STAMP FORMING BEHAVIOUR OF PALM FIBER COMPOSITE

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SUPERVISORS DECLARATION

"I hereby declare that I have read this thesis 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 (Structure and Material)"

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : …………………………..
Author : Nur Al Hafizuddin bin Mohd Arabai
Date : …………………………..

Specially dedicated to my beloved father Mohd Arabai bin Hj Nasri and beloved mother Alfiah Binti Keriti, brothers and sisters, to all family members, lecturers and friends.

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ABSTRACT

In V-bending process, the most sensitive feature is elastic recovery during unloading called spring-back. This phenomenon will affect bend angle and bend curvature. This research reflects the different parameters on spring-back in V-bend die of oil palm empty fruit bunch (OPEFB) fiber reinforced polypropylene (PP) such as forming rate, tool radius and temperature are studied. The composites were produced by mixing chamber of Haake PolyLab Open System modular torque rheometer and punched by hot pressed machine. Then, V-bending test was carried out using Universal Testing Machine (Instron: 5585). The effect of tool radius, feed rate and temperature to spring-back angle of PFC had been investigated and the result shows tool radius and temperature give significant effect to spring-back angle. Based from the result obtained, the suggested temperature and tool radius that should be used to get the smallest spring-back angle or greatest shape conformance is 150(^{o}C) and 2mm.

ABSTRAK

Dalam proses pembentukan lengkungan V, ciri yang paling sensitif adalah pemulihan elastik semasa beban diangkat yang dipanggil sebagai ‘spring-back’. Fenomena ini akan menjejaskan sudut bengkok dan kelengkungan. Kajian ini mencerminkan parameter yang berbeza pada ‘spring-back’ di dalam lengkungan V oleh serat tandan sawit kosong diperkukuh polipropilena (PP) seperti kadar pembentukan, jejari alat dan suhu akan dikaji. Komposit ini dihasilkan oleh ruang pencampuran Haake PolyLab Sistem Terbuka reometer tork modular dan di tekan oleh penekan mesin panas. Kemudian, ujian V-lentur telah dijalankan dengan menggunakan Mesin Ujian Universal (Instron: 5585). Kesan radius alat, kadar suapan dan suhu kepada sudut ‘spring-back’ PFC telah disiasat dan hasilnya menunjukkan radius alat dan suhu memberi kesan yang besar kepada sudut ‘spring-back’. Berdasarkan dari keputusan yang diperolehi, suhu yang disyorkan dan radius alat yang perlu digunakan untuk mendapatkan sudut ‘spring-back’ yang paling kecil atau bentuk pematuhan yang terbaik adalah 150 (^{o}C) dan 2mm.

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α-value	=	alpha value
T_g	=	Glass Transition Temperature
T_r	=	Room Temperature

CHAPTER 1

INTRODUCTION

This project will focus on composite created from natural fiber reinforced polymer matrix. Composites are hybrid materials made of polymer resin reinforced by fibers, combining the high mechanical and physical performance of the fibers and appearance, bonding and physical properties of polymers. Natural composites have various benefits due to its friendly characteristics such as no skin irritation and lightweight.

1.1 Background Research

The advantage of composite materials over conventional materials stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. By definition, composite materials consist of two or more constituents with physically separable phases. However, only when the composite phase materials have notably different physical properties it is recognized as being a composite material. Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone. The reinforcement may be platelets, particles or fibers and are usually added to improve mechanical properties such as stiffness, strength and toughness of the matrix material. Long fibers that are oriented in the direction of loading offer the most efficient load transfer. This is because the stress transfer zone extends only over a small part of the fiber matrix interface and perturbation effects at fiber ends may be neglected. In other words, the ineffective fiber length is small (S. Kindo, 2010).

Fiber reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. Fiber can be classified into two groups that are natural fiber and synthetic fiber. Natural fiber is made from animal, mineral and plant while synthetic fiber is made from polymer, metal and glass.

Natural fiber provide several benefits such as low cost, green availability, low densities, recyclable, biodegradable, moderate properties and usually produce in abundant amount at one time. These fibers are also renewable materials and have relatively high strength and stiffness (S. Joseph et al., 2006).

Natural fibers include those made from animal, mineral sources and plant. Animal fibers generally consist of animal hair, silk fiber, and avian fiber. For synthetic fibers, it consists of asbestos, ceramic fibers, and metal fibers. While the example of the plant fibers are seed fiber, leaf and skin fiber (S. Kindo, 2010).

This research is carried out by using oil palm empty fruit bunch (OPEFB) fiber. Scientific name for OPEFB is Elaeis guineensis (N.L. Kwei et al., 2007). This product includes empty fruit bunches fiber and shell. This research will only use empty fruit bunch fiber to make the composite. The OPEFB fiber is clean, biodegradable, and compatible compared to other fiber from wood species. OPEFB fiber is extracted from empty fruit bunch (EFB) and during the manufacturing process of oil palm fiber, EFB is shredded, separated, refined, and dried. The fresh oil palm fruit bunch contains about 21% palm oil, 6-7% palm kernel, 14-15% fiber, 6-7% shell, and 23% empty fruit bunch (M.Z.M. Yusoff et al., 2009). About 27 million acres of oil palm is produced in 42 countries worldwide and from them, Malaysia ranked first and second largest exporter and producer of oil palm in the world. The oil palm plantation has gradually dominated the Malaysian agricultural crop with a total plantation area that exceeds 4 million hectare (W.M. Basri, 2005). The oil palm industry not only produces crude palm oil as the main product but also generates a huge amount of biomass in the form of trunks, fronds and EFB. By exploiting this kind of waste materials, it's not only maximizes the use of oil palm but also helps to preserve natural resources and maintain ecological balance (D.C.L. Teo et al., 2006).

It is estimated that over 3.6 tonnes per hectare of oil palm waste product were produced annually (M.Z.M. Yusoff et al., 2009). In the past few years, EFB are mainly incinerated to produce bunch ash to be used back to the field as fertilizer. By using the conventional method of burning these residues, it creates an environmental problem and generates severe air pollution. Nowadays, only a small part of oil palm biomass is used for generation of power, fertilizer or processed to produce fibers for mattress, munching mat and medium density fiberboard. There are huge amount of EFB left to decay or dumped into landfills (S. Rahim and M. Suffian, 2006). The fibrous biomass is yet to be commercially exploited. Technology development in the industry is still focused on process development and improvement rather than creating and inventing newer products for value added application. The need for materials that is not harmful to the body but have appropriate properties has increased due to lack of resources and increasing environmental pollution. Thus, composites which were prepared from recycled materials are actively being sought after (M.A.A. Bakar et al., 2007). The OPEFB has been chosen to be the raw material (fiber) to produce composite in this research due to its abundant, low cost than other source, clean and nontoxic abrasive renewable. Various researchers had reported the incorporation of EFB into polymers to obtain cost reduction and reinforcement (A. Kalam, et.al. 2005, C.T. Ratnam, 2007 and H.D. Rozman, et.al. 2001a). The mechanical properties of EFB/polypropylene composites were investigated and had found that EFB has increased the tensile modulus but decreased the tensile strength of the composites (H.D. Rozman et.al 2001b).

This project is using Polypropylene (PP) as the matrix and Maleic Anhydride Polypropylene (MAPP) as the coupling agent for the composite. Polypropylene is a semi-crystalline polymer that is used extensively due to its unique properties, cost and easy to fabricate. Meanwhile, MAPP is an effective functional molecule for the reactive compatibility between PP and OPEFB. MAPP can improve the bonding between PP and OPEFB fibres.

1.2 Objectives

1. To identify the effects of forming rate on the spring-back of palm fiber composite
2. To identify the effect of tool radius/thickness ratio on the spring-back of palm fiber composite.
3. To identify the effect of temperature on the spring-back of palm fiber composite.

1.3 Problem Statement

Renewable material is reliable and plentiful and will potentially be very cheap once technology and infrastructure improve. Renewable materials produce only minute levels of carbon emissions and therefore help to combat climate change. One way of promoting renewable material is to use natural fiber as an alternative to metal used in industries.

Researches on palm fiber composite have mainly focused on tensile and flexural properties. Stamp forming behavior of thermoplastic based palm fiber composite (PFC) is yet to be well understood, thus there is great need to study this behavior in order to improvise material characteristics in the production processes. V-bending is a single curvature deformation test particularly utilized to characterize the spring-back or deviation angle from the final shape of a product. The three significant forming parameters selected for this study will be forming rate, tool radius and forming temperature. PFC is expected to replace the current available structures (monolithic metal) with light weight structure (PFC) in construction, automotive and consumer goods.

1.4 Scope

V-bending will be utilized to characterize the spring-back angle of palm fiber composite.

CHAPTER II

LITERATURE REVIEW

Literature review is the most important step to retrieve information related with the topic. Literature review can be done by searching all the information from internet, journals, books, magazines, and other sources. In this chapter, the information of the materials used in composites and the preparations were investigated.

2.1 Composite

Composite is a structure made of materials which maintain their identities even after the component fully formed. Two main components in composites are matrix and reinforcement as shown in Figure 2.1.

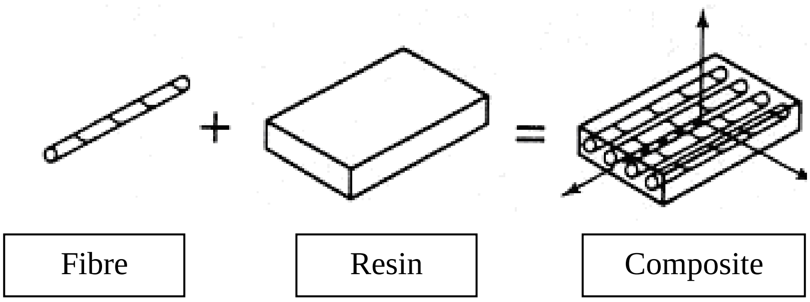

Figure 2.1: Composite composition

Composite is expected to improve the mechanical characteristics such as the stiffness, toughness as well as ambient and high temperature resistance (W.D Callister, 2003). Typical fibres used are glass, carbon, aramid and natural fibers. Epoxy, polyester and polypropylene are common resins used in the fabrication of composite. Merging fibre and resin can make the poor capabilities and drawbacks of the individual components disappeared. For instance, composites will have a high stiffness and strength with a low weight and their corrosion resistance is often excellent (W.D. Callister, 2003). Composites are now a part of everyday life, and have entered nearly all major industrial sectors, including aerospace, ground transport, packaging, sports industry and civil engineering. Most current applications are modern; however, some are in fact quite ancient.

S. Kindo (2010) stated that, composites can be grouped into three categories based on the nature of the matrix each type possesses. Methods of fabrication also vary according to physical and chemical properties of the matrices and reinforcing fibers.

(a) Metal Matrix Composites (MMCs)

Metal matrix composites, as the name implies, have a metal matrix. Examples of matrices in such composites include aluminium, magnesium and titanium. The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large co-efficient of thermal expansion, and thermal and electrical conductivities of metals can be reduced by the addition of fibers such as silicon carbide.

(b) Ceramic Matrix Composites (CMCs)

Ceramic matrix composites have ceramic matrix such as alumina, calcium, alumino silicate reinforced by silicon carbide. The advantages of CMC include high strength, hardness, high service temperature limits for ceramics, chemical inertness and low density. Naturally resistant to high temperature, ceramic materials have a tendency to become brittle and to fracture. Composites successfully made with ceramic matrices are reinforced with silicon carbide fibers. These composites offer the same high temperature tolerance of super alloys but without such a high density.

The brittle nature of ceramics makes composite fabrication difficult. Usually most CMC production procedures involve starting materials in powder form. There are four classes of ceramics matrices that is glass, conventional ceramics, cement and concreted carbon components.

(c) Polymer Matrix Composites (PMCs)

The most common advanced composites are polymer matrix composites. These composites consist of a polymer thermoplastic or thermosetting reinforced by fiber. These materials can be fashioned into a variety of shapes and sizes. They provide great strength and stiffness along with resistance to corrosion. The reason for these being most common is their low cost, high strength and simple manufacturing principles. Due to the low density of the constituents the polymer composites often show excellent specific properties.

For a good reinforcement, few thing to be concern about are high elastic modulus, high strength, low density, and easy wetted by matrix. The fiber can be categorised in three designs that is unidirectional, biaxial and laminates or any combination of three of them. Besides, there are three main types of geometries for the reinforcement which are particle-reinforced, fibre-reinforced and structural composite (W.D. Callister, 2003). Fiber based reinforced composites will be emphasized in this study where OPEFB is the filler reinforcement. PMC system using OPEFB as filler reinforcement material will be developed and further emphasized in the current study.

2.1.1 Polymer Matrix Composite

PMC is also known as Fibre Reinforcement Polymers (FRP). The most common matrix materials for composites are polymeric materials. The reason for this is two-fold. First, in general the mechanical properties of polymers are inadequate for much structural purpose. In particular their strength and stiffness are low compared to the metals and ceramics. This meant that the reinforcement at least, initially does not need to have exceptional properties. Secondly, the processing of PMC does not involve high pressures and high temperatures as well as utilize the sample fabrication development. For these reasons polymer matrix composites developed rapidly and can be used for the structural applications. Today glass-reinforced polymers are still by far the most popular composite materials in terms of volume advantages with the exception of concrete (F.L. Matthews and R.D. Rawlings, 1994). There are also disadvantages in PMC. The main disadvantages are their low maximum working temperatures, high coefficients of thermal expansion, dimensional instability, and sensitivity to radiation and moisture. Absorption of water from the environment may cause harmful effects which degrade the mechanical performance, including swelling, formation of internal stresses and lowering of the glass transition temperature (F.L. Matthews and R.D. Rawlings, 1994).

2.2 Matrix

There are three major components in composites; which are the matrix, filler reinforcement and the interface phase. The matrix phase of composite may be a metal, polymer or ceramic. In general, metals and polymers are used as matrix when some ductility is desirable (F.L. Matthews and R.D. Rawlings, 2002). The matrix adds toughness to the composite while fibers have good tensile strength. The matrix gives compression strength to the composite. Matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mould cavity or onto the mould surface.