


DESIGN AND IMPACT ANALYSIS OF AUTOMOTIVE B-PILLAR

SAIFUL BAHRI BIN ABDUL WAHAB

KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

“I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the Bachelor of Mechanical Engineering (Structure & Material)”

Signature :
Name of Supervisor :
Date :



Ir. Tanchee Fui
27.05.2006

DESIGN AND IMPACT ANALISYS OF AUTOMOTIVE B-PILLAR

SAIFUL BAHRI BIN ABDUL WAHAB

A thesis report submitted to Faculty of Mechanical Engineering in partial fulfillment of
the requirement award of Bachelor degree of Mechanical Engineering
(Structure & Material)

Faculty of Mechanical Engineering
Kolej Universiti Teknikal Kebangsaan Malaysia

Mei 2006

“I hereby the author, declare this report entitled “DESIGN AND IMPACT ANALISYS OF AUTOMOTIVE B-PILLAR” is my own except for quotations and summaries which have been duly acknowledged”

Signature : *t. t*

Author :

Date :

ACKNOWLEDGEMENTS

Alhamdulillah with His Mercy and Blessings, this project was finally successful. I would like to express my deepest gratitude and appreciation to my supervisor, Mr. Tan Chee Fai from Faculty of Mechanical Engineering, Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM), for his tremendous help, advice, inspiration and unending guidance to me until completing this thesis.

Besides that, I would like to express my sincere thanks to all my family and friends because understand, patience and co-operation. May Allah bless all them. Finally the author is expressing his sincere gratitude to Allah once again who made the study to complete.

ABSTRACT

This project (PSM) is carried out with the purpose of design and impact analysis of automotive B-pillar. The scope of this study is to know the basic system of beam and pillar loaded by the forces. The basic of the analysis is used Nastran/Patran and CosmosXpress software to aid the finite element method. The comparison among the 4 type of beam will be tested to choose the best one beam that can be used in this project like rectangular hollow bar beam and T beam. The designs of the test rig are used Solid Work 2005 software. The fabrication process of the product will be used manufacturing process in the Fakulti Kejuruteraan Mekanikal lab (FKM). The important of the system of the test rig here is to test the pillar strength before the product sell to the customers. The factory can use this product to test their pillar system with the simply usage.

ABSTRAK

Projek (PSM) ini dijalankan adalah untuk mereka cipta dan menganalisis impak yang dikenakan pada automotif B-pillar. Skop bagi projek ini adalah untuk mengetahui sistem asas dalam bendul dan penyokong yang telah dikenakan daya-daya. Sistem asas dalam penganalisaan adalah menggunakan Nastran/Patran dan Solid Work 2005 dalam mengetahui kelemahan sesuatu bahan. Proses merekabentuk adalah menggunakan perisian Solid Work 2005. Manakala proses mereka bentuk bahan menggunakan kaedah proses pembuatan yang dijalankan di makmal Fakulti Kejuruteraan Mekanikal (FKM). Kepentingan sistem penganalisa ini adalah untuk menguji kekuatan penyokong sebelum produk tersebut boleh dijual kepada pelanggan. Kilang-kilang perindustrian boleh menggunakan produk ini untuk menguji sistem penyokong dengan cara yang mudah.

CONTENTS

CHAPTER	SUBJECT	PAGE
	VERIFICATION TITLE	
	DECLARATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSRTRACT	v
	ABSTRAK	vi
	CONTENTS	vii
	LIST OF TABLE	xii
	LIST OF FIGURE	xiii
	LIST OF SYMBOL	xvii
	LIST OF APPENDIXS	xviii
	REFERENCES	110
CHAPTER I	INTRODUCTION	
	1 Introduction	1
	2 Objectives	2
	3 Problem Statement	3

CHAPTER II LITERITURE REVIEW

2.1	Material	4
2.2	Relationship between torque and power	6
2.3	Stress	7
2.4	The phase in design	9
2.5	Uncertainty	10
2.6	Units	12
2.7	Principal Metal	13
2.8	Beam Specification	14
2.9	Standard Hollow Bar Dimension	15
2.10	Hands Tools Safety	16
2.11	Finite Element Analysis (FEA)	17
2.12	NASTRAN and PATRAN	18
2.13	Test Rig Manufacturing Processes	20
2.14	Joining Processes and Equipment	25
2.15	Comparison of Various Joining Methods	27
2.16	Welding Accessories	28
2.17	Safety Equipment	29
2.18	Welding Safety	30
2.19	Motor Specification	31
2.20	Operating Instruction-WARN Works® 1700	34
2.21	Winch Installation to fixed location	37

CHAPTER III METHODOLOGY

3.1	Methodology	45
3.2	Project Solution	48
3.3	CONCEPTUAL DESIGN	51
3.3.1	Designs of the lower beam	51
3.3.2	The pulley system on the beam	55
3.3.3	The test space concept on the test rig	58
3.3.4	The power suppliers as the load forces	60
3.4	Designs	63
3.5	Design Selection	67
3.6	Designs Comparison	68
3.7	Pillar Tester Specification	69
3.7.1	Model 1.2 Specifications	70
3.8	Model 1.2 manual	72
3.9	Test Rig Installation	74

CHAPTER IV RESULT

4.1	Results of Project and Analysis	78
4.2	Finished Project	79
4.3	Beam surface analysis by MSC/Nastran	80
4.4	Cantilever Beam	82
4.5	Finite Element Analysis to Aid Profile	83
4.5.1	The Finite Element Method	83

4.5.2	Finite Element Method to Aid profile	84
4.5.3	Rectangular Profile	85
4.5.4	U Profile	86
4.5.5	H Profile	87
4.5.6	T Profile	88
4.6	Beam Selection	90
4.7	Static Beam Analysis by CosmosXpress Study	91

CHAPTER V DISCUSSION

5.1	Result Discussion	97
5.2	Calculation	98
5.3	Bar Calculation of Torque T	100
5.4	Torque Discussion	102
5.5	Patran Discussion	103
5.6	CosmosXpress Discussion	104
5.7	Cantilever Beam Discussion	105
5.8	Beam Section Analysis	106

CHAPTER VI CONCLUSION

6.1	Conclusion	108
6.2	Suggestions for Future Work	109

LIST OF TABLE

TABLE NO.		PAGE
2.8	Beam Specification	14
2.9	Wall thickness dimension	15
2.15	Characteristics	27
2.19(a)	Motor Specification	31
2.19(b)	Motor Performance	32
2.19(c)	Pulling Power	32
3.6	The 3 Model Comparisons in the SolidWork 2005 assembly	68
4.5.6	The Result of Deformation from Various Profiles of Beams	89
5.8(a)	The Result of Deformation from Various Profiles of Beams	106
5.8(b)	Deformation	107

LIST OF FIGURE

FIGURE NO.		PAGE
2.3	Beam displacement	8
2.4	The phase in design	9
2.11	Example of Finite Element Analysis	18
2.12	Example of the Nastran and Patran result	19
2.13(a)	Cutting process with the Chop-Saws	20
2.13(b)	Example of cutting part	21
2.13(c)	Grinding process	21
2.13(d)	Example part to be grinded	21
2.13(e)	Welding process	22
2.13(f)	Welding part	22
2.13(g)	Hardware part	23
2.13(h)	Milling machine that can be use to be a driller in same time	23
2.13(i)	Screw joining in this process	24
2.16	Arc Welding	28
2.17	Safety equipment	29
2.19(a)	Winch dimensions are shown in inches	32
2.19(b)	WARN Works® 1700	33
2.19(c)	Winch Dimensions	33
2.20(a)	Real View of WARN Works® 1700	34
2.20(b)	The WARN Works® 1700 Utility	36
2.21(a)	Mounting location	37
2.21(b)	Secure the winch	37
2.21(c)	Discard nut	38
2.21(d)	Determine switch orientation	38
2.21(e)	Install switch onto motor by sliding slotted copper bus bars	38
2.21(f)	Install ¼-20 washer and new nut from hardware pack	39

2.21(g)	Install battery cables	39
2.21(h)	Operating for Power In	40
2.21(i)	Operating for Power Out	40
2.21(j)	Engaged	41
2.21(k)	Disengage – Freespool	41
3.1	Flow chart	46
3.3.1(a)	Base beam for the test rig (Scissor type)	51
3.3.1	Model example	52
3.3.1(b)	2 triangle beams combination	52
3.3.1(c)	2 square beam combination	53
3.3.1(d)	Square and triangle base beam combination	54
3.3.2	The pulley system on the beam	55
3.3.2(a)	Adjustable pulley concept	55
3.3.2(b)	The notch on the base beam concept	56
3.3.2(c)	The top notch on the basis beam	56
3.3.2(d)	The adjustable pillar for the pulley holder	57
3.3.3(a)	metal square surface	58
3.3.3(b)	Circle surface for the test space	59
3.3.3(c)	X-beam test space	59
3.3.4(a)	Chain power	60
3.3.4(b)	The wire power	61
3.3.4(c)	The pillar bracket	62
3.4(a)	Design 1.4- Isometric View	63
3.4(b)	Design 1.4- Bottom View	63
3.4(c)	Design 1.3- Isometric View	65
3.4(d)	Design 1.3- Bottom View	65
3.4(e)	Design 1.2- Isometric View	66
3.4(f)	Design 1.2- Bottom View	66
3.5	Design 1.2	67
3.7	Model 1.2 Pillar Testers	69

3.8(a)	Base beam	72
3.8(b)	Supported Bracket	72
3.8(c)	Roller	72
3.8(d)	Roller Base	73
3.8(e)	Bolts and Nuts	73
3.8(f)	T-pillar and L-pillar	73
3.9(a)	Joint the supported pillar	74
3.9(b)	Another supported pillar	74
3.9(c)	Use the washer when joining the bolts and nuts	74
3.9(d)	The supported pillar will be joined like in the figure	75
3.9(e)	T-pillar will be putted on the beam recline to the M6 holes	75
3.10(f)	L-pillar will be putted on the beam	75
3.9(g)	The view of the L-pillar	76
3.9(h)	The roller bar will be installed	76
3.9(i)	The roller will be installed	76
3.9(j)	The finished installing is ready to test	77
3.9(k)	The motor will be installed	77
4.2	Finished Project	79
4.3(a)	Geometric view	80
4.3(b)	Top View	81
4.3(c)	Side View	81
4.4	Hollow Bar section	82
4.5.2(a)	Rectangular profile	84
4.5.2(b)	Rectangular side view	84
4.5.3(a)	U profile	85
4.5.3(b)	U side view	85
4.5.4(a)	H profile	86
4.5.4(b)	H side view	86
4.5.5(a)	T profile	87
4.5.5(b)	T side view	87
4.6	The dimension of rectangular hollow bar	90

4.7(a)	Analysis Static Beam Model 1.1 and Model 1.2	91
4.7(b)	Model Design 1.2	92
4.7(c)	Analysis Static Beam 1.2 overall surfaces with 1000N	92
4.7(d)	Square plate test	93
4.7(e)	Analysis Static Plate Model 1.3 on the node point with 1000N	93
4.7(f)	Model 1.4 square space	94
4.7(g)	Analysis Static Plate Model 1.4 on the node point with 1000N	94
4.7(h)	The bracket that supported pulley	95
4.7(i)	The bolt screw with Stress Distribution of 500N	96
5.2	Example calculation	98
5.3(a)	Hollow Bar Dimension	100
5.3(b)	length of bar	101
5.4(a)	The deformation	102
5.4(b)	Dimension of Hollow Bar	102
5.5	Surface beam analysis	103
5.6(a)	L-pillar from Model 1.2	104
5.6(b)	Example of L-pillar analysis by CosmosXpress	104
5.7	Cantilever beam analysis by Nastran/Patran	105

LIST OF SYMBOL

SYMBOL	DEFINITION
A	Area = mm ² / m ²
b	width
G	gravity
F	force
y	y-axis
x	x-axis
ξ	Horizontal displacement
η	Vertical displacement
t	thickness
θ	angle
$V(x)$	shearing force per unit length
$q(x)$	downward force per unit area
P	Pressure
ν	Poisson ratio
I	geometrical moment of inertia
Nd	uncertainties
E	energy
T	torque

LIST OF APPENDIXS

LIST	TITLE	PAGE
A	Solid Work 2005 Software	111
B	Drawing Model 1.2	112

LIST OF APPENDIXS

LIST	TITLE	PAGE
A	Solid Work 2005 Software	111
B	Drawing Model 1.2	112

CHAPTER 1

INTRODUCTION

1.1 Introduction

As a pillar is loaded, different regions of the pillar are subjected to varying internal shear forces and bending moment. Like a simple words the pillar will deflect. Determining the deflection of the pillar under a giving loaded condition is of particular interest. This is generally accomplished either by integration or by using area moment-method.

This project presents herein focus on integration. Most of this analysis will be use in the constructions side to check the failure of the pillar to support the beam. The material in use just a cheaper cost to analyze the pillar. So in this case we put the metal characteristic in the object measuring (pillar-tester) to the subject (B-pillar or other pillar) we use in producing or constructing method. As a good pillar-tester that we can sell to our customers may be in one day so we must know what the customer need such as their confident, easy using object, portable, low cost, flexible, and lightweight.

So the objectives not just to have our good report to our reader but we need to prove our project in good condition. The pillar that we need to test is an L-pillar, I-pillar, and E-pillar also. So to test the pillar in the lowest measuring like 1 kilo Newton for the one pulling by the wire cable connected with the motor system.

1.2 OBJECTIVES

The Objectives of the projects as follows:

- Using the knowledge about static load and dynamic force to calculate the beam reaction after load applied.
- This project is important to use in industry to check the pillar.
- Design the proportional models using SolidWork 2005 software and can be choose the best one to make an example product.
- So knowing the method for the test rig, the pillar test rig must be portable, lightly, flexible and useful.
- This project will be analyzed with Finite Element Method such as Nastran/Patran software to know their problem and fatigue.
- This project will be fabricated to make an example for the test rig system.

1.3 PROBLEM STATEMENT

To make sure this design is useful we must know the problem that we will occur. The major case in this pillar-checker is about the specification of the metal consumption.

- a) During on pillar-tester inspection, the most problem is unable of inspector to move in a stable condition. So the failure of the tester may be created by the pulling force applied.
- b) From the design given we know the place where the failure will happen if we use the larger force. So the lowest force such as 1 kilo Newton to check the failure part for the first analysis.
- c) For the cable method we need to check the metal in use either it suitable or not to make a movement while pulling in progress.
- d) How about the pillar for hold the pulley to pull the cable? This method was important to make sure our checker will work in good condition. So we need to select the good strength of the cable connecting with the power supply.
- e) The good motion and the less friction for our cable we need to check our angular position upon the pulley in use. The angular is from the pulley to the motor side.
- f) Other part that needs to make attention is from the pillar position on the tester surface. The good foundation to put the pillar must be analyzed. Use both of screw or wench to lock this part.

CHAPTER 2

LITERITURE REVIEW

2.1 Material

Alloy Steels 4130 related trades name is **Chrome moly-4130**

Principal Design Features: AISI 4130 is a low alloy steel containing molybdenum and chromium as strengthening agents. The carbon content is nominally 0.30% and with this relatively low carbon content the alloy is excellent from the fusion weld ability standpoint. The alloy can be hardened by heat treatment.

Applications: Typical applications for 4130 low alloy steel include. Structural use such as aircraft engine mounts and welded tubing applications.

Machinability: This alloy is readily machined by conventional methods. Machinability is best with the alloy in the normalized and tempered condition. Although the alloy may be machined in the fully heat treated condition, machinability becomes more difficult with increasing strength (hardness) of the alloy.

Forming: Formability is best in the annealed condition for which the ductility is very good. Bend radii of 1t on annealed sheet material may be made.

Welding: 4130 alloy is noted for its weldability by all of the commercial methods.

Heat Treatment: Heating at 1600 F followed by an oil quench will harden the 4130 alloy. For best results a normalizing pre-hardening heat treatment may be used at 1650 to 1700 F followed by the 1600 F soak and oil quench.

Forging: Forge at 2200 F maximum down to 1750 F.

Hot Working: 4130 in the annealed condition has excellent ductility. Thus it is usually not necessary to do hot working to form parts. If hot working is needed it can be done in the range of 2000 F to 1500 F.

Cold Working: Cold working by conventional methods is readily accomplished on this alloy.

Annealing: 4130 (and most of the other low alloy steels) may be annealed at 1550 F for a time long enough to allow thorough heating of the section size. It should then be cooled in the furnace at a rate of less than 50 F per hour down to 900 F, followed by air cooling from 900 F.

Aging: Not applicable to this alloy.

Tempering: Tempering is done to restore some of the ductility that may be lost after the hardening heat treatment and quench, Alloy 4130 is tempered at between 750 F and 1050 F depending upon the strength level desired. The lower of tempering temperature the greater of the strength.

Hardening: Hardening is accomplished by heat treatment or by cold working.

The 4130 alloy is a through hardening alloy and should not be case hardened.