Faculty of Mechanical and Manufacturing Engineering Technology

STUDY OF FIBER LOADING EFFECT ON THERMAL AND RHEOLOGICAL PROPERTIES OF BIO COMPOSITE FUSED FILAMENT FABRICATION

Muhammad Mufqi Bin Aminallah

Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

2019

STUDY OF FIBER LOADING EFFECT ON THERMAL AND RHEOLOGICAL PROPERTIES OF BIO COMPOSITE FUSED FILAMENT FABRICATION

MUHAMMAD MUFQI BIN AMINALLAH

B071610794

950915-10-6153

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Study of Fiber Loading Effect on Thermal and Rheological Properties of Bio Composite Fused Filament Fabrication**

SESI PENGAJIAN: **2019/2020**

Saya **MUHAMMAD MUFQI BIN AMINALLAH (B071610794)**

mengaku membenarkan Laporan 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.

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

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

☐ TIDAK TERHAD

Disahkan oleh:

_____ _____

MUHAMMAD MUFQI BIN AMINALLAH

Alamat Tetap:

No 10 Jalan Seloka, U2/30 Taman
TTDI Jaya, 40150 Shah Alam,
Selangor Darul Ehsan

Cop Rasmi:

Tarikh: _____ Tarikh:_____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declare this thesis entitled “Study of Fiber Loading Effect on Thermal and Rheological Properties of Bio Composite Fused Filament Fabrication” is the result of my own research except as cited in the references.

Signature : …….……...

Author’s Name : Muhammad Mufqi Bin Aminallah

Date : …….....

APPROVAL

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

……..

(Dr. Mastura Binti Mohammad Taha)

Project Supervisor

mastura.taha@utem.edu.my

ABSTRAK

Kajian ini dijalankan untuk menentukan sifat Fizikal, Termal dan Rheologi bagi variasi jumlah kegunaan menggunakan Kenaf Fiber dengan campuran Acrylonitrile butadiene stirena (ABS) untuk Proses Fabrikasi pencetakan filamen yang menunjukkan dengan menggunakan ujian analisis dan hasil eksperimen. Objektif projek ini adalah untuk mengkaji kesan pemuatan serat pada ciri-ciri komposit serat semula jadi dan untuk mengkaji tingkah laku fizikal, haba dan rheologi komposit serat semulajadi dalam cetakan 3D. Di samping itu, sebagai pencapaian yang perlu dicapai untuk kajian ini, pelbagai skop kajian telah digariskan iaitu pembesaran yang dibuat dalam tekstur serbuk komposit kenaf fiber. Membezakan sifat terma degradasi terma, peralihan kaca, suhu lebur dan haba gabungan menggunakan analisis DSC. Kenal pasti kelikatan sebenar dan kadar ricih yang tinggi menggunakan analisis rajah meter kapilari. Pembuatan filamen untuk gentian kenaf dengan komposit ABS melalui Fabrikasi pencetakan filamen. Kajian penyelidikan ini melibatkan proses penyediaan bahan serbuk serat kenaf dengan jumlah 5%, 7.5% dan 10% dengan campuran ABS. Selepas itu, ujian itu menjalankan sifat fizikal yang memperoleh keputusan penyerapan air dan kandungan lembapan untuk menunjukkan peratusan berat, ketebalan dan pengukuran kandungan. Sudah tentu, kandungan lembapan kenaf serat menyatakan bahawa 0% kandungan serat kenaf dalam ABS adalah 10% lebih rendah daripada serat 5%, 7.5% dan 10% kenaf. Kemudian, sifat termal serat kenaf dilakukan oleh Pengimbasan Calorimetri untuk memperoleh nilai suhu lebur 219.83 ° C untuk serat kenaf yang serat kenaf 5% menunjukkan 105.48 ° C peralihan kaca untuk menentukan kemerosotan material atau mengalami perubahan bahan. Selanjutnya, kertas ini membincangkan pengukuran rintangan ricih polimer yang dicairkan oleh rejim kapilari. Penekanan khusus diletakkan pada penyiasatan kesan pemanasan likat dan tekanan ketergantungan kelikatan dalam aliran kapilari. Semasa ujian untuk sifat-sifat reologi, sampel serat kenaf dan ABS pada asalnya berbentuk ketulan kecil, yang dibuat cecair oleh pemanasan dan terpaksa mengalir keluar silinder melalui 5 mm, 20 mm dan 30 mm panjang acuan kapiler dengan 1 mm diameter Keputusan yang diperoleh dari ujian menunjukkan bahawa kelikatan komposit kenaf serat apabila peningkatkan kadar ricih yang tinggi..

ABSTRACT

This research study was carried out to determine the Physical, Thermal and Rheological Properties of variable volume use Kenaf Fiber with the mixture of Acrylonitrile butadiene styrene (ABS) for the Fused Filament Fabrication process that indicate by the using of analysis testing and experimental results. The objective of this project are to study the impact of fiber loading on natural fiber composite characteristics and to investigate the physical, thermal and rheological behavior of natural fiber composite in 3D printed. In addition, as the attainment that need to be achieve for this study, an assorted scope of study have been outlined which is enlargement made in the texture of the kenaf fiber composite powder. Differentiate the thermal properties of thermal degradation, glass transition, melting temperature and heat of fusion using DSC analysis. Identify the true viscosity and high shear rate using capillary rheometer analysis. Fabrication of filament for kenaf fiber with ABS composite through Fused Filament Fabrication. This research study involve a process of material preparation of kenaf fiber powder with volume of 5 %, 7.5 % and 10 % with the mixture of ABS. Thereafter, the test carry out the physical properties which to obtain the results of water absorption and moisture content as to indicate percentage of weight, thickness and content measurement. Certainly, the moisture content of kenaf fibers specify that 0 % of kenaf fiber content in ABS is 10 % degrade than 5 %, 7.5 % and 10 % kenaf fiber. Then, thermal properties of kenaf fiber was carried out by Differential Scanning Calorimetry to obtain melting temperature value of 219.83 °C for kenaf fiber which 5 % kenaf fiber indicate 105.48 °C of glass transition to determine material degradation or undergoes change of substance. Next, this paper discusses shear viscosity measurements of polymer melts by the capillary rheometer. Particular emphasis is placed on investigating the effects of viscous heating and pressure dependence of viscosity in capillary flows. During the test for rheological properties, sample of kenaf fiber and ABS is originally in the shape of granules, which made fluid by heating and forced to flow out of a cylinder through a 5 mm, 20 mm and 30 mm capillary die length with 1 mm diameter. The results obtain from the testing shows that the kenaf fiber composite viscos when increasing of high shear rate.

DEDICATION

This study is dedicated to my beloved parents Mr. Aminallah Jaafar and Mrs. Noorullhamezon Binti Mohd Noor, not to forget to my big family, siblings and ATS-SAC crew who never stop to support me and encourage me to perform this study and completed my bachelor degree.

ACKNOWLEDGEMENT

Bismillahirrahmanirrahim.

Alhamdulillah, Thanks to Allah SWT, who gave me the opportunity to successfully complete the final year project together with His willingness.

First and above all else, I want to thank my supervisor Dr Mastura Binti Mohammad Taha for her essential supervision, support and encouragement to complete the thesis and to act as lecturer at Faculty of Mechanical and Manufacturing Engineering Technology at Universiti Teknikal Malaysia Melaka (UTeM).

Secondly, I would like to thanks to all my lecturers, assistant engineer, colleague and course mate who had involved directly or indirectly throughout to complete this study for my bachelor degree final year project.

I would really like to extend my deep gratitude to my beloved parents, my big family and ATS-SAC family for their moral support and cooperation. Finally, thanks to all who were involved in this project's essential aspects.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

%	-	percentage
°C	-	Celcius
mm	-	Millimetre
In	-	Inch
kg	-	Kilogram
g	-	Gram
PSI	-	Pounds per Square Inch
MPa	-	Megapascal
RPM	-	Revolution per Minutes
A	-	Ampere
µL	-	Microlitre
µg	-	Microgram
s^{-1}	-	Shear Rates
kN	-	Kilonewton
Pa·s	-	Pascal-second

LIST OF ABBREVIATIONS

NFC	-	Natural Fiber Composite
PLA	-	Polylactic Acid
ABS	-	Acrylonitrile Butadiene Styrene
PVC	-	Polyvinyl Chloride
PE	-	Polyethylene
PP	-	Polypropylene
TGA	-	Thermogravimetric Analysis
DSC	-	Differential Scanning Calorimetry
Tg	-	Glass Transition Temperature
Hf	-	Heat of Fusion
AM	-	Additive Manufacturing
FFF	-	Fused Filament Fabrication
SLM	-	Selective Laser Melting
SLA	-	Stereolithography
NaOH	-	Sodium Hydroxide
N2	-	Nitrogen Gas
O2	-	Oxygen Gas
ASTM E1131	-	Standard Test Method for Compositional Analysis by Thermogravimetric
ASTM D3418	-	Standard Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers
ASTM D3835	-	Standard Test Method for Determination of Properties of Polymeric Materials
ASTM D570	-	Standard Test Methods for Water Absorption of Plastic
ASTM D6980	-	Standard Test Methods for Determination of Moisture in Plastic By Loss in Weight

CHAPTER 1

INTRODUCTION

1.0 Research Background

Since the advent of the moment, natural fibers have occurred in human existence. A Composite material is one of the combination of two different materials with proper properties and produced with the reinforcement of matrix structure. This type of material can be performed in the consuming of less energy than any other fibers therefore they can initiate less pollution for this world. For the past year, many researchers have done their attentiveness in the process of bio-composite. Which are the current industries offers high technology machine also had been attracted to this bio-composite material.

Furthermore, the achievability of manufacturing for the bio-composite products can be throughout for the use of Fused Filament Fabrication (FFF). The using of kenaf fiber composite with a combination of other material such as Acrylonitrile Butadiene Styrene (ABS), as Bio-composite is to produce a sustainable material for the additive manufacturing industry. In the automotive and mechanical sectors, the use of natural fibers has grown significantly. Thus, one of the most commonly used kenaf fibers effectively integrated into a multitude of apps that are becoming progressively essential for the use of kenaf fibers, particularly for plastic strengthening. The environmental and financial benefits of bio-composite are so appealing that countless study has been carried out to enhance the setbacks with these benefits but a few disadvantages of this bio-composite with small mechanical characteristics, heat instability and notable humidity tolerance.

The thermal and rheological properties of a bio-composite are the result of both matrix and fiber properties that depend heavily on the matrix or fiber interface. Furthermore, the mass or volume fraction of the fibers, the fiber aspect ratio of which the length to width ratio is a crucial factor in the properties of natural fibers strengthened by bio-composites. Bio-composite heat disturbance involves degradation of crystallinity, mass and organoleptic degradation characteristics such as odor and color, and can result in gaseous goods at elevated temperature degradation that can produce elevated porosity, low density and decreased mechanical characteristics.

1.1 Problem Statement

The reinforcing effects of kenaf fibers were evaluated at various fiber loadings. This is due to the gradual increase in cellulose and hemicellulose components in the composites, resulting in greater energy loss at the starting temperature. Kenaf fiber has reduced heat strength than the polypropylene (PP) matrix, resulting in a reduced starting temperature and greater weight loss at the starting point. The effect of fiber loading is depending on the weight percent of the kenaf fiber composite which a comparison of the previous study is effected to the weight percent of the kenaf fiber composite that had selected to increase the cellulose and hemicellulose substances.

A disadvantage of this bio-composite material is its poor mechanical characteristics, heat instability and notable resistance to humidity. For all that, to investigate the suitability combination of natural fiber and polymer of kenaf fiber and ABS for 3D printer which the clarification is to experiment on degradation temperature of the material using the thermogravimetric analysis and the melting temperature of the material by differential scanning calorimetry analysis. Despite that, to study the best composition of kenaf fiber with

ABS is based on the viscosity and shear rate which to running an experiment on the capillary rheometer to figure out. This is related to the function of 3D printing to create 3D solid objects from a digital file to produce a product from biodegradable filaments through the additive process.

1.2 Objective

The purpose of this study is to be the focal point on the manufacturing of FFF for the bio composite material. These are the major objective for this study:

i. To study the effect of fiber loading on natural fiber composite characteristics.
ii. To investigate the physical, thermal and rheological behavior of natural fiber composite in 3D printed.

1.3 Scope of Study

This study is to complete acknowledge of the experimental for the material testing to create a filament and using on the FFF for making any product to the industry. The combination of kenaf and ABS will produce a bio composite material which more affable surrounding with improve of physical properties as experimental on the material has been done. Furthermore, as the attainment that need to be achieve for this study, an assorted scope of study have been outlined.

i. Enlargement made in the texture of the kenaf fiber composite powder.
ii. Differentiate the thermal properties of thermal degradation, glass transition, melting temperature and heat of fusion using DSC analysis.
iii. Identify the true viscosity and high shear rate using capillary rheometer analysis.

iv. Fabrication of filament for kenaf fiber with ABS composite through Fused Filament Fabrication.

1.4 Structure of Study

Chapter 1: Briefly explain on the introduction of fibre loading effect on thermal and rheological properties of bio composite fused filament fabrication. An objective is emphasize to be a focal point for this study and scope of the study is determined in order to be a guidelines to complete this study.

Chapter 2: The study of researcher paper for the specific title that related to the scope of study from the journal articles, review study that obtained from online resources. This research will be a benchmark for this study purpose. In short, the aim of a literature review is to provide the reader with information and thoughts on a subject.

Chapter 3: This chapter consist of the methodology for this study which consist guidance to complete this study with the information of material properties, procedure, parameter setup for an experiment process and analysis of the bio composite material.

Chapter 4: This significance result of experiment is stated in this chapter as a discussion to be make with several calculation and theory to determine the thermal and rheological properties of the material.

Chapter 5: Contention on this conclusion of the study that consist and improvement for the future use of bio composite material. A several recommendation is stated to consider the different clarification for this study.