PHYSICAL PROPERTIES AND ENERGY ABSORPTION OF EPOXIDIZED NATURAL RUBBER/RECLAIMED RUBBER FOAM

AMIRUL HAKIMI BIN MOHD ZAIN

B051010064

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

PHYSICAL PROPERTIES AND ENERGY ABSORPTION OF EPOXIDIZED NATURAL RUBBER/RECLAIMED RUBBER (ENR/RR) FOAM

This report is submitted with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Hons.)

by

AMIRUL HAKIMI BIN MOHD ZAIN

B051010064

880504-11-5425

FACULTY OF MANUFACTURING ENGINEERING

2014

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **PHYSICAL PROERTIES AND ENERGY ABSORPTION OF EPOXIDIZED NARUTAL RUBBER/RECLAIMED RUBBER (ENR/RR) FOAM**

SESI PENGAJIAN: **2013/14 Semester2**

Saya **AMIRUL HAKIMI BIN MOHD ZIAN**

mengaku membenarkanLaporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

_______________________ _______________________

AlamatTetap:

1348 PJALAN KENANGA

BATU BUROK, 20400 KUALA TERENGGANU

TERENGGANU DARUL IMAN

Cop Rasmi:

DECLARATION

I hereby, declared this report entitled 'physical properties and energy absorption in ENR/RR pore' is the results of my own research except as cited in references.

Signature	:	………………………………
Author's Name	:	Amirul Hakimi Bin Mohd Zain
Date	:	23th JUNE 2014

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment to the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Materials) (Hons.). The member of the supervisory is as follow:

……………………………………..

(Dr Noraiham Binti Mohamad)

ABSTRAK

Objektif untuk kajian ini adalah untuk menentukan kesan jenis busa terhasil terhadap tenaga serapan. Bahan yang telah dipilih untuk kajian ini ENR/RR, dan nisbah untuk setiap sampel telah ditetapkan untuk menghasilkan busa yang berlainan. Untuk proses yang pertama, ENR/RR akan dimasukkan kedalam mesin pencampuran dalaman bagi mengisar bahan tersebut sehingga sebati. Selepas itu, bahan yang telah siap diadun akan dikisar menjadi hancur. Tujuan adalah untuk dimasukan kedalam proses mampatan.Ini adalah untuk menghasikan bahan dalam bentuk lapisanuntuk dijadikan sampel. Proses seterusnya, adalah proses penghasilan busa didalam sampel. Setiap proses yang dialankan mempunyai parameter yang tersendiri mengikut keadaan bahan yang digunakan. Sampel yang telah siap diproses akan dijalani eksperimen untuk melihat daya serapan yang dapat dihasilkan. Eksperimen yang dijalankan berdasar tajuk ini adalah eksperimen jatuhkan bola. Tujuan eksperimen ini adalah untuk megkaji daya serapan tenaga yang boleh diserapkan oleh sampel. eksperimen jatuhkan bola ini dijalankan 3 kali bagi mendapatkan bacaan purata dan mengelakkan berlaku ralat. Manakala saiz busa didalam sampel pula telah ditentukan oleh mikroskop optik. Dengan mikroskop optik, busa apat dilihat dengan lebih jelas dan setiap gambaran telah direkod untuk dianalisiskan. Saiz busa yang terhasil berbeza dalam setiap sampel dan tenanga serapan juga menunjukkan perbezaan. Ini menunjukkan saiz busa yang optimum menghasilkan kadar serapan tenaga yang tinggi.

ABSTRACT

The objective of this study is to determine the effect of pore type on energy absorption. The material used for this study is the blend of ENR and RR. The ratio is varied in order to produce different types of pore. Initially, ENR and RR are inserted into the internal mixing for compounding. The blend is crushed into small aggregates before hot compressed using hot press to form ENR/RR sheet. Then, foaming process is performed on the ENR/RR blend. Sample were perform under experiments in which, the experiment were conducted for this study is the ball drop test. The purpose of this experiment was to observe the effects of pore against energy absorption. With this test, it was observed that the pore reduce the impact. Each of these samples was conducted 3 times and done in accordance with the parameters of the resulting ratio. To get the size of the pore in the sample, an optical microscope was used and the pore can be clearly seen. The results of each experiment and were recorded in the optical microscope and draw conclusions about the study. The size of pore that produces shows different in every sample. Pore that have optimum size also produce more pore unit in volume show the energy absorption high compare to the other sample.

DEDICATION

This report is dedicated to my parents (En Mohd Zain bin Shamsuddin and Puan Rohani binti Ismail).

ACKNOWLEDGEMENT

I would like to gratitude to Allah S.W.T for His generous blessing and undying strength bestowed upon me during the course of this research.

Firstly, I would like to extend my heartiest gratitude to Dr Noraiham Mohamad as my supervisor who had given me guidance and support me during the research. And not to be forgotten to other lecturers, my friends and other person whose name is not mentioned here.

Secondly, I want to thank my lovely mother and father because they support me to conduct this study. With prayers and moral support from both of them, I have gained strength to endure in this study. Thank you very much also to my mentor, Nor Nadiah binti Abdul Hamid for help. I also want thank to UTeM management especially from faculty of manufacturing because giving me opportunity to get more experiences and knowledge during the research.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

0	-	Degree
C	-	Celcius
CO_2	-	Carbon Dioxide
CS	-	Benzothiazyl-2-cyclohexyl-sulphenamide
EMI	-	Electromagnetic Interference
ENR	-	Epoxidized Natural Rubber
EPS	-	Expanded Polystyrene
EPDM	-	Ethylene Propylene Dience Monomer Rubber
HRSI	-	High-Temperature Reusable Surface Insulation
J	-	Joule (N.m)
MM	-	Milimeter
MPa	-	Mega Pascal
$NaHCO_3$	-	Sodium Bicarbonate
NR	-	Natural Rubber
PSI	-	Pressure
RR	-	Reclaimed Rubber
SEM	-	Scanning Electron Microscopy
SBR	-	Styrene Butadiene Rubber
TMTD	-	Tetramethylthiuram-disulfenamide
XSBR	-	Carboxylated Styrene-Butadiene Rubber

CHAPTER 1

INTRODUCTION

1.1 Background

In industrialized countries, rubber products are everywhere to be found, though few people recognize rubber in all of its applications. Since 1920, demand for rubber manufacturing has been largely dependent on the automobile industry, the biggest consumer of rubber products. Rubber forms a part of many mechanical devices in the kitchen, helps to exclude draughts and to insulate against noise. Sofas and chairs may be upholstered with foam rubber cushions, and beds may have natural rubber pillows and mattresses. Clothing and footwear may contain rubber for example elasticized threads in undergarments or shoe soles. Still other applications have been developed due to special properties of certain types of synthetic rubber, and there are now more than 100,000 types of articles in which rubber are used as a raw material (Pothen 2011).

The use of rubber in so many applications results in a growing volume of rubber waste. With the increase in demands, the manufacturing and use of rubber and the rubber products has increased tremendously both in the developed and less developed countries. By the middle of 1980s less than 1% of the worldwide polymer consumption was in the form of reclaim. At the beginning of 20th century half of the rubber consumed was in the form of reclaim. It is expected that in 21st century most of the scrap rubber will be recycled in the form of reclaim because of day to day increase in environmental awareness. One of the various problems which mankind faces as it enters into the 21st century is the problem of waste disposal management.

Although reclaim rubber is a product of discarded rubber articles it has gained much importance as additive in various rubber article formulations. It is true that mechanical properties like tensile strength, modulus, resilience and tear resistances are all reduced with the increasing amounts of reclaim rubber in fresh rubber formulation. But at the same time the reclaim rubber provides many advantages if incorporated in fresh rubber. The increase in the awareness of waste management and environment related issues has led to substantial progress in the utilization of rubber waste. Recycling materials back into its initial use often are more sustainable rather than finding new applications.

1.2 Problem statement

Since polymeric materials do not decompose easily, disposal of waste polymers is a serious environmental problem. Large amounts of rubbers are used as glove and tires for airplanes, trucks and car. Reclaimed rubber is the product resulting when waste vulcanized scrap rubber is treated to produce a plastic material which can be easily processed, compounded and vulcanized with or without the addition of either natural or synthetic rubbers. Reclaiming of the waste rubber can cost half than that of natural or synthetic rubber, some properties that are better than those of virgin rubber, requires less energy in the total production process than does virgin material and it is an excellent way to dispose of unwanted rubber products, which is often difficult.

Although reclaim rubber is a product of discarded rubber articles it has gained much importance as additive in various rubber article formulations. It is true that mechanical properties like tensile strength, modulus, resilience and tear resistances are all reduced with the increasing amounts of reclaim rubber in fresh rubber formulation. But at the same time the reclaim rubber provides many advantages if incorporated in fresh rubber. The increase in the awareness of waste management and environment related issues has led to substantial progress in the utilization of rubber waste. Recycling materials back into its initial use often are more sustainable rather than finding new applications.

Epoxidized natural rubber (ENR) is a versatile material due to its unique properties. It shows combination properties of natural rubber and durability of selected for its ability to be combined with other material with different mixture ratios. Furthermore, the research about ENR/RR blend still not wide this used and need more information will be required in this research. To understand concept of ENR blend, need a few sample of rubber blend that related with ENR blends. Pore that related with rubber is hard to understand because not much research about that can be found. All the research about ENR or RR must be related with pore in rubber, because in this topic we focusing in pore type as an energy absorption in pore under impact. There have many of pore type; it is because for the shock absorption application, it needs optimum size of pore to make it perfect absorption.

Energy absorption can also be applied in various fields. For example, they could be put to reduce the rate of injury in an accident such as in a car bumper, safety helmet, and others. Moreover, energy absorption can also be used by athletes in sports in which to reduce the shock foot in the shoe or insole. Sometimes, the human body also requires a cushion from damaging shockwave, especially during your strenuous activity. This means, we can apply to energy absorption in many applications.

1.3 Objective

The main objectives on this research are:

i. To prepare epoxidized natural rubber/reclaimed rubber blend though melt compounding using internal mixer.

ii. To introduce pores in epoxidized natural rubber/reclaimed rubber by adding blowing agent though two step of heat transfer.

iii. To correlate energy absorption with dimension pore epoxidized natural rubber/reclaimed rubber pore.

1.4 Scope

This research is to study the compounding pore in epoxidized natural rubber/reclaimed rubber by preparing different ratio of epoxidized natural rubber/reclaimed rubber blend though melt compounding using internal mechanical testing. Then, introduce compounding pore in epoxidized natural rubber/reclaimed rubber by adding blowing agent, though two steps of heat transfer. The prepared machines that were used internal mixer for blending all the material and additive together. For the secondary process is compounded moulding that used to compact the material to be a sample. This process involves heating and cold working. Some analysis, such as morphology was performed to support the data. This analysis is for to correlate absorption with ENR/RR ratio.

CHAPTER 2

LITERATURE REVIEW

2.1 Solid Foam

Solid foams form an important class of lightweight cellular engineering materials. These foams can be divided into two types based on their pore, open-cell-structured foams and closed cell foams. Solid foams are cellular materials, materials which are made up from a framework of solid material surrounding gas-filled voids (bubbles). Solid foams can be 100 times lighter than the equivalent solid material (Julia *et al.*, 2006). Figure 2.1 show the honeycomb that easily seen their cellular structure. This structure allow the minimization of the amount of used material to reach minimal weight and minimal material cost.

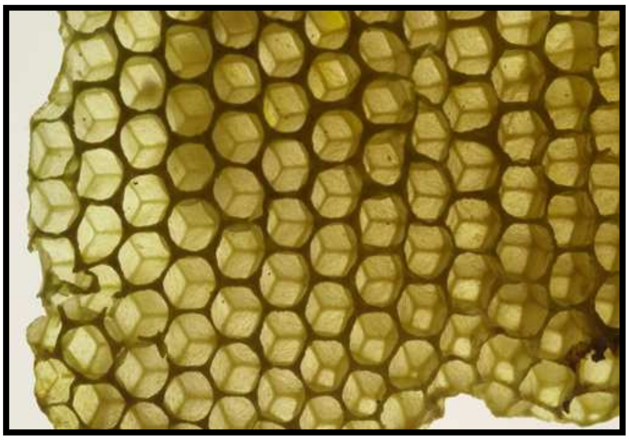

Figure 2.1: The bee's honeycomb is a two-dimensional cellular structure (Source: Waynesword)

Recent developments in metal foams, especially aluminium, have produced a new class of lightweight materials, which are excellent energy absorbers. This property is useful in reducing the impact of a car crash.

Figure 2.2 show an open cell structure of ceramic that have low density materials has developed to produce lightweight porous structures for aerospace and industrial applications. Open cell structured foams contain pores that are connected to each other and form an interconnected network that is relatively soft. Open cell foams will fill with whatever they are surrounded with. If filled with air, it will give good insulation, but, if the open cells filled with water, the insulation properties would be reduced. Foam rubber is a type of open-cell foam (Sivertsen, 2007).

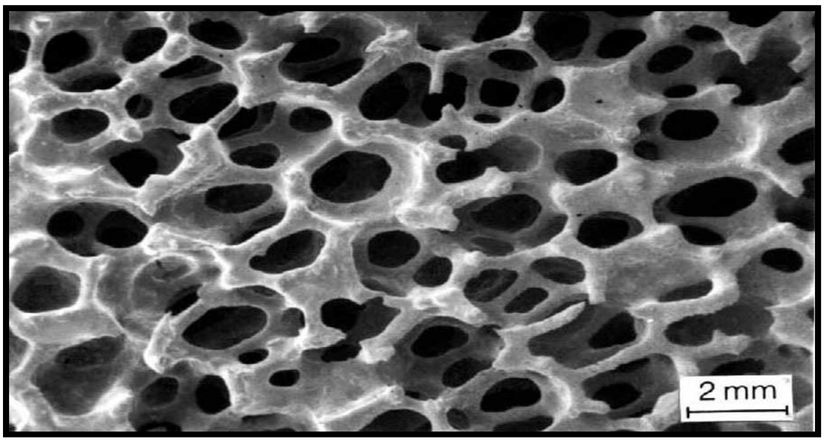

Figure 2.2: Open-cell Structure in Ceramic Foam (source: ultramet ceramic)

Closed-cell foams do not have interconnected pores. The closed-cell foams normally have higher compressive strength due to their structures. However, closed-cell foams are also in general denser, require more material, and as a consequence are more expensive to produce. The closed cells can be filled with a specialized gas to provide improved insulation. The closed-cell structure foams have higher dimensional stability, low moisture absorption coefficients, and higher strength compared to open-cell-structured foams. All types of foam are widely used as core material in sandwich-structured composite materials (Sivertsen, 2007).

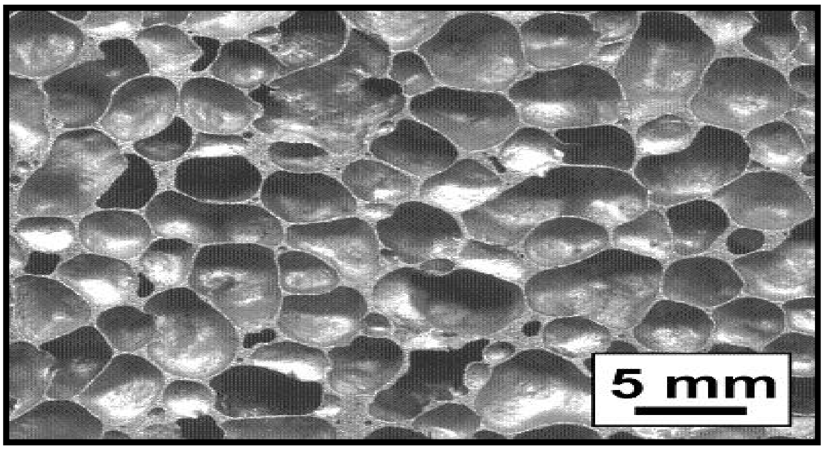

Figure2.3 : Example of Closed-Cell Structure in Alminium Foam (Source: invention high strength)

2.2.1 Classification Material of Solid Foam

Solid foam can be classified based on type of its basic material whether polymers, composites, steel, ceramic and so on.

Ceramic foams made from a wide range of ceramic materials, both oxide and nonoxide, are being considered for a whole range of potential applications. These include hot gas filters, interpenetrating composites and biomedical applications as well as thermal insulation, kiln furniture and catalyst supports amongst others. Three of these are described briefly below as well as a new processing route based on gel casting (Biastto, 2006). Ceramic materials with controlled porous microstructures can be produced using particle stabilised foams, freeze casting, sacrificial templates and partial sintering. The structure can be characterised with micro computed tomography as shown in Figure 2.4.

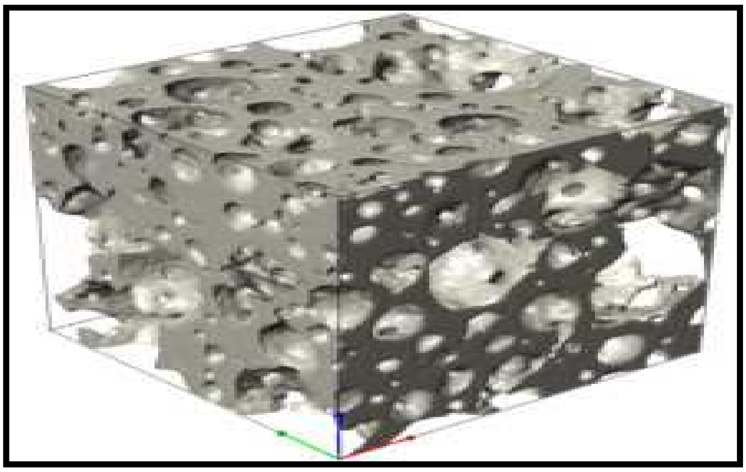

Figure2.4: Porous Ceramic (source: Ceramic Engineering)

There's a polymer that's soft (or in solution), and a lot of gas (usually not air) that's blown in to make a whole bunch of tiny little bubbles (foam). The big difference is that the polymer bubbles will stay. The gas that's blown in to make the foam is called a "blowing agent" or "foaming agent". The best kind of gas to use is one that will not react with anything, especially with the polymer, will be fire-resistant, and will be nontoxic. Nontoxic is important not only for the folks who make these foams, but for whoever buys them. The amount of gas or foaming agent, used controls the size and the number of the bubbles, known as "foam cells" after it hardens.

Figure2.5: A type of polymer foam (source: Polymer Application)