A STUDY ON TENSILE PROPERTIES OF ACRYLNITRILE BUTADIENE STYRENE (ABS) SUBJECTED TO THERMAL DEGRADATION

HUZAIMAH BINTI AB RAZAB

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY ON TENSILE PROPERTIES OF ACRYLNITRILE BUTADIENE STYRENE (ABS) SUBJECTED TO THERMAL DEGRADATION

HUZAIMAH BINTI AB RAZAB

A report submitted in fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering (Structures & Materials)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

DECLARATION

I declare that this project report entitled "A Study on Tensile Properties of Acrylonitrile Butadiene Styrene (ABS) Subjected to Thermal Degradation" 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 (Structures & Materials).

Signature	:	.....
Name of Supervisor	:	.....
Date	:	.....

DEDICATION

I dedicated this Final Year Report to Faculty of Mechanical Engineering, my supervisor, Dr. Mizah Binti Ramli, my beloved parents and friends.

ABSTRACT

Nowadays, ABS polymers are widely used in order to upgrade of new and more versatile of polymer time by time. ABS is one of the thermoplastic polymer types which have some properties such as it can be reheated to soften and reshape after reheating process occurs. It also does not undergo significant chemical change. The ABS polymer has weaker bonding among molecules when reheating that allowing reshaping occurs. Some of application of ABS relates with varying temperature. However, the performances of ABS polymer can change based on different temperatures applied on it. So, this project was conducted to investigate the strength and tensile properties of ABS samples at thermal degradation with varying temperatures and duration of heat treatment applied. Besides, morphological study were conducted in order to investigate the behavior and changes surface of samples when thermal degradation process applied on it with different time duration and room temperature. There are few procedures, equipment and machine used for achieving these project objectives such as hot press machine, laser machine, tensile machine and scanning electron microscope. After completing the testing, it can be concluded that the longer time duration for heat treatment on thermal degradation process, the higher brittleness of the ABS material. The morphological surface of ABS material shows the different time duration of heat treatment on samples, it results difference changes of surface behaviour of ABS samples.

ABSTRAK

Pada masa kini, Polimer ABS telahpun digunakan secara meluas dan ditambahbaikkan produk terbaru yang lebih versatile dari semasa ke semasa. Polimer ABS terdiri daripada thermoplastik polimer yang mempunyai ciri-ciri tertentu seperti dapat dibentuk kembali selepas proses pre-pemasanan untuk dileburkan dan dibentuk semula. Selepas proses pemanasan, Polimer ini juga tidak mengalami perubahan kimia yang ketara serta mempunyai rintangan suhu yang tinggi. Polimer ABS mempunyai ikatan yang lemah antara molekul-molekul apabila dipanaskan dimana ia membenarkan pembentukkan semula berlaku. Namun, prestasi kekuatan ABS polimer boleh berubah berdasarkan keadaan suhu yang digunakan keatasnya. Oleh itu, projek ini dikendalikan bertujuan untuk mengkaji ciri- ciri kekuatan penarikkan sampel ABS pada keadaan pemburukkan thermal keatas sampel tersebut. Selain itu, kajian morpologikal juga dijalankan bagi menyiasat sifat dan perubahan sampel-sampel tersebut apabila dikenakan suhu dan masa yang berbeza semasa proses pemburukan termal. Terdapat beberapa prosedur dan alatan serta mesin yang digunakan bagi menjayakan projek ini seperti mesin 'hot press', mesin laser, mesin tensil dan elektron mikroskop. Selepas mengkaji keadaan kekuatan bahan dan kajian morpologikal pada permukaan sampel-sampel, hal ini dapat dirumuskan bahawa semakin lama masa yang diambil untuk ujian pemanasan, tahap kerapuhan pada bahan ABS menjadi semakin tinggi. Kajian morpologikal juga menunjukkan perubahan pada struktur dan sifat keatas sampel ABS apabila ia dikenakan tindakan suhu dan masa yang berbeza.

ACKNOWLEDGEMENT

First of all, I would like to take the opportunity to express my deepest appreciation to my supervisor Dr. Mizah Binti Ramli and ex supervisor, Dr. Azmi Bin Nordin for giving me this opportunity to do final year project with them. They never hesitated to give me advice and guidance whenever I confronted problems. I am thankful for their patience and advice while leading me in this project. Their knowledge in composites and materials field helps me a lot to fulfill my project objectives.

Secondly, I would like to thank a senior named Muhammad Azrain Bin Mohammad for spending his time to guide me. They would share his knowledge in the field of composites with me and guide me to do experiment. Apart from that, I would like to thank chief assistant engineer, Mr. Rashdan Bin Seman by approving my application for reservation laboratory in Fasa B. Also, I would like to thank assistant engineer, Mr. Rizal for his guidance to using Hot Press Machine in NDT laboratory, Mr. Wan Saharizal for lending me using Instron Tensile Machine in Mechanic Structure Laboratory, and Mr. Hairul Nezam for his kindness by lending me using Laser Machine and Humidity Oven in Prototype and Innovation Laboratory. Without their help, I am not sure to be able to complete my Final Year Project this year.

I would like to thank my course mates for giving me their support, patience and encouragement. Finally, I would like to thank my family for their support.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVATIONS

ABS	=	Acrylonitrile Butadiene Styrene
PVC	=	Poly Vinyl Chloride
PE	=	Poly Ethylene
PP	=	Poly Propylene
EN ISO	=	International Organization for Standardization
HB	=	Horizontal Burn
UL	=	Underwriters Laboratories
FR	=	Flame Retardant
ESC	=	Environmental Stress Cracking
SEM	=	Scanning Electron Microscope
UTM	=	Universal Testing Machine
LOI	=	Limiting Oxygen Index

LIST OF SYMBOL

m	=	Mass
ρ	=	Density
v	=	Volume of Material
ε	=	Engineering Strain
σ	=	Engineering Stress
P	=	Applied Load
A_o	=	Original Area of Cross-section Sample
L_o	=	Original gauge length
E	=	Modulus of Elasticity

CHAPTER 1

INTRODUCTION

1.0 Background

1.1 Polymer

The word of polymer was known since 1866 by Berthelot in an article of the Chemical Society of France, noted that "sty Rolene (styrene) was heated at 200°C during a couple hours then transforms itself into a resinous polymer" (Nouveau, 1900). Then in year 1920, Herman Staudinger proposed concept of polymers which is been used until today and for his work he got Nobel Prize in 1953 in science of macromolecules (Nouveau, 1900). The introduction of new and more versatile of polymer was upgraded time by time.

There are two types of polymer that are thermosetting polymer and thermoplastic polymer. The main different of these both type of polymer is thermosetting polymer cannot be reheated to soften, shape and mould meanwhile thermoplastic polymer can be reshape after reheating process and they also do not undergo significant chemical change. Process of shaping and reheating of the thermoplastic polymer can be repeated (Wiley, 2011). Example of thermoplastic polymer is poly Ethylene, Polyamide, Polystyrene, poly Vinyl Chloride (PVC) and Acrylonitrile Butadiene Styrene (ABS) polymer.

1.1.2 Thermoplastic Polymer

Thermoplastic polymer is the materials that are made of polymers that are connected by van der Waals forces to produces linear or branch structures (Wiley, 2011). This kind of polymer tends to be constituted of long chain monomers and

possess a common property. They soften when heated and are frequently used to form shapes. This is because the bonding among molecules is weak and become weaker when reheating to allowing reshaping occurs.

Thermoplastic polymers are dissolving in certain solvent and swell in presence of certain solvents. Thermoplastic also highly creep materials (Toyolac, 2012). ABS polymers have these criteria because ABS polymers are in thermoplastics categories. The strength of ABS polymer can be measured by conducting tensile test according to international standard EN ISO 527 Plastics (CEN, 1996). There are some applications of ABS polymers like casing for telephone, luggage, Lego, computer housings, pipes, and car bumpers. Figure 1.1 below shows the casing of electronic device that was made by using ABS polymer materials

Figure 1.1 Casing of Telephone by Using ABS Polymer.

(Source: Campo, 2007)

Even though ABS plastics are widely used for mechanical purposes, they also have excellent electrical properties that are over a wide range of frequencies. These properties are little affected by temperature and atmospheric humidity which

is acceptable operating range of temperatures. The final properties will be influenced to some level by the conditions under which the material is processed to the final product. For example, moulding at a high temperature can enhance the gloss surface and heat resistance of the product meanwhile the highest impact resistance and strength are obtained by moulding at decrement in temperature (Kulich, Gaggar, Lowry, & Stepien, 2007). ABS polymers also have disadvantages like poor weatherability because it is not weather resistant and opacity (Kulich et al., 2007). ABS polymers also have poor solvent resistance and will produce high smoke when it is burned. Table 1.1 below shows the standard properties of ABS polymers.

Table 1.1: Mechanical Properties of Acrylonitrile Butadiene Styrene (ABS) Polymer

Common Name	Density (g/cc)	Flexural Strength (MPa)	Tensile Strength (MPa)	Elongation at break (%)	Heat Resistance (^{o}C)	Melting Temperature (^{o}C)	Wall Thickness (3mm)
ABS	75.84	1.04	25 – 50	3 – 75	110	175 – 200	3

(Source: Test Standard Labs LLC, 2014)

1.2 Problem Statement

Nowadays, ABS polymers are widely used in many applications. Among other type of polymer, ABS is commonly used as a principal material for devices and housing appliances. The certain application of ABS is relates with the varying temperatures. Therefore, it can affect the performances of ABS application due to the temperature effect on ABS. The past research shows that ABS plastics was sensitive to boiling treatment and the strength rate of ABS decreased significantly with increasing boiling time (Chong et al.,2014). Apart from that, Fraunholcz (2004) found that ABS polymer at elevated temperature facilitate molecular arrangement and change the surface of boiling treated may be attribute to molecular arrangement. However, it is possible to optimize treatment and reprocessing conditions in order to produce better ABS performance specifications. Based on that, a new method, heat treatment on thermal degradation will be conducted on different temperature with several duration conditions in order to analyze the tensile properties of ABS polymers at different temperature and time as compared to the room temperature properties. Thus, the surface of ABS also will also tested in electron microscope in order to investigate morphological surface on each conditions.

1.3 Objectives

The objectives of this study are:

1. To investigate the tensile properties of ABS material at differences temperature and time duration.

2. To characterize the morphological surface of ABS material at differences of temperature and time duration.

1.4 Scope of Project

The focus of this project is to conduct literature review on ABS polymer material and other thermoplastic polymers on its tensile properties under varying temperature. After that do the sample preparation such as prepare raw material and mold it into pieces then setting the experimental apparatus. The sample will be fabricates according to the ISO 527 plastic standard. Then, experimental testing will be conduct by using Humidity Oven at varying temperature and using INSTRON machine for tensile testing. All the experiment results and data will be analyzed and relates with the morphological surface study at fracture surface of the specimen in order to understand the behavior and characteristics of ABS under varying temperature. Finally, do report writing.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter review the history of ABS plastics, application, challenges, properties of ABS, processes and mechanisms of ABS by discussing the literature published in recent years. Advance technology in industry nowadays has produce complex and sophisticated components and device in order to match world demands. Along with this development, researcher has explored the advancement of ABS polymer materials potential to completing the lack of technology components in term of preventive maintenance involved temperature.

ABS is a thermoplastic polymer that has butadiene part that will distributed over the acrylonitrile-styrene matrix. This material has high toughness, excellent dimensional stability, easy to process, chemical and wears resistance. ABS also can enhance the strength and structural integrity as well as to improve durability and thermal resistance resulting in plastic properties of the material.

2.2 Acrylonitrile Butadiene Styrene (ABS)

2.2.1 Definition of ABS

The name of ABS is derived from combinations of three main monomers which are Acrylonitrile, Butadiene and Styrene. The bonding of this monomer is shown as figure 2.1 below.