ENERGY ABSORPTION OF TRIANGULAR RINGS SUBJECT TO TRANSVERSE LOADING

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"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechanical Engineering
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"I hereby declared this report is mine except summary and each quotation that I have mentioned the resources"

Signature : ……

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Date :

To my beloved father and mother

ACKNOWLEDGEMENT

Alhamdullilah, thanks giving to ALLAH S.W.T., eventually, my PSM report is successfully completed. I would like to take this opportunity to thank my PSM supervisor, Prof. Dr. Mohd Radzai Said for his kindly guidance and advices to complete this PSM report successfully.

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Thanks.

ABSTRACT

This report is focused on study the energy absorption on the triangular ring subjected to transverse loading. It is also concerned to the application of the energy absorption device in daily life. Commonly the energy absorption device was used in vehicle where the collision always occurs. There are several types of vehicle was used energy absorption device such as in car, train, submarine and also the helicopter. This device was used to reduce the impact load and it converted the kinetic energy into elastic energy (solids), pressure energy (fluid) and plastic and elastic energy (deformable solids). Besides, the selection of the material is important, so the hardness testing experiment is used to define the mechanical properties on the specimen. The approximation value of the ultimate stress is taken because to define the ultimate stress accurately, tensile testing must be used. The specimen has to be shaped by using bending machine and welding process. The technical drawing is draw by using the Solid Work software to make the works easier. Besides, the compression test was conducted to obtained value of energy absorption. On the other hand, the analysis was prepared using ABAQUS software. Furthermore, the load-displacement trend in experiment and computer simulation is compared.

ABSTRAK

Penyelidikan ini bertumpu pada kajian pada penyerapan tenaga pada gegelung segitiga bergantung kepada beban melintang. Ia turut berkaitan mengenai aplikasi penggunaan alat peyerapan tenaga dalam kehidupan seharian. Umumnya, alat penyerapan tenaga ini digunakan di dalam pengangkutan di mana perlanggaran sering berlaku. Terdapat beberapa jenis pengangkutan yang menggunakan alat penyerapan tenaga seperti kereta, keretapi, kapal dan helikopter. Alat ini digunakan untuk mengurangkan beban hentaman dan menukarkan tenaga tersebut, iaitu tenaga kinetik kepada tenaga keanjalan (pepejal), tenaga tekanan (cecair) dan kepada tenaga plastik dan keanjalan (pepejal berbentuk). Selain itu, pemilihan bahan adalah penting, maka eksperimen ujian kekerasan dilaksanakan untuk mendapatkan sifat-sifat mekanik pada spesimen. Nilai anggaran untuk daya akhir digunakan kerana untuk mendapatkan nilai akhir yang baik, ujian ketegangan perlu dilakukan. Bahan spesimen perlu dibentuk menjadi segitiga dengan bantuan mesin pembentuk dan proses kimpalan. Lukisan kejuruteraan dilukis menggunakan perisian *Solid Work* untuk memudahkan kerja. Selain itu, ujian mampatan dilaksanakan untuk mendapat nilai tenaga serapan. Selain itu, analisis dilakukan menggunakan perisian ABAQUS. Tambahan lagi, arah perubahan beban di dalam eksperimen dan simulasi komputer dibandingkan.

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LIST OF ABBREVIATIONS AND SYMBOLS

HR	= Rockwell hardness number
BHN	= Brinell hardness number
D	= diameter of the spherical indenter impression in mm
D_i	= diameter of the resulting indenter impression in mm
HV	= Vickers Pyramid Number
F	= Load in kgf
d	= arithmetic mean of the two diagonals
λ	= slenderness ratio
ρ	= density
σ_m	= crush stress
P_{max}	= initial peak load
P_m	= average crush load
E_s	= specify energy absorption
W	= total energy absorbed
σ_{ult}	= Ultimate stress
σ	= stress
E	= Modulus of elasticity
σ_{yield}	= Yield stress
δ	= displacement

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CHAPTER 1

INTRODUCTION

1.1 Overview

The serious or fatal traffic accidents are considered as one of the most threatening dangers in daily life. It is an unexpected event that can change people's life radically. Although a safe driving style minimizes accident risk, car occupants are also exposed to unexpected road conditions and risky or druken drive bahaviour of other road users. Especially, frontal accidents on country roads against other cars have a high fatality rate. Due to efforts to avoid frontal collisions, the car front is generally only partly involved and not always axially. In addition, the incompatibility between different vehicles yields more fatalities. These collision situations are now not legally tested. Only a few car manufactures are using such collision situations as safety design goal for longer time.

Due to this, it is much important to given the structures which are light weight and has the highest energy absorption capability not only in automobile but also in submarine and aerospace industries. There are a lot of number of researcher that interested in studying the thin-walled structures such as shell, tubes and stiffeners. All this structures have been identified as a very effficient impact energy absorbing sytem and known as energy absorber.

In this research, transverse loading with compression test were conducted on triangular ring. The material were used in this research is mild steel. Mild steel was choosen because of it is a low carbon steel where it has low tensile strength but cheap and malleable. The results of the experiments will compared with ABAQUS which to make the comparison between experimentally and theoretically.

1.2 Objective

The main objective of this paper is to study load-displacement curves with respect to energy absorption and the densification load on single ring which is in triangular ring shapes. In addition, is to conduct a hardness testing experiment for determining the ultimate stress of the specimen.

1.3 Problem Statement

Recent days, there are many shapes of energy absorbing device such as circular tube and rectangular tube. However, for this research, the energy absorption is identified on triangular ring. From the previous research, there is less research on the triangular ring as energy absorbing device. Therefore, in this research the potential for this shape to absorb the energy during the collision was identified.

1.4 Scopes

In this research, it was based on energy absorption approaches. There is experiments which is Rockwell Hardness testing will be used in this research. This experiment is performed to determine the mechanical properties. The mild steel was shaped into triangle with welding and bending machine. The proposal for PSM can be referring in Appendix D. In PSM II, further experimental work was being performed to obtain the energy absorption. The simulation that was done on

ABAQUS is only running for certain time. It is because of the time limited for the simulation.

1.5 Chapter Outline

Chapter 2 includes several of literature reviews that give explanation on application of the energy absorption devices. In addition, there are also including the information that involved along the experiment was done.

Chapter 3 discusses on the methodology for this project regarding the experiment that have been conducted. The preparation for the specimen and the other procedure that have been involved was being explained here. On the other hand, the flow chart on the activity has being included.

Chapter 4 discusses on the preparation using the ABAQUS software. The explainantion on every task will be covered on this chapter. Besides, the brief on comparison between experimentaly and result on ABAQUS simulation also will be discussed.

Chapter 5 discusses the results and analysis for the data obtained. The results were produced from the estimation and validation technique using Sigma Plot 10.0 software. On the other hand, the comparison result between experimental and analytical also has being included.

Chapter 6 discusses the conclusion that can be made from the results obtained and recommendation for the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, literature review has been done to explore the previous research related to energy absorption. There are several collisions that always occur, such as in submarine, automobile and aerospace. In ship collision, there are various researches from previous about the energy absorption. The obvious critical parts on ship are tanker area and hull of ship.

On the vehicle crashes there are some phenomena where the collision always occurs. Energy absorption was applied to the vehicle to reduce the vehicle collision. In addition, from the previous paper, the researcher was making some analysis to find the solution to decrease the phenomena.

Besides, the hardness testing also has been reviewed for the testing activity. It is important to identify the material properties.

On the other hand, the literature review has been continued to discover the previous research which related to the experiment that was done. There are several experiment had been done from the previous research regarding to energy absorption.

2.2 Energy conservation during a tanker collision

Tanker vessels are encountered amongst those carriers of high design standards, due to the nature of the cargo handled. Several historical hazardous events have revealed that action is needed to prevent incidents with high risk factors and subsequent consequences to the environment. As the time goes by, classification societies modify current rules with the objective of introducing more reliable designs. However, the issue of energy dissipation on the structural members during collision is still an enigma due to its complex nature and the numerous factors involved [1].

This paper attempts to demonstrate the energy dissipation during a “head-on” collision of a tanker vessel with a rigid surface. It actually broadens the problem of a ship to ship collision to an issue where one of the two members under collision to an issue where one of the two members under collision is rigid, non-deformable [1].
The factors controlling the modeling are the following:

1) The initial velocity of the vessel.
2) The angle of impact.
3) The added mass of the ship.
4) The properties of the material used.
5) The distribution of the lumped masses along the collision bulkhead.

2.3 Train-to-train Impact Test of Crash Energy Management Passenger Rail Equipment

The purpose of this paper is to establish the degree of enhanced performance of different design strategies for passenger rail crashworthiness. The researcher, which is Federal Railroad Administration (FRA), was conducting the test where it has been the development of structural crashworthiness and interior occupant protection strategies. There are three types of model has been tested, which is each

test have been conducted for six tests. This tested is incorporating with Crash Energy Management (CEM) features [2].

The entire test tested for each equipment type was including:

1. single car impact into a fixed barrier
2. two coupled car impact into a fixed barrier
3. cab car-led train collision with standing conventional locomotive-led train

The results from the single and two car full scale impact tests show that the CEM design has superior crashworthiness performance over the conventional equipment. In train-to-train test existing equipment at a closing speed of 48.29km/h, the colliding cab car crushed by approximately 6.71m. No crush was imparted to any of the trailing equipment. During the train-to-train test of CEM equipment at a closing speed of 49.89km/h, the front of the cab car crushed by approximately 0.91m and the crush propagated back to all of the unoccupied ends of the trailing passenger cars. The controlled deformation of the cab prevented override [2]. Figure 2.1 shows the frames from train-to-train test movies of conventional and CEM equipment.

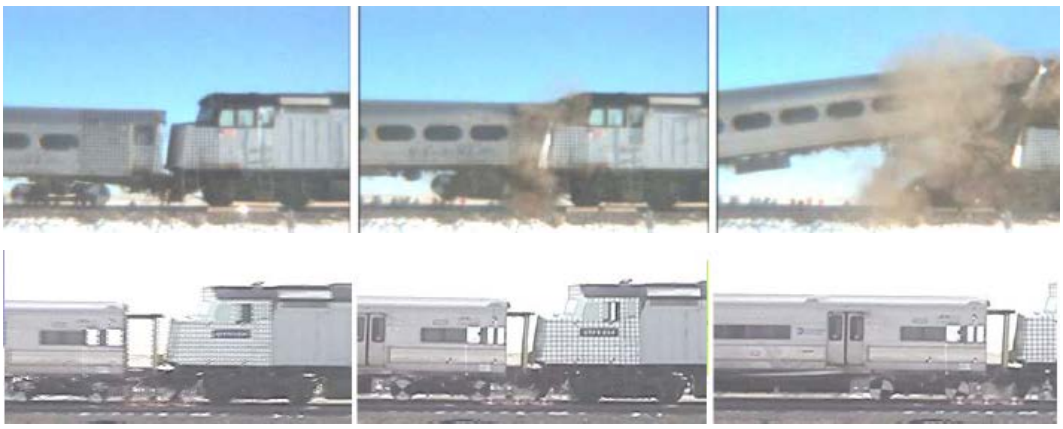

Figure 2.1: Frames from Train-to-Train Test Movies of Conventional and CEM Equipment [2].

Basically, in test that has been conducted, a moving car-led train impacted a standing locomotive-led train. The locomotive-led train included two hopper cars, ballasted such that both trains weigh nearly the same. Besides, the cab car-led train includes four coach cars and trailing locomotive. The impact occurred on tangent track, with the cab car-led train initially travelling at 49.56km/h [2].

CEM end structures were installed at each end of each passenger car. The cab car crush zone includes four key elements:

1. A deformable anti-climber arrangement
2. A push-back coupler mechanism
3. An integrated end frame, which incorporates an operator compartment
4. Roof and primary energy absorbing element.

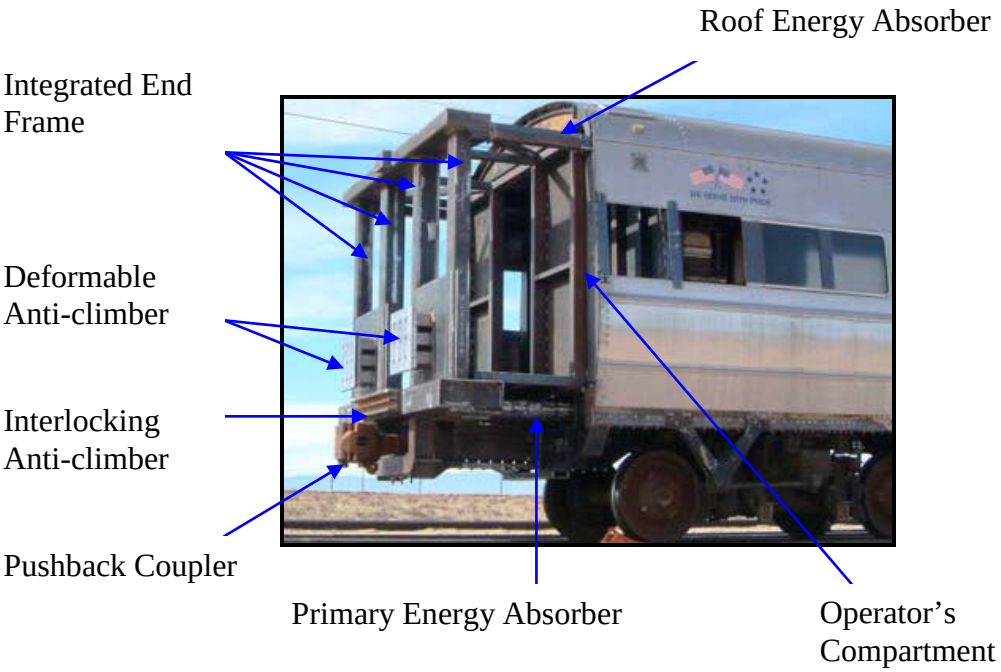

Figure 2.2: Cab Car Crush Zone [2].

A similar design was developed for non-cab end crush zones. The non-cab end design does not include the deformable anti-climber or incorporate the operator's

compartment [3]. Figure 2.2 shows the cab car crush zone meanwhile Table 2.1 shows the summary of in-line test result.

Table 2.1: Summary of In-line Test Result [2].

Test Description	Critical Measurement	Results	
		Conventional Equipment	CEM Equipment
Single-car Test	Occupant volume Force-crush characteristic Mode of deformation	Loss Decreasing Ramp	Preserved Increasing Controlled
Two-car Test	Occupant volume Interaction of coupled cars Distribution of crush	Loss Sawtooth buckled Focused on impact car	Preserved Remained in-line Distributed
Train-to-train Test	Occupant volume Colliding equipment interaction Distribution of crush	Loss Override Focused on impact car	Preserved Engagement Distributed

2.4 Intelligent 3D Deformation Modeling in Vehicle System Dynamics

Crash analysis is very helpful for experts of road vehicle accidents where since their work requires simulations and data. The simulations can do more precise and contribute towards the determination of the factors causing the accident. The results of the analysis of crashed cars which is the energy absorbed by deformed car-body is one of the most important. The information about the deformation process is