Faculty of Mechanical and Manufacturing Engineering Technology

DYNAMIC STUDY OF COAL ASH BASED CHLOROPRENE RUBBER FOR AUTOMOTIVE SEAL APPLICATIONS

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Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

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DYNAMIC STUDY OF COAL ASH BASED CHLOROPRENE RUBBER FOR AUTOMOTIVE SEAL APPLICATIONS

AHMAD AQLAN BIN MOHD ROSEDI

A thesis submitted
in fulfilment of the requirement for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DECLARATION

I hereby, declared this report entitled “Dynamic Study of Coal Ash Based Chloroprene Rubber for Automotive Seal Applications” is the result of my own research except as cited in the references.

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Date	:	.....

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours. The member of the supervisory is as follow:

Signature	:	……....
Supervisor Name	:	Hairul Effendy Bin Ab Maulod
Date	:	……....

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DEDICATIONS

To my lovely parents,

With love, sacrifice and their unconditional support throughout my life,

To my friends and family,

Who always willing to help to prepare and complete this report,

Also,

For those who always pray for my success

And last but not forgotten,

For project supervisor who has given guidance for me produce this report.

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ABSTRACT

Nowadays, there are many filler was used in the industrial sector to get the best mechanical properties on their product. But just a certain filler will give the best result on their performance. Coal ash had been choose due their availability, low cost, low density and recyclability. One way to reducing the production cost but still maintaining the properties of the composite is by using a filler such which is coal ash. This study is focusing on effect of fatigue properties for chloroprene rubber at different ash filler loading. In order to produce material compound, different composition had been studied to improve their physical and mechanical properties. The optimum compounding formulation of the fabricated compound will observed at the combination of chloroprene compound and coal ash based on 100 phr of the chloroprene rubber and different proportions coal ash at 5, 10, 20, 30 and 40 phr. Chloroprene rubber and coal ash were successfully develop by using an internal mixer and hot compressing method. The compound will be cut into a dumb-bell specimen according to ISO standards dimension. The compound will undergo a few testing to determine physical and mechanical testing. The fatigue test and shore hardness test will determine physical properties of the compound. The morphological study of the compound was done by using optical microscope and scanning electron microscope (SEM) on fracture surface of specimen. Overall, the different formulation will affected the fatigue behavior of the sample.

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ABSTRAK

Pada masa kini, terdapat banyak pengisi digunakan di dalam sektor perindustrian untuk mendapatkan bahan yang terbaik pada produk mereka. Tetapi hanya pengisi tertentu sahaja yang akan memberikan hasil terbaik pada prestasi mereka. Abu arang kayu telah dipilih kerana ketersediaan mereka, kos rendah, kepadatan rendah dan kitar semula. Di samping itu juga, terdapat satu cara untuk mengurangkan kos pengeluaran tetapi masih mengekalkan sifat komposit adalah dengan menggunakan pengisi seperti abu arang batu. Kajian ini memberi tumpuan kepada kesan sifat kelesuan untuk getah *chloroprene* pada pemuatan pengisi abu yang berbeza. Untuk menghasilkan sebatian bahan, komposisi yang berbeza telah dikaji untuk meningkatkan sifat fizikal dan mekanikalnya. Perumusan pengkomposan yang optimum dari gabungan fabrikasi akan dilihat pada gabungan kloroprena dan abu arang batu berdasarkan 100 *phr* getah *chloroprene* dan sebatian abu arang yang berbeza pada 5, 10, 20, 30 dan 40 *phr*. Getah *chloroprene* dan abu arang batu telah berjaya dibangunkan dengan menggunakan pengadun dalaman dan kaedah pemampat panas. Kompaun tersebut akan dipotong menjadi spesimen *dumbbell* mengikut dimensi *standard ISO*. Bahan ini akan menjalani beberapa ujian untuk menentukan ujian fizikal dan mekanikal. Ujian kelesuan dan ujian kekerasan akan menentukan sifat fizikal sebatian. Kajian morfologi bahan itu dilakukan dengan menggunakan mikroskop optik dan *scanning electron microscope (SEM)* pada permukaan yang patah pada spesimen. Secara keseluruhannya, perumusan yang berbeza akan mempengaruhi kelakuan keletihan sampel.

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LIST OF ABBREVIATIONS

CR	-	Chloroprene Rubber
CA	-	Coal Ash
PHR	-	Per-Hundred Rubber
SEM	-	Scanning Electron Microscope
UTM	-	Universal Tensile Machine
HDPE	-	High-Density Polyethylene
NBR	-	Nitrile Butadiene Rubber
MW	-	Marble Waste
ATH	-	Aluminium trihydroxide
ZnO	-	Zinc oxide
NaOH	-	Sodium hydroxide
MgO	-	Magnesium oxide
Si–OH	-	Silanol Group
SiO2	-	Silicon Dioxide
CaO	-	Calcium Oxide
wt%	-	Weight Percentage
Ca	-	Calcium
Mg	-	Magnesium
Na	-	Sodium
Fe	-	Iron
Ni	-	Nickel
Rh	-	Rhodium
K	-	Kelvin
FA	-	Fly Ash
mK	-	Millikelvin
MPa	-	MegaPascal

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CHAPTER 1

INTRODUCTION

This chapter will explain the overview of the project and the purpose of this project. The chapter includes the background of the study, problem statement, objectives that are expected to be achieved and the scope of the study that is going to be conducted.

1.1 Background of study

Nowadays the usage of rubber is very high demand in the industrial sector. The utilize of rubber in so numerous applications results in developing the volume of rubber items. Rubber is widely used in automotive industry because rubber is very durable and easily moulded into a difference shapes. The automotive industry is the biggest consumer of rubber product with approximately 80% of the total rubber production. There are two type of rubber (elastomer) that was regularly used in markets such as natural rubber and synthetic rubber. One of the foremost popular synthetic rubber utilized in industrial application these days are chloroprene rubber (CR).

Chloroprene rubber (CR) is one of the most common types of material used in industrial or automotive to use primarily for gaskets, cable jackets, tubing, seals, O-rings, tire-sidewalls, gasoline hoses and weather-resistant products such as wetsuits and orthopedic braces. In any case, it is additionally utilized as a base resin in cement, electrical insulations, and coatings. In addition, it was strongly shown that the chloroprene rubber is the most valuable material today for the industrial.

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Many research and testing (tensile) was investigated with the chloroprene rubber today to know its fatigue behaviour with a filler such as silica, cellulose, fly ash and so on. Tests have been carried out until either failure or stabilization of the surface temperature (Cruanes, Berton, Lacroix, Méo, & Ranganathan, 2014). Thus, there are many types of testing was investigate with this chloroprene rubber to see the fatigue damage or failure and using scanning electron microscope (SEM) for observation at macroscopic scale to see the specimen fatigue failure surfaces. Strain energy density and maximum stress dissipated energy density managed to describe well the tension fatigue behaviour (J.L. Poisson, Meo, Lacroix, Berton, & Ranganathan, 2015).

This project is about the dynamic study of coal-ash based chloroprene rubber for automotive seal application. The effects of coal-ash fillers on chloroprene rubber (CR) compounds are been studied, in search of fatigue properties. Thus, this project is aimed at the potential use of coal ash (CA) in chloroprene rubber (CR) compound.

1.2 Problem Statement

Elastomers are progressively and most broadly utilized as a part of mechanical applications, for example, tires, belts, pulleys and so on. The multiaxial understanding phenomenon that began in rubber parts has become a much-needed mechanical issue. The fatigue criteria were then created to illustrate the multiaxial fatigue behaviour of the material and at that time assessed their fatigue life, depending on their application. Subsequently, pressure based on the criteria began to be investigated as the fatigue gauge of rubber components. However, this parameter category has reached its limit with multiaxial applications and cannot integrate multiaxial behaviour. Therefore, energy-based criteria have experienced real success in the past decade, due to their scalar nature and their ability to unite the results of multiaxial fatigue. In particular, the density of energy released is

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adjusted from the approach to improving attractive yields with chloroprene rubber for uniaxial results.

Fatigue life for industrial components made of elastomeric materials is important due to widespread use since the early time. The different loading from simple to complex will evaluate, including variable amplitude non-proportional multiaxial loading, which is a realistic loading condition in the much industrial application

Dynamic mechanical study of material is important since materials are subjected to loading and unloading of stress during its lifetime. Failure of materials in fatigue is catastrophic and without warning even in conditions that would normally not lead to failure.

Chloroprene development currently focuses more on the strong structure that related to the coal ash filler used as a binder material to ensure chloroprene rubber (CR) can be achieved as good material in its lifecycle. This project study is to evaluate the formulation of coal ash (CA) to improve the filler to mix it with chloroprene rubber (CR) compounds.

To get the best formulation on the mixing of chloroprene rubber (CR) compound with coal ash (CA) as a mixing material, some project studies on the fatigue properties of polypropylene and coal ash is needed. The best formulation on the mixing of chloroprene rubber (CR) compound with coal ash (CA) will be interpreted in the automotive seal applications.

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1.3 Objectives

The objective of the project is to : -

i) To characterize the current formulation of Chloroprene Rubber (CR) with Coal Ash (CA) filler.

ii) To prepare the compound of Chloroprene Rubber (CR) and Coal Ash (CA).

iii) To study the fatigue properties of Chloroprene Rubber (CR) with Coal Ash (CA) filler.

1.4 Scope

This project is focusing on the dynamic properties in terms of short and long-term cyclic loading for Chloroprene Rubber (CR) with Coal Ash (CA) filler through a melt of compound by mixing material using an internal mixer then proceeded by several testing such as fatigue test to identify its fatigue life. The scope of this study also focusing on the behaviour of the material under dynamic loading. In this project will be using the equipment such as fatigue testing machine, scanning electron microscope (SEM), optical microscope, density and shore hardness as the support to finding the result analysis in this project.

1.5 Organization of Project Study

This project study is divided into five chapters that discuss the analytical and experimental project performed. The effects of coal ash on chloroprene rubber have been studied, in search of improvements on their physical and mechanical properties. The organization of this project study is as follows.

The first chapter begins with an introduction to project study and also brief about objectives, problem statement, scope, and the thesis overview.

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Chapter two begins on the literature background of this study. It discusses the history of chloroprene rubber, types of filler and type of fly ash. The important element that included in this chapter is about the mechanical properties and used of chloroprene rubber with the coal ash for the fatigue testing.

Chapter three is about the explanations on the methodology used for overall project work, raw materials, procedure property analysis that had been done. In chapter four, shows the testing and analysis result and discuss the reason of the result. Finally, chapter five discusses about the conclusion and recommendation of this research. The objectives of this research were discussed in order to make the conclusion for this research. Lastly, the recommendations were suggested in improving the research in future.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will explains about all findings obtained from many literature reviews, which may come from the internet, journals, article, and books about the topic related to this study. This section includes findings of the overview of chloroprene rubber (CR), properties of chloroprene rubber (CR), structure and characteristics of chloroprene rubber (CR).

Every year the usage of rubber has been increasing significantly for use in a wide range of applications in the non-tire sector of the industry. It is used for seals, strip and other components in the automotive industry, window gaskets, and roofing sheet in buildings, bridge and building bearing pads, chemical plant lining and electric cable covering.

Neoprene is dispersed by free-radical polymerization of chloroprene. In commerce era, this polymer is set up by free radical emulsion polymerization. Polymerization is continuous utilizing potassium persulfate. Bifunctional nucleophiles, metal oxides (e.g. zinc oxide), and thioureas are created to cross-connect solitary polymer strands.

Chloroprene rubber is the name of the polymer for synthetic rubber known as neoprene. The neoprene or known as chloroprene rubber has more than 75 years of proven performance in varied industrial applications. Neoprene, was a greatly valuable synthetic rubber. This rubber was created in 1931 and expected to be the primary claim to fame elastomer. Thus, this is one of the most authoritative types of synthetic rubber with an annual consumption of almost 300000 tons worldwide.

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Chloroprene rubber has a peak adjustment of mechanical properties and resistance to weakness at one point to compare with common rubber. Neoprene rubber has major oils, chemicals, and heat resistance. This type of elastic (elastic chloroprene or Neoprene) is widely used in the same design application.

2.2 Synthetic Rubber

Synthetic rubber is a man-made rubber moulded in manufacture plant by incorporating it from oil and different minerals based on Figure 2.1. Synthetic rubber is mostly polymer or counterfeit polymer. It has flexible moisture or deformation under tension but can also return to past estimates without deformation unchanged. In other hand, it is like when a certain chemical is included, then the resulting rubber is used to make a rubber product switch. There are many case that used synthetic rubber as a substitute for natural rubber. Contingent upon the going with chemicals and their related properties, synthetic rubber can be difficult as bowling balls or as flexible as rubber bands or as smooth as sponges. When the nature of the growing material is needed, the resulting rubber will be considered.

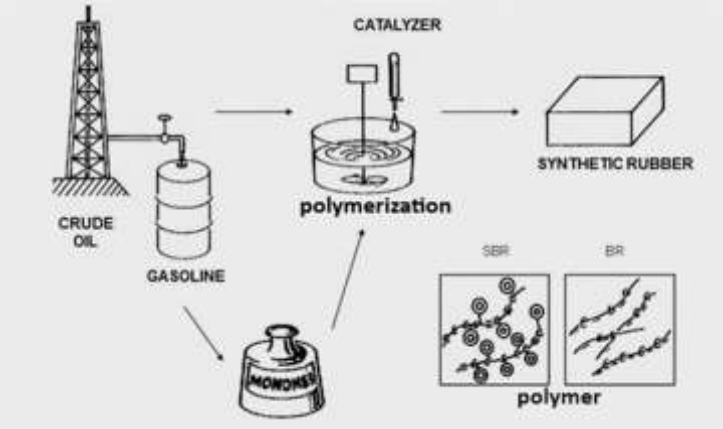

Figure 2. 1: Synthetic rubber manufacturing process

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Today about 70% synthetic rubber is used in all types of rubber applications in the industry. Synthetic rubber is misleadingly made from petrochemical feedstocks. Unrefined oil is the central crude fabric for distinctive sorts of rubber in the synthetic category. As is limited to ordinary rubber where there is such a kind of chemical, there are about 20 types of chemicals of various synthetic rubber, and in all kinds of rubber, there are multiple grades. The type of rubber that is distinctive, especially the type of artificial rubber has the characteristics of the property and their point of interest. The industry chooses the rubber sorts which most clearly meet the requests of a planning utilize.

There are nearly twenty types of chemicals used to make various types of synthetic rubber. It is clear that there are various types of synthetic rubber such as Acrylic Rubber (ACM),Butadiene Rubber (BR),Butyl Rubber (IIR), Chlorosulfonated Polyethylene (CSM)/ Hypalon, Ethylene Propylene Diene Monomer (EPDM), Fluoroelastomers (FKM)/ Viton, Isoprene Rubber (IR),Nitrile Rubber (NBR), Perfluoroelastomer (FFKM), Polychloroprene (CR)/ Neoprene, Polysulfide Rubber (PSR),Silicone Rubber (SiR), Styrene Butadiene Rubber (SBR).

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