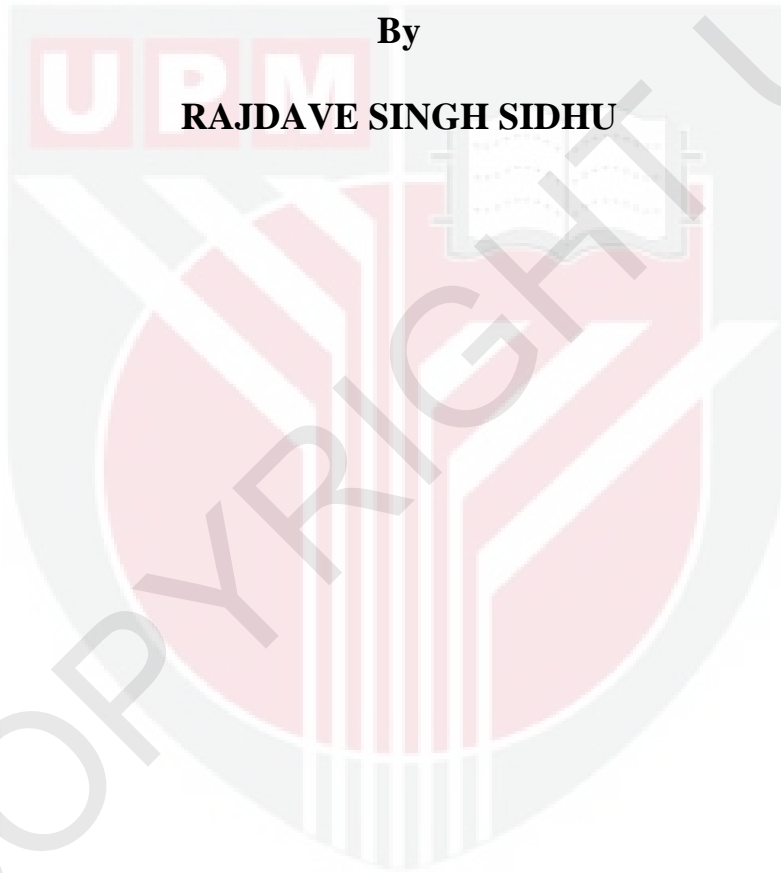
**RAJDAVE SINGH SIDHU**

**ITMA 2010 10**

# **FATIGUE CHARACTERISTIC OF AUTOMOTIVE JOUNCE BUMPER**

**By**

**RAJDAVE SINGH SIDHU**

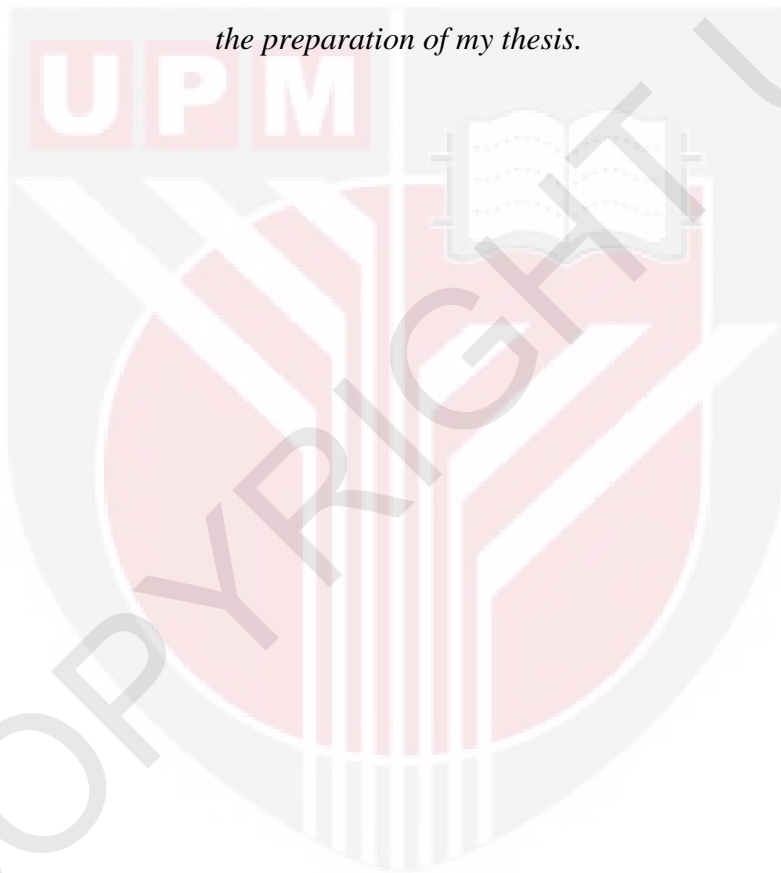


**Thesis submitted to the School of Graduate Studies, Universiti Putra  
Malaysia, in fulfillment of the requirements for the Degree of Master of  
Science**

**December 2010**

## DEDICATION

*I would like to thank my beloved parents Bachitar Singh and Kashmir Kaur, my brother Hardave Singh and the love of my life Jagdeesh Kaur for their patience and support during the preparation of my thesis.*



Abstract of thesis presented to the Senate of Universiti Putra Malaysia  
in fulfilment of the requirement for the degree of Master of Science

## **FATIGUE CHARACTERISTIC OF AUTOMOTIVE JOUNCE BUMPER**

By

**RAJDAVE SINGH SIDHU**

**DECEMBER 2010**

**Chairman : Associate Professor Aidy Ali, PhD**

**Faculty : Institute of Advanced Technology**

Most rubber components in the automotive industry are subjected to static and dynamic loading. Research on fatigue analysis and ways to enhance fatigue life is constantly done as it's directly related to the safety and reliability of a product. Fatigue life determination carried out experimentally has the best accuracy however these methods are not feasible when the components are constantly being renewed. The study was done on an automotive rubber jounce bumper with a rubber hardness of 60 IRHD. The test was conducted in displacement controlled environment under compressive load. The compression test reveals that the jounce bumper is able to withstand a maximum force of 7 KN. The fatigue life of the rubber jounce bumper was successfully determined at three zones by separating the safe zone from the potential danger zone. The existing models by Kim, Harbour, Woo and Li were used to compare and validate the fatigue life. The SEM result shows the existence of decohesions in the control jounce bumper.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Master Sains

## **SIFAT KELESUAN BUMPER GETAH OTOMOTIF**

Oleh

**RAJDAVE SINGH SIDHU**

**DISEMBER 2010**

**Pengerusi : Professor Madya Aidy Ali, PhD**

**Fakulti : Institut Teknologi Maju**

Sebahagian besar komponen getah dalam industri otomotif dikenakan pembebanan statik dan dinamik. Analisa kelesuan dan cara-cara untuk meningkatkan jangka hayat komponen giat dilakukan untuk memperbaiki tahap keselamatan dan kebolehpercayaan produk. Pengujian tahap kelesuan komponen secara eksperimen mempunyai ketepatan paling tinggi dan harus diaplikasi untuk mendapatkan keputusan yang tepat. Kajian ini menggunakan bumper getah otomotif dengan tahap kekerasan getah 60 IRHD. Ujian dilakukan dalam persekitaran yang terkawal menggunakan beban mampatan. Ujian mampatan menunjukkan bumper getah mempunyai kekuatan maksimum 7 KN. Kelesuan bumper getah berjaya diperolehi dan boleh dibahagikan kepada tiga zon. Model-model yang dihasilkan oleh Kim, Harbour, Woo & Li telah digunakan untuk tujuan perbandingan dan menguji keupayaan model untuk mendapatkan nilai kelesuan yang paling hampir dengan nilai eksperimen. Ujian menggunakan pengimbas miroskop elektron (SEM) mendedahkan kewujudan 'decohesion' di dalam bumper getah.

## ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to my supervisor, Associate Professor Dr Aidy Ali, for his guidance, encouragement, assistance, and counsel throughout the course of this study and in the preparation of this thesis. Sincere appreciation is also extended to Dr Mohd Roshdi for serving as my co-supervisor.

I would like to thank Ms Sharon Kaw, Mr Syamsul and Mr Suhaimi from Malaysian Rubber Board for their help, knowledge and ideas. I would like to thank Mr Wildan Ilyas from the Strength of Material Laboratory, Department of Mechanical and Manufacturing Engineering for his continuous assistance and guidance.

I would also like to thank my friends Syazwan Abdul Samad, Asmawi Sainnudin, Mohd Khairul Azhar, Mohd Faisal Badry and Mohd Hakim Abdullah who made my stay at UPM a memorable one.

I certify that a Thesis Examination Committee has met on 23<sup>rd</sup> of December 2010 to conduct the final examination of Rajdave Singh Sidhu on his thesis entitled “Fatigue Characteristic of Automotive Rubber Jounce Bumper” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science Automotive Engineering.

Members of the Examination Committee are as follows:

**Associate Professor Datin Dr Napsiah Ismail, PhD**

Jabatan Kejuruteraan Mekanikal dan Pembuatan  
Fakulti Kejuruteraan  
Universiti Putra Malaysia  
43400 UPM Serdang  
(Chairman)

**Prof. Ir. Dr. Barkawi Sahari, PhD**

Jabatan Kejuruteraan Mekanikal dan Pembuatan  
Fakulti Kejuruteraan  
Universiti Putra Malaysia  
(Internal Examiner)

**Dr. Nuraini Abdul Aziz, PhD**

Jabatan Kejuruteraan Mekanikal dan Pembuatan  
Fakulti Kejuruteraan  
Universiti Putra Malaysia  
(Internal Examiner)

**Prof. Dr. Hanafi Ismail, PhD**

Pusat Pengajian Kejuruteraan Bahan dan Sumber Mineral  
Kampus Kujuruteraan  
Universiti Sains Malaysia  
14300 Nibong Tebal  
Pulau Pinang

**BUJANG KIM HUAT, PhD**

Professor and Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia.

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

**Aily Ali, PhD**

Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**Roshdi Hassan, PhD**

Faculty of Engineering  
Universiti Putra Malaysia  
(Member)



**HASANAH MOHD GHAZALI, PhD**

Professor and Dean  
School of Graduate Studies  
Universiti Putra Malaysia.

Date:



## DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

---

**RAJDAVE SINGH SIDHU**

Date: 23 December 2010



## TABLE OF CONTENTS

	<b>Page</b>
<b>DEDICATION</b>	ii
<b>ABSTRACT</b>	iii
<b>ABSTRAK</b>	iv
<b>ACKNOWLEDGEMENTS</b>	v
<b>APPROVAL</b>	vi
<b>DECLARATION</b>	vii
<b>LIST OF TABLES</b>	xii
<b>LIST OF FIGURES</b>	xiii
<b>NOMENCLATURE</b>	xv
<b>CHAPTER</b>	
<b>1 INTRODUCTION</b>	
1.1 Introduction	1
1.2 Problem statements	2
1.3 Project Objectives	3
1.4 Scope of study	3
1.5 Chapter Arrangements	4
<b>2 LITERATURE REVIEW</b>	
2.1 Introduction	5
2.2 Rubber	5
2.3 Overview of Fatigue Analysis	6
2.3.1 Crack Nucleation Approach	8
2.3.2 Application of Crack Nucleation Approach	9
2.3.3 Crack Growth Approach	10

2.3.4	Application of Crack Growth Approach	10
2.3.5	Crack Nucleation versus Crack Growth Approach	11
2.4	Jounce Bumper (JB)	12
2.5	Jounce Bumper Preconditioning	14
2.6	Failure Criterion	15
2.7	Effects of load types, amplitudes and frequencies	17
2.8	Fatigue Life prediction Models for rubber	20
2.9	Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray Spectroscopy (EDS)	21
2.10	Summary of review	24
<b>3</b>	<b>METHODOLOGY</b>	
3.1	Introduction	25
3.2	Test Sample	26
3.3	Jig Design and Setup	27
3.4	The Instron 3382 Universal Testing Machine and Instron 8871 model Fatigue System	29
3.5	Test Procedure	31
3.6	Fatigue Damage Model Comparison	39
3.7	JSM-6701F Field Emission Scanning Electron Microscope (FESEM) Procedure	41
<b>4</b>	<b>RESULTS AND DISCUSSION</b>	
4.1	Introduction	42
4.2	Compression Test Results	42
4.3	Fatigue Test Results	43
4.4	Comparison between Experimental Fatigue Life and Model Fatigue Life	49
4.5	SEM/EDS Results and Analysis	50
<b>5</b>	<b>CONCLUSIONS AND RECOMMENDATIONS</b>	
5.1	Conclusions	53

5.2	Recommendations	54
	<b>REFERENCES</b>	55
	<b>APPENDICES</b>	57
	<b>BIODATA OF THE STUDENT</b>	82



© COPYRIGHT UPM