



UNIVERSITI PUTRA MALAYSIA

***PERFORMANCE OF FRONT BUMPER AND HOOD SYSTEM WITH
PEDESTRIAN SAFETY SUBJECTED TO FRONTAL IMPACTS***

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PEDESTRIAN SAFETY SUBJECTED TO FRONTAL IMPACTS**

By

MAI NURSHERIDA BINTI JALALUDDIN

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

September 2011

DEDICATIONS

My dearest parents;

Haji Jalaluddin Bin Haji Udin and Hajjah Sharipah Sapiah Binti Syed Hassan

Al-Jamalulail.

My husband;

Mohd Rosdan Bin Sulaiman

My dearest children;

Aishah Umairah Binti Mohd Rosdan & Akid Naquiuddin Bin Mohd Rosdan.

My beloved brother and sisters;

Mai Juzilin Binti Haji Jalaluddin, Mai Jasmina Binti Haji Jalaluddin, Mai Shahzima

Binti Haji Jalaluddin, Mior Nur Izam Bin Haji Jalaluddin and Allahyarhammah

Leftenan Mai Elny Sefrina Binti Haji Jalaluddin

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

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September 2011

Chairman: Professor Barkawi Bin Sahari, Ir. PhD

Faculty: Faculty of Engineering

A performance of front bumper and hood system with pedestrian safety subjected to frontal impacts is presented and discussed in this project. The aim of this study is to analyze the effect of steel, aluminum and composite material on energy absorption and pedestrian safety of automotive front bumper system and hood. The front bumper beams and hood made of e-glass/epoxy composite and carbon epoxy composite are studied and characterized by impact modeling using LS-DYNA V971, according to United States New Car Assessment Program (US-NCAP) frontal impact velocity and based on European Enhanced Vehicle-safety Committee.

The most important variable of this structure are mass, material, head injury criteria, leg injury criteria and Specific Energy Absorption (SEA). The results are compared with bumper beam and hood made of mild steel. Three types of materials are used in the present study which consists of mild steel as references material, Aluminum AA5182, E-glass/epoxy composite and carbon fiber/epoxy composite with three different fiber orientations $[0^\circ/60^\circ]_s$, $[0^\circ/30^\circ/60^\circ]_s$ and $[0^\circ/30^\circ/60^\circ/90^\circ]_s$.

The beams were subjected to impact loading to determine the internal energy and SEA. The in-plane failure behaviors of the composites were evaluated by using Tsai Wu failure criterion. The results for the composite beams are compared to that of the reference beam to find the best material with highest SEA. LS-DYNA Finite Element Analysis software was used. The results showed that carbon fiber/epoxy composite bumper can reduce the bumper mass and has the highest value of SEA followed by glass fiber/epoxy composite, aluminum AA5182 and mild steel.

For the pedestrian safety, the dummy was subjected to frontal impact to determine the head injury criteria. The results for the composite materials and aluminum AA5182 are compared to that of the reference material to find the best material with lowest value of Head Injury Criterion (HIC). The results showed that aluminum AA5182 with thickness 1.0 mm hood has the lowest HIC value with 549.70 for HIC15 and 883.00 for HIC36 followed by mild steel with 657.40 for HIC15 and 980.90 for HIC36, glass fiber/epoxy composite with 639.60 for HIC15 and 921.70 for HIC36 and carbon fiber/epoxy composite bumper with 1197.00 for HIC15 and 1424.00 for HIC36. From the present work, the carbon glass fiber/epoxy bumper beams and aluminum AA5182 hood are proposed since it met the European New Car Assessment Programme (N-CAP) criteria.

For Leg Injury criteria determination, the legform model was used to stimulate accidents against the front of the car. The European New Car Assessment Program (NCAP) parameter was used to simulate accidents involving pedestrian impact at 40km/h, where dummy models or legform served as impactors. For legform simulation results, the tibia acceleration 91.5 g, 4.2 mm shear displacement and 12.0°

bending angle graphs are below the regulation limit. It is because there are no contact between the front bumper beam and the legform, so that the injury is less. This is shows that the clearance between the bumper shell and front bumper beam are enough. The appropriate value is 75 mm. As a conclusion, the minimum clearance between the leg and the bumper



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

**PRESTASI BUMPER DEPAN DAN SISTEM KAP ENJIN DENGAN
KESELAMATAN PEJALAN KAKI DIKENAKAN DAMPAK HADAPAN**

Oleh

MAI NURSHERIDA BINTI JALALUDDIN

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Pengerusi: Profesor Barkawi Bin Sahari, Ir. PhD

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Sebuah prestasi bumper depan dan sistem kap enjin dengan keselamatan pejalan kaki yang mengalami kesan dampakan hadapan dipersembahkan dan dibincangkan dalam projek ini. Tujuan kajian ini adalah untuk menganalisis pengaruh besi keluli dan bahan komposit pada penyerapan tenaga dan keselamatan pejalan kaki sistem automotif bumper depan dan kap enjin kereta. Bumper depan dan rasuk kap enjin yang diperbuat dari e-glass/epoxy komposit dan karbon epoksi komposit yang dipelajari dan ia dipercirikan dengan pemodelan impak menggunakan LS-DYNA V971 dan menurut kriteria impak kelajuan hadapan “United States New Car Assessment Program” (US-NCAP) dan berdasarkan “European Enhanced Vehicle-safety Committee”.

Pembolehubah yang paling penting dari struktur ini adalah jisim, bahan, kriteria kecederaan kepala, kriteria kecederaan kaki dan “Specific Energy Absorption” (SEA). Keputusan yang diperolehi dibandingkan dengan rasuk bumper dan kap enjin yang diperbuat daripada besi keluli lembut. Tiga jenis bahan yang digunakan dalam

kajian ini yang terdiri daripada besi keluli lembut sebagai bahan rujukan, Aluminium AA5182, E-glass/epoxy komposit dan karbon / epoxy komposit dengan tiga orientasi komposit yang berbeza iaitu $[0^\circ/60^\circ]_s$, $[0^\circ/30^\circ/60^\circ]_s$ dan $[0^\circ/30^\circ/60^\circ/90^\circ]_s$.

Rasuk menjadi subjek utama di dalam bebanan impak untuk menentukan tenaga dalaman dan SEA. Perilaku kegagalan dalam rasuk yang diperbuat daripada komposit dinilai dengan menggunakan kriteria kegagalan Tsai Wu. Keputusan untuk rasuk komposit dibandingkan dengan rasuk rujukan untuk mencari bahan terbaik dan diukur dengan nilai SEA yang tertinggi. Analisis dilakukan dengan menggunakan perisian “LS-DYNA Finite Element Analysis”. Keputusan kajian menunjukkan bahawa rasuk bumper yang menggunakan serat karbon/epoksi komposit dapat mengurangkan jisim rasuk dan mempunyai nilai SEA yang tertinggi diikuti dengan serat glass / epoxy komposit, aluminium AA5182 dan besi keluli lembut.

Untuk keselamatan pejalan kaki, “dummy” menjadi sasaran di dalam perlanggaran impak hadapan untuk menentukan kriteria kecederaan di kepala. Keputusan simulasi dibandingkan diantara bahan-bahan komposit, aluminium AA5182 dan bahan rujukan untuk mencari bahan terbaik dengan nilai “Head Injury Criteria” (HIC) yang terendah. Keputusan kajian menunjukkan bahawa kap enjin yang menggunakan bahan aluminium AA5182 dengan ketebalan 1.0 mm memiliki nilai HIC terendah dengan 549.70 untuk HIC15 dan 883.00 untuk HIC36 diikuti dengan bumper besi keluli lembut dengan 657.40 untuk HIC15 dan 980.90 untuk HIC36, serat glass / epoxy komposite dengan 639.60 untuk HIC15 dan 921.70 untuk HIC36 dan karbon komposit/epoksi komposit dengan 1197.00 untuk HIC15 dan 1424.00 untuk HIC36. Dari kajian ini, serat gelas karbon / epoxy bumper angka dan aluminium kap

AA5182 dicadangkan kerana memenuhi kriteria European New Car Assessment Programme (N-CAP).

Untuk penentuan kriteria kecederaan di kaki, model “legform” digunakan untuk merangsang kemalangan terhadap bahagian depan kereta. Parameter yang digunakan adalah berdasarkan “European New Car Assessment Program” (NCAP) untuk mensimulasikan kesan kemalangan yang melibatkan pejalan kaki pada 40km / j, di mana model “dummy” atau “legform” menjadi sebagai “impactor”. Untuk hasil simulasi “legform”, percepatan tibia 91.5 g, perpindahan luncurkan dengan nilai 4.2 mm dan 12.0 ° untuk pembengkokan sudut di bawah batas regulasi. Hal ini kerana tidak ada hubungan antara rasuk bumper depan dan legform, oleh sebab itu, kecederaan adalah kurang. Hal ini menunjukkan bahawa jarak antara rangka luar bumper dan rasuk bumper depan sudah mencukupi. Nilai yang sesuai dan diterima adalah 75 mm.

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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

MAI NURSHERIDA BINTI JALALUDDIN

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I certify that a Thesis Examination Committee has met on (26th September 2011) to conduct the final examination of Mai Nursherida Binti Jalaluddin on her thesis entitled “Performance of Front Bumper and Hood System With Pedestrian Safety Subjected to Frontal Impacts” 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 Masters of Science.

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TABLE OF CONTENTS

	DEDICATIONS	Page
	ABSTRACT	ii
	ABSTRAK	iii
	ACKNOWLEDGEMENT	vi
	APPROVAL	ix
	DECLARATION	x
	LIST OF TABLES	xii
	LIST OF FIGURES	xvi
	LIST OF ABBREVIATIONS	xvii
	xx	
 	CHAPTER	
1	INTRODUCTION	1
1.1	Background	1
1.2	Problem Statement and Justification of Study	2
1.2.1	Vehicle accidents and their consequences	4
1.2.2	Consequences of vehicle accidents	5
1.3	Aim and Objective of Study	6
1.4	Scope of work	7
1.5	Thesis outline	7
2	LITERATURE REVIEW	
2.1	Automotive Body Structure.	9
2.2	Crushing Test Methodologies	11
2.3	A review on materials for validation purpose	12
2.3.1	Steel SPHC	12
2.3.2	Aluminum AA5182	14
2.3.3	(a) Composite Materials and Structures	20
2.3.3	(b) Damage in woven-fabric composites subjected to low-velocity impact	21
2.3.3	(c) Impact damage response on composite materials	26
	(i) Delamination	26
	(ii) Matrix cracking	26
	(iii) The Tsai Wu Failure Criterion	27
2.4	Automotive crashworthiness characteristics	29
2.4.1	Crashworthiness Parameter	29
2.5	New Car Assessment Program (NCAP)	33
2.5.1	Overall rating calculation	35

2.5.2	Assessment protocol – Pedestrian Occupant Protection.	36
2.5.3	Pedestrian Safety	38
2.5.4	Human body's tolerance to impact	39
2.6	Front bumper and hood system for pedestrian safety literature	46
2.6.1	Design and analysis of an automotive beam in low speed frontal crashes	46
2.6.2	Optimization of reversible hood for protecting a pedestrian's head during car collisions	49
2.7	Summary of review	52
3	METHODOLOGY	55
3.1	Method of Approach	55
3.2	Preliminary Literature Survey	57
3.3	Identifying The Design Requirement	57
3.4	Preparing the Model Development	58
3.4.1	Features Geometry	59
3.4.2	Meshing	59
3.4.3	Geometric Section	59
3.4.4	Material Properties	59
3.4.5	Contact Interface	59
3.4.6	Boundary Conditions	60
3.4.7	Initial velocity	60
3.4.8	Preparing for Analysis	60
3.5	Running the Analysis (Solver)	61
3.6	Extraction of Results (Post Processing)	61
3.7	Analysis of Results	62
3.8	Satisfactory output & Methodology for Validation	64
3.9	Computer Aided Engineering Tools	67
3.9.1	Geometric Modelling using CATIA software	67
3.9.2	Finite Element Mesh development using HyperMesh	67
3.9.3	Crash analysis using LS-DYNA software	68
3.10	Modelling the Front Bumper System and Hood for Pedestrian Safety	69
3.10.1	Building a Model for Analysis	70
3.10.2	Mesh Development	72
3.10.3	Geometric Section	72
3.10.4	Contact Surface	73
3.10.5	Boundary Conditions	73
3.10.6	Initial Velocities	74
3.10.7	Preparing for Analysis	74
3.10.8	Running the Analysis	75
3.11	Material Properties	76
3.12	Discussion	78

4	RESULTS AND DISCUSSIONS	80
4.1	Introduction	80
4.2	Results for Front Bumper System	82
4.2.1	Crash Behavior of Mild Steel Front Bumper Beam Subjected to Frontal Impacts	83
4.2.2	Results of front bumper beam with different material and thickness	87
4.2.3	Results of Front Bumper beam in terms of Crush Force, SEA, and mass reduction	90
4.3	Crash Behavior of Pedestrian Crash Subjected to Frontal Impacts	96
4.3.1	Head Injury Criterion (HIC)	97
4.3.2	Results for Leg Injury	108
5	CONCLUSIONS AND RECOMMENDATIONS	113
5.1	Conclusion	113
5.2	Recommendations	116
	REFERENCES	117
	APPENDICES	
	APPENDIX A	123
	APPENDIX B	127
	APPENDIX C	133
	APPENDIX D	152
	BIODATA OF STUDENT	157
	LIST OF PUBLICATIONS	158