"I have read this literary work and that in my opinion it is fully adequate, in scope and quality, as a masterpiece for the Bachelor of Mechanical Engineering (Structure & Material)"

Signature : ....

Supervisor's Name : EN HAIRUL BIN BAKRI

Date : 25/5/2010

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STUDY ON SHOCK ABSORBING PROPERTIES OF ALUMINIUM CIRCULAR TUBE

SITI AMINAH BINTI MOHD SUBARI

This report submitted in partial
fulfillment of the conditions of the award of a
Bachelor of Mechanical Engineering (Structure & Material)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

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"I declared that this project report entitled "Study on Shock Absorbing Properties of Aluminium Circular Tube" is written by me and is my own effort except the idea and summaries which I have clarified their sources."

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Name of Candidate : SITI AMINAH BINTI MOHD SUBARI

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Name of Candidate : SITI AMINAH BINTI MOHD SUBARI

Date : ....

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To my beloved parents

Encik Mohd Subari Bin Mohd Tahip and Puan Azizah Binti Mahpoz

My siblings

And also

To all my trusted friends

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All praises to God for His blessings and guidance. Thanks for giving me strength to complete this project report. I am really grateful as I have completed this Projek Sarjana Muda with the help and support, encouragement and inspirations by various parties. All the knowledge and information that they give are really helpful.

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ABSTRACT

This research had carried out involving shock absorbing system on strengthening structure. Dynamic explicit finite element method was performed on the thin walled circular tube. Dynamic test were conducted for velocity 5.0 m/s, 7.7 m/s and 10 m/s with on impacting mass 60 kg in order to assess the crush behavior, impact load and the deformation of the specimen. By installing the solid masses to the sidewall of the specimen, initial bending occurred to the specimen due to inertia force which produced by great velocity change during shock impact. In order to get the best design, there were two cases was tested. The first one was circular tube without solid mass and second was circular tube with solid mass. In the second case, the rectangular solid mass was attached to the aluminum alloy circular tube. The case where solid mass was installed shown that the deformation started to occur at the portion where the solid mass was installed. It clearly shown that the deformation can be controlled by using solid mass. Furthermore, lower value of impact load was obtained compared to the case without solid mass.

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ABSTRAK

Kajian ini telah dijalankan melibatkan penyerapan kejutan sistem pada stuktur penguatan. Kaedah dinamik elemen hingga jelas di jalankan keatas tiub bulat. Ujian dinamik di adakan pada kelajuan 5.0 m/s, 7.7 m/s dan 10 m/s dengan berat impak sebanyak 60 kg untuk menilai sifat-sifat hancuran, beban impak dan juga perubahan bentuk pada specimen tersebut. Dengan memasang solid mass di sisi spesimen tersebut, pembengkokan awal akan berlaku pada spesimen disebabkan oleh daya inersia yang berlaku yang di hasilkan oleh perubahan halaju semasa kejutan impak. Dua model telah direka untuk dinilai bagi mendapatkan rekaan yang terbaik. Rekaan yang pertama adalah tiub bulat tanpa 'solid mass'. Dan rekaan yang kedua adalah tiub bulat dengan 'solid mass'. Untuk kes yang kedua, segiempat 'solid mass' di pasang pada dinding tiub bulat aluminium. Kes di mana 'solid mass' di pasangkan telah menunjukkan perubahan berlaku bermula pada bahagian di mana 'solid mass' itu di pasang. Ini jelas sekali menunjukkan perubahan bentuk boleh dikawal dengan memasang solid mass pada tiub stuktur tersebut. Selanjutnya, nilai beban impak yang diperolehi adalah lebih rendah berbanding kes tanpa solid mass.

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CONTENT

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LIST OF TABLE

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LIST OF FIGURE

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NO	TITLE	PAGE

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LIST OF SYMBOL

F	=	Force
E	=	Energy absorbed
σ_C	=	Crush strength
A	=	Cross-sectional area of cylindrical structure
S_T	=	Compressive stroke
ρ	=	Density
w	=	Width
h	=	Height
l	=	Length
Q	=	Force acting
σ_o	=	Initial yield stress
U.T.S	=	Ultimate tensile strength
E	=	Total elongation
v	=	Velocity

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LIST OF APPENDICE

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In recent year, many researches had carried out involving shock absorbing system on strengthening structure. Therefore, irregular structure designed to prevent of buckling and to structure deformation stability. There is also has some research involving the deformation control by adding the notch at hollow cylinder. But, all this research need some change in stiffness of strengthen structure and fabrication process.

In this research, focus given on inertia force resultant during collision. By manipulating the inertia force, particular section (desired point) in hollow cylinder, it point used as origin to buckling distortion. As trial analysis, solid mass installed in particular point or section of hollow cylinder. Acceleration occurs during collision because of occurrence of bending deformation on the cylinder's wall and this point will be the origin of the deformation.

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The objectives of this research are to control the deformation during collision by using Aluminum Alloy. Aluminum alloy have good physical and mechanical properties which is light in weight and high value of recyclable. For the first step, Computer Aided Engineering (CAE) is used to test an applicability method.

In the traditional designing approach, engineers construct physical prototypes which have many major drawbacks, typically expensive to build and modify, repeatability can be difficult and dramatic changes can be harder to conceive. Today's, Computer prototyping or simulation-based design has became an important supplement to the design process due to needs to reduce cost, and time.

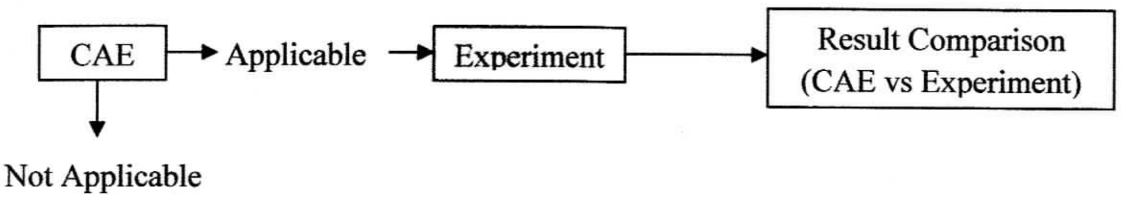

Figure 1.1: Flow of the research

As shown in Fig.1.1, this research is still on early stage i.e to check the applicability of the model. To analyze whether this research are applicable or not applicable to applied as an energy absorbing device in the front structure of a vehicle body. This research begin analyze in CAE following by experiment if the analyze result is applicable. After that, the result of the CAE and experiment result will compared.

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1.2 PROBLEM STATEMENT

Nowadays, many industrial product around us and most of them used counter measure against shock impact ie. safety evaluation is very important to be considered in designing car. Other than that, there have other factor in designing car which are high demand to lighter weight bodies of car, safety factor and reduce raw material used to produce car must to be considered. As the former represent only the own car safety, but now they also considered another car.

To reduce the risk of impact acceleration from affecting passenger's body during accident, space frame is fabricated to perform plastic deformation. This deformation is continuous bulking distortion which one of the plastic unstability phenomenon. Deformations at the strengthening structure during collision absorb the impact energy and as a result, safe the passengers.

In term of energy and environment problem, Kyoto declaration declares that reducing of CO_2 in industrial sector, public area and transportation. In Malaysia, transportation sector producing high CO_2 and mostly comes from cars. So, it is very important to reduce of producing CO_2 from the car by designing lighter bodies of car.

Two important factor that have to be considered in the car designing are lighter body of car and recyclable. The suitable material for requirement of the two factors is aluminum alloy that have good in mechanical and physical properties that gives light weight and also can be 100 % recyclable without any loss of its natural qualities.

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1.3 OBJECTIVE

The objectives of this Projek Sarjana Muda project are to describe study on shock absorbing properties of circular tube. The project aim to:

- To design shock-absorbing structure.
- To study/analyze the effect of shock energy to the designed structure
- To control the deformation of designed structure when the shock load applied

1.4 SCOPE

- Design the best structure via FEM (checked whether the deformation can be enrolled or not)
- Analyze the effect of shock energy to the structure

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CHAPTER 2

LITERATURE REVIEW

2.1 Energy Absorber

An energy absorber is a system that converts, totally or partially, kinetic energy into another form of energy. Energy converted is either reversible, like pressure energy in compressible fluids and elastic strain energy in solids, or irreversible, like plastic deformation energy. Energy dissipated in plastic deformation of metallic energy absorbers is the absorbing system. A.A.A. Alghamdi (2001)

When designing a collapsible energy absorber, one aims at absorbing the majority of the kinetic energy of impact within the device itself in an irreversible manner, thus ensuring that human injuries and equipment damages are minimal. The conversion of the kinetic energy into plastic deformation depends, among other factors, on the magnitude and method of application of loads, transmission rates, deformation or displacement patterns and material properties. A.A.A. Alghamdi (2001)

The components of deformable energy absorbers include such items as steel drums, circular tubes, tubular rings, square tubes , corrugated tubes, multicorner columns, frusta, struts, honeycomb cells, sandwich plate and some other special shapes such as stepped circular thin-walled tubes and top-hat thin-walled sections.

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These elements were used when filled with liquids, foam, wood shavings and sand. A.A.A. Alghamdi (2001)

These elements can be arranged in a variety of geometries. Some of the most well-known arrangements include, axial crushing of tubes, lateral crushing of tubes, tube inversion, tube nosing and tube splitting. Many researchers investigated the crushability and absorption rate of some classical materials. These include wood and concrete. A.A.A. Alghamdi (2001)

Johnson and Reid in two review papers identified the dominant modes of deformation of simple structural elements. Reid (1985) reviewed the progress in metallic energy absorbers from 1978 to 1985. Later on, Jones published a literature overview article on the dynamic plastic behavior of structures in which he cited 194 references, the majority of which were published after 1978. Reid (1993) reviewed plastic deformation of axially compressed energy absorbers.

Each energy absorber system has its own characteristics and special features which one needs to be familiar with in order to be able to understand how metallic structures respond to impulsive loads. Because of the extreme complexities of collapse mechanisms, some of these performance characteristics were determined only through experimental procedures. Consequently, the resulting empirical relations are confined to limited applications. A.A.A. Alghamdi (2001)

The study of deformation in energy absorbers accounts for geometrical changes, and interaction between various modes of deformation such as the concertina (axis symmetric) mode of collapse and the diamond (non-axis symmetric) mode of collapse, for axially loaded tubes, as well as strain hardening and strain rate effects.

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2.2 Design on energy absorbing

The optimization problem takes into account that have many design variables describing to be used as an energy absorbing device in front of a vehicle body.

2.2.1 Tapered tubular steel

The behaviour of a tapered tubular structure has been analysed. The component analysed is made of DC06 (ex FeP06) steel with nominal yield strength σ_y = 180MPa, nominal ultimate tensile strength σ_u = 270 - 350MPa and nominal elongation A = 38% (EN 10130). The component has a circular cross section throughout the whole length and it is partly cylindrical and partly tapered. The total length has been fixed as L = 400 mm, while the main cylindrical diameter has been fixed as d_{max} = 80 mm. The thickness of the metal sheet t = 1.2 mm. Avalle and Chiandussi (2004)

The optimization process has been carried out by changing the length l of the tapered end and its smaller diameter d_{min}. The load uniformity parameter LU has been considered as objective function. The numerical model of the component is made of 8256 nodes and 8192 four node Belytschko-Tsay shell elements. The material has been modeled as a bilinear isotropic hardening material with a Young modulus E = 210GPa, a yield strength σ_y = 211MPa and a hardening plastic modulus E = 750MPa. Strain rate has been taken into account by using a Cowper-Symond constitutive law with D = 100 and q = 4. Hardening and strain-rate parameters come from experimental tests performed in the laboratory of the Department of Mechanical Engineering of the Politecnico di Torino. The crush behaviour was studied by simulating the impact of a rigid barrier with a mass m = 500 kg, roughly equivalent to half the mass of an average european car, travelling at a speed v = 13.9m/s (50 km/h). Avalle and Chiandussi (2004)

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The search for the optimal solution has been performed by the launch of several optimization processes starting from different initial values of the design variables (geometrical configurations) inside the domain of admissibility. The identification of different optimal solutions demonstrated that the objective function analyzed is highly non-linear with respect to the design variables. Avalle and Chiandussi (2004)

The optimization processes allowed for the identification of two promising local optima that have been analysed in detail. Figure 2.2 shows the behaviour of the objective function and of the design variables during the optimization process that led to the identification of the first local optimum (solution A). The initial tapered extremity length and minimum diameter have been set up to l = 150mm and d_{min} = 50 mm, respectively. The identified optimal solution is characterized by a tapered extremity length l = 132mm and by a minimum diameter d_{min} = 42.8 mm. The optimization process required 14 iterations to converge. The progressive collapse of the optimal structural configuration of the tapered thin-walled tubular structure is shown in figure 2.1 at four different time steps, the crushing force is a function of the tube shortening reported in figure 2.2. The load uniformity parameter of solution A reaches a value of about LU = 1.66. The maximum and mean crushing forces for this optimal configuration are F_{max} = 35.7 kN and F_{avg} = 21.5 kN, respectively. Avalle and Chiandussi (2004)

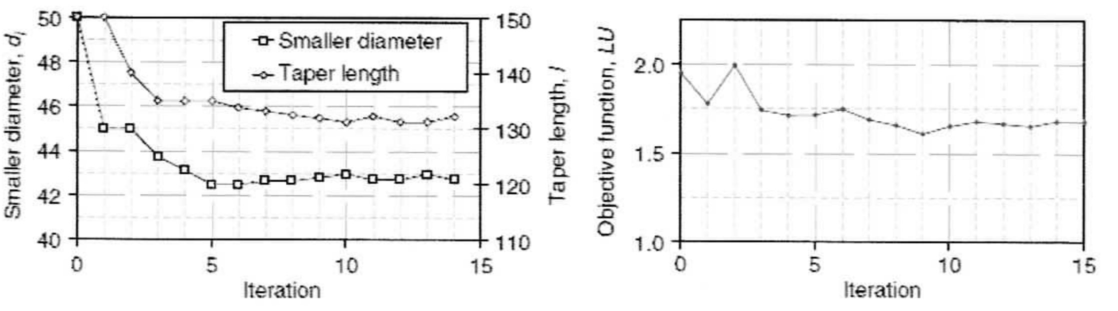

Figure 2.1: Design variable (left) and objective function (right) behaviour during the optimisation process for optimal configuration A.

(Source:Avalle (2004))

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