UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CUTTING FORCE MEASUREMENT OF NATURAL FIBER REINFORCED POLYMER MATRIX COMPOSITES

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

by

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ABSTRAK

Malaysia merupakan salah satu pengeluar dan pengeksport minyak kelapa sawit terbesar di dunia, yang menyumbang 11% daripada pengeluaran minyak dan lemak dunia dan 27% daripada minyak dan lemak eksport. Walau bagaimanapun, proses penggilingan minyak kelapa sawit sangat tidak cekap, dengan hanya 10% daripada jisim yang boleh diekstrak akan menjadi minyak kelapa sawit. 90% baki produk sampingan biasanya dibuang atau dibakar. Oleh itu, kajian ini bertujuan untuk menggunakan salah satu bahan buangan proses, tandan buah kosong (EFB), untuk menjadi bahan fasa pengukuhan untuk komposit matriks polimer. Justeru, 4 jenis tandan buah tandan kosong minyak (OPEFB) komposit matriks polimer dengan serat yang berbeza kepada nisbah epoksi telah berjaya dihasilkan. Analisa mekanikal mendapati bahawa peningkatan kandungan serat dalam komposit akan mengurangkan kekuatan tegangan bahan. Sebagai komposit, bahan mesti menjalani proses sekunder setelah proses dilakukan untuk menghapuskan 'flash' / 'burr' yang terjadi semasa proses pemesinan, dan untuk memastikan dimensi yang betul. Oleh itu, kekuatan pemotongan sampel komposit nisbah serat yang berbeza diukur dengan menggunakan dinamometer. Data kekuatan pemotongan dianalisis dan ditunjukkan bahawa peratusan berat bahan memainkan peranan besar dalam kekuatan pemotongan komposit. Semakin tinggi kandungan serat OPEFB, semakin rendah daya pemotongan itu.

ABSTRACT

Malaysia is one the largest producers and exporters of palm oil in the world, accounting for 11% of the world's oils & fats production and 27% of export trade of oils and fats. However, the milling process is highly inefficient, with only 10% of the mass can be extracted to become palm oil. Most of the byproduct are usually discarded or burned. Thus, this study aims on using on one of the wastes of the process, empty fruit bunch (EFB), to be the reinforcement phase material for a polymer matrix composite. As a result, 4 types of oil pam empty fruit bunch (OPEFB) fiber polymer matrix composite with different fiber to epoxy ratio has successful been fabricated. It is analysed that the increase in fiber content in the composite will reduce the tensile strength of the material. As a composite, the material must undergo secondary process after the process is done to eliminate flashes/burrs that occurs during the machining process, and to ensure the correct dimensions. Thus, the cutting force of the composite samples of different fiber ratio are measured by using dynamometer. The cutting force data were analyzed and it is shown that the weight percentage of material plays a huge part in the cutting force of the composite. The higher the OPEFB fiber content, the lower the cutting force is.

DEDICATION

To my beloved parents and family,

That has supported me through thick and thin.

To my friends,

That guided me through this challenging road.

To my teachers and lecturers,

That has made me who I am today.

and,

To my past and future self,

That has never giving up. We made it aren't we. Cheers.

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LIST OF ABBREVIATIONS

PMC	Polymer matrix composite
MMC	Metal matrix composite
CMC	Ceramic matrix composite
CFRP	Carbon fiber reinforced composite
GFRP	Glass fiber reinforced composite
NFRP	Natural fiber reinforced composite
EFB	Empty fruit bunch
OPEFB	Oil palm empty fruit bunch
MPOB	Malaysia Palm Oil Board
UTM	Universal Testing Machine
ANOVA	Analysis of varience

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter will explain the overview 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.

1.2 Background of Study

Nowadays, there is a growing awareness of the interconnectivity of global environmental factors, sustainability principle, industrial ecology and ecoefficiency. Hence, green engineering is being unified into the advancement of the next generation of materials, products, and processes. Furthermore, tougher environmental laws and regulations offer the incentive for the developments of new materials and products that are green and environmentally friendly. Composite materials, especially "green composites" such as natural fiber composites, fit well into this relatively new category.

The oil palm tree (*Elaeis guineensis jacq*.) originates from West Africa where it grows in the wild and later was developed into an agricultural crop. It was introduced to Malaysia, then Malaya, by the British in early 1870's as an ornamental plant. Today, 4.49 million hectares of land in Malaysia is under oil palm cultivation; producing 17.73 million tonnes of palm oil and 2.13 tonnes of palm kernel oil. Malaysia is one the largest producers

and exporters of palm oil in the world, accounting for 11% of the world's oils & fats production and 27% of export trade of oils & fats. The industry provides employment to more than half a million people and livelihood to an estimated one million people. (MPOC, 2019)

Several researches had been conducted on the use of EFB fiber as the reinforcing material in a polymer composite. Most of the researches focus on the mechanical properties of such materials such as its tensile strength and impact toughness (Bakri *et al.*, 2015; Saepulloh and Nikmatin, 2017). Oil palm fiber loading in some polymeric matrices increases the strength properties whereas the strength of composite was less in some cases. Others study about its thermal, acoustical and morphological properties (Faizi *et al.*, 2017; Saba, Jawaid and Sultan, 2017). The thermal stability, dielectric constant, electrical conductivity, etc. were enhanced upon the integration of the oil palm fiber.

As is with other synthetic and natural fiber composites, secondary process is a must in order to convert it into a real product. Processes such as trimming, and drilling are the most typical secondary processes that are done to any composites. These machining operations are completed mostly by conventional machining (CM) techniques. However, due to the heterogeneity and anisotropy of the composite materials, their machining processes tend to be problematic. Some common issues arise during composite machining are delamination, fiber pullout and abrasiveness of the fiber causes rapid tool wear and increased cutting force. These problems are more apparent in synthetic fiber composites, i.e. carbon fiber reinforced composite (CFRP), and glass fiber reinforced composite (GFRP), since their reinforcement materials are harder and more brittle. Hence the selection of good cutting tool and the cutting condition is very significant in the machining process.

1.3 Problem Statement

The need to reuse of oil palm biomass has become more apparent day by day. This is because out of palm oil processing yield, only 10% are finished products i.e. palm oil and palm kernel oil, and the remaining 90% are harvestable biomass waste in the form of empty fruit bunches (EFB), palm kernel shell (PKS), palm oil mill effluent (POME), and palm kernel cake (PKC). From a supply-side perspective, by 2020 Malaysia's palm oil industry is expected to generate about 100 million dry tonnes of solid biomass, including not only the EFB, MF and PKS, but also the oil palm fronds and trunks. The effective use of oil palm biomass has become a necessity due to a lack of effective disposal management choices (AIM, 2019).

Moreover, since this study deals with natural fiber (OPEFB) composites, their machining parameters is also needed to be studied. Plentiful research has been done based on natural fiber-reinforced plastic composites. Material properties and theoretical properties have dominated in every research area. However, very few of these researches focusing on the machinability of the natural fiber composite, especially OPEFB fiber reinforced polymer composite. In order to apply these materials into their maximum potential, machining properties, such as the cutting force needed, must also be studied.

1.4 Objectives

The aims of this study are:

i. To fabricate oil palm empty fruit bunch (OPEFB) fiber reinforced polymer matrix composites.

ii. To analyze the mechanical properties of the OPEFB fiber reinforced polymer matrix composite.

iii. To measure the cutting force required to machine the OPEFB fiber reinforced polymer matrix composite.

1.5 Scope of Study

In order to fabricate a fiber reinforced composite (FRP), there have to be a mixture between reinforcement (fiber) phase and matrix (polymer) phase. The ratio between reinforcement and matrix phase can affect the outcome of the product in terms of visual properties, mechanical properties etc. This ratio is typically denoted by the weight percentage (wt. %) of fiber.

This study focuses only on a few fiber weight percentages, namely 30 wt.%, 40 wt.%, 50 wt.% and 60 wt% of fiber in a composite. This ratios of fiber and polymer are chosen based on the findings on various study, that states that these values have the most effect on the composite properties. Furthermore, there are arguably a lot of factors that will affect the cutting force of a composite. However, only two factors that will be the focus of this study, that are the fiber weight percentage and machining feed because these factors are considered as the most influential to the cutting force by past research and studies (Patel *et al.*, 2018).

1.6 Significance of the Study

The significances of this study are as explained below:

i. Since oil palm biomass makes up for most of the biomass waste in Malaysia, the study may open new possibility of reusing this abundant material, thus adding value to it.

ii. The study complements the current needs for green technology due to a rising concern in climate change. Green technology and materials produce less carbon emission in the manufacturing process. In addition to less biomass waste, this can help reducing carbon emissions, thus can help minimizing the impact of manufacturing industry to the climate change.

iii. There are little to no research conducted concerning the cutting force of the natural fiber composite, let alone OPEFB fiber composite. This study may be useful to whomever that want to fabricate an actual product by using OPEFB fiber composites.

iv. The study can give better understanding of machining natural fiber composite, in contrast to synthetic fiber composite. Similarities and differences of machining these two distinct materials can be understood, and the data can be used by the industry to help them make a better choice in what material to be used in making their product.

1.7 Organization of Study

This study focuses on the cutting force measurement of natural fiber (OPEFB) composite. Besides, the mechanical properties of said composite are also being discussed. The organization of the study is as follows. Chapter Two (2) discussed about the literature review that has been done prior to the experimental setup result analysis. The review is done mainly to gather adequate knowledge on topics related to the study, such as on polymer composite and the machining of the composite.

Chapter Three (3) of the study will be concerning on the design of experiment (DOE) of this study. The materials and equipment used in the study will be thoroughly discussed in order to provide clear understanding what, how and why certain methods are used. Methods in analyzing experimental data will also be discussed in this chapter.

Chapter Four (4) discuss about the results of the study that has been done based on the methods discussed on the previous chapters. Based on the data gathered from the experiments, the outcome of the study will be analysed by using proper methods.

In Chapter Five (5), the study is concluded and recommendation for further studies are presented. Any research gap in this study are going to be discussed and ways to close the gap will be suggested.