AN EXPERIMENTAL INVESTIGATION OF MULTI-RING UNDER QUASI-STATIC AND DYNAMIC LOADING

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DECLARATION

I declare that this project report entitled “An experimental investigation of multi-ring under quasi-static loading and dynamic loading” is the result of my own work except as cited in the references

Signature : ……………………………….

Name : ……………………………….

Date : …………………………….....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

Signature :. ....

Name of Supervisor : ....

Date : ....

DEDICATION

To my beloved mother and father

ABSTRACT

Energy absorbers play an important role in reducing the amount of impact subjected to structure to ensure the safety of the human in that structure. Rings are good energy absorbers since it is low in cost and addition of internal rings make it a better energy absorber when subjected to lateral loading. Two types of experiment were conducted which were the tensile test and compression test. Tensile test was conducted to determine the mechanical properties of the mild steel and compression test consisting of quasi-static loading and dynamic loading was conducted onto the ring to determine the energy absorbing capacity. Comparisons were made experimentally between multi ring and single ring under quasi-static loading and dynamic loading and motion recording were done using a camera for the respective experiments. A mild steel multi-ring consisting of four internal rings were fabricated in this project. The energy absorbing capacity was obtained from the area under the graph until the plateau zone. It was proven that multi-ring has a better energy absorbing capacity than single ring when it was quasi-statically loaded and dynamically loaded since there is an addition of constraints.

ABSTRAK

Penyerap tenaga memainkan peranan yang amat penting dalam mengurangkan kesan impak yang dikenakan pada sesuatu struktur untuk memastikan keselamatan manusia di dalam struktur tersebut. Cincin adalah penyerap tenaga yang baik kerana ianya murah dan penambahan cincin secara dalaman dapat meningkatkan kapasiti penyerapan tenaga. Dua jenis eksperimen telah dijalankan iaitu ujian regangan dan mampatan. Ujian regangan telah dijalankan untuk mengetahui ciri-ciri mekanikal bahan yang digunakan dan ujian mampatan dijalankan untuk mengetahui kapasiti penyerapan tenaga cincin. Perbandingan telah dibuat secara eksperimen antara cincin tunggal dan cincin berbilang dimana beban kuasi-statik dan beban dinamik telah dikenakan dan pergerakan impak telah direkodkan menggunakan kamera untuk setiap eksperimen. Cincin berbilang tersebut mempunyai empat cincin dalaman yang diperbuat daripada keluli lembut. Kapasiti penyerapan tenaga telah diperoleh daripada keluasan graf sehingga zon plateau. Ianya telah terbukti bahawa cincin berbilang mempunyai kapasiti penyerapan tenaga yang lebih tinggi daripada cincin tunggal apabila dikenakan beban kuasi-statik dan beban dinamik.

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RSM	Response surface method
SEA	specific energy absorption
CFE	crushing force efficiency
MIG	Metal inert gas

LIST OF SYMBOL

E	=	Modulus of elasticity/Energy absorbed
σ	=	Engineering stress
ε	=	Engineering strain
G	=	Modulus of rigidity
F	=	Force/Force indentation stroke
L	=	Initial length
A	=	Area
Δx	=	Transverse displacement
$\dot{\varepsilon}$	=	Strain rate
$\dot{\sigma}$	=	Stress rate
P	=	Flattening force
δ	=	Deflection
P_k	=	Peak crushing force
P_m	=	Mean crushing force
σ_v	=	Standard quasi-static tensile characteristic of a given material

M_0 = Moment per unit length

σ_{od} = Dynamic yield stress

σ_o = Static yield stress

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Energy absorbers has been given much of an attention to researchers around the world because of its ability to protect the occupant or reducing the injury of the occupant placed in a particular structure. Studies regarding crashworthiness have great attention to the behavior of thin-walled structures, which is used as energy absorbers in fields such as aeronautical and automobile (Li et al., 2013). In order to further understand the energy absorption of a structure, understanding of materials engineering, structural mechanics, impact mechanics, and theory of plasticity is important. Usually thin-walled tubes of different geometry and materials are used to absorb kinetic energy through plastic material deformation. There are many ways of destroying thin-walled tubes in order to analyze the energy absorbed such as lateral compression, lateral indentation, axial crushing, tube inversion and tube splitting. (Baroutaji et al., 2016). Axially loaded structures have drawn attention to many researchers since axial crushing has high energy absorbing capacity. However, its disadvantage is that it has very large fluctuations of the collapse load about a mean load and unstable deformation mode. This project focuses on the effects of lateral loading on short circular tube. Energy absorbing capacity of laterally loaded structures are higher compared to laterally indented structures because bending collapse mode generated from lateral loading results in a smooth force-deflection response. Besides, it does not undergo any unstable deformation mode (Baroutaji et al., 2015). A research study has found out that circular tube structures under lateral quasi-static loading using response surface method (RSM) and showed that specific energy could be increased by increasing the thickness and reducing the diameter of the tubes (AlaviNia and Chahardoli, 2016). On the other hand, a study conducted shows that an elliptical ring has greater energy absorbing capacity compared to circular ring because of its higher displacement stroke (Morris et al., 2007). The effects multi-ring structure subjected to laterally quasi-static loading and laterally dynamic loading will be studied throughout this project.

1.2 PROBLEM STATEMENT

Energy absorption plays a vital role in engineering structures and fields such as in the automobile and aeronautical industries. These impact energy absorption devices are highly responsible in ensuring the safety and life of human beings. Besides, impact energy absorption devices are used to avoid high impact loads on commercial goods packages. In the current world, it is important for a designer to design an impact energy absorbing device which could limit loads and deceleration on the structure and occupants. Circular rings are used as thin-walled energy absorbers since it is low in cost compared to solid tubular energy absorbers and is widely used in crash barriers. Multi-circular rings increases the energy absorption capacity when impact is exerted on a structure compared to a single ring.