Faculty of Mechanical and Manufacturing Engineering Technology

EFFECT OF STITCHING ON KENAF WOVEN FABRIC EMBEDDED THERMOSET BINDER SYSTEM IN INTRAPLY COMPOSITE

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DEDICATION

Dedicated to

my beloved father, Lye Teik Khon

my appreciated mother, Chiow Wai Kam

my adored siblings, Merlyn Lye Chuok Zhin, Melanie Lye Chuok Xin and Adrian Lye Qe Bin

my teammates Duncan Ling Ruey Shan, Finiks Anak Kanis and my senior Mohd Amirhafizan Bin Husin

my special friend Ang Siew Khim for giving me moral support, cooperation, encouragement and also understandings.

Thank You So Much & Love You All Forever

ABSTRACT

Natural fibers have the high tendency to replace synthetic fibers because its offer high strength properties, eco-friendly, low cost and low density. Therefore, the development of natural fibers has been the interest to researcher and many fields of the manufacturers such as aircraft and automotive used as reinforcement to fabricate a high strength property of composite materials. Besides that, there are many researchers focused on the natural fibers-based composite in the form of laminate, but there is no specific study on the combination of stitches and natural fibers to fabricate an intraply composite. The effect of stitching on kenaf woven fabric embedded thermoset binder system in intraply concept was investigated. The purpose of this study is to develop an intraply composite by incorporating kenaf fibers as reinforcement with different stitching parameters and epoxy resin as matrix. There are eight types of stitch designs will be stitched on kenaf woven fabric by using singer 8280 electronic sewing machine. This intraply composite is fabricated by combination of hand lay-up technique and vacuum bagging technique to enhance the properties of the composite. Furthermore, all fabrications and the testing methods are based on ASTM standards. Next, the fracture surface morphology of the samples tested were analyzed by using scanning electron microscopy (SEM). In this study, the result revealed that T60/60 stitch woven kenaf produced the best mechanical performance by increased the specific strength of 53.17 % compared to unstitch woven kenaf. From the study, the performance of best stitch design has potential to produce natural helmet as to replaced synthetic thermoplastic to enhance the impact and tensile properties of the composite

ABSTRAK

Serat semulajadi mempunyai kecenderungan tinggi untuk menggantikan serat sintetik kerana menawarkan sifat kekuatan tinggi, mesra alam, kos rendah dan kepadatan rendah. Oleh itu, perkembangan serat semulajadi telah menjadi kepentingan penyelidik dan banyak bidang pengilang seperti pesawat dan automotif yang digunakan sebagai pengukuhan untuk menghasilkan kekuatan tinggi bahan komposit. Di samping itu, terdapat banyak penyelidik yang menumpukan pada komposit berasaskan gentian semulajadi dalam bentuk lamina, tetapi tidak ada kajian khusus mengenai gabungan jahitan dan serat semulajadi untuk membuat komposit intraply. Oleh itu, matlamat kajian ini adalah untuk mengkaji kesan jahitan pada kain tenunan kenaf yang tertanam termoset pengikat sistem dalam konsep intraply. Tujuan kajian ini adalah untuk membangun komposit intraply dengan menggabungkan serat kenaf sebagai pengukuhan dengan parameter jahitan yang berbeza dan resin epoksi sebagai matriks. Terdapat lapan jenis reka bentuk stitch yang akan dijahit pada kain tenunan kenaf dengan menggunakan penyanyi 8280 terlebih dahulu mesin jahit elektronik. Komposit intraply ini dibuat dengan gabungan teknik pemasangan tangan dan teknik pembaut vakum untuk meningkatkan sifat komposit. Tambahan pula, semua fabrikasi dan kaedah ujian berdasarkan piawaian ASTM. Seterusnya, morfologi permukaan patah sampel yang diuji dianalisis dengan menggunakan mikroskop elektron imbasan (SEM). Dalam pengajian ini menunjukkan bahawa T60 / 60 stitch tenunan kenaf menghasilkan prestasi mekanikal yang terbaik dengan meningkatkan kekuatan spesifik sebanyak 53.17% berbanding dengan kenaf tenunan yang tidak teratur. Dari kajian ini, prestasi reka bentuk jahitan terbaik berpotensi menghasilkan topi keledar asli untuk menggantikan termoplastik sintetik untuk meningkatkan kesan dan sifat tegangan komposit

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Material
CFRP	-	Carbon fiber reinforced polymer
FRP	-	Fiber reinforced polymer
RTM	-	Resin Transfer Molding
SEM	-	Scanning electron microscope

LIST OF SYMBOLS

cm	-	Centimeter
m	-	Mass
mm	-	Millimeter
m^2	-	Meter square
MPa	-	Mega Pascal
GPa	-	Giga Pascal
wt %	-	Weight Percentage
°C	-	Degree Celsius
kN	-	Kilo Newton
kg	-	Kilograms
Pa	-	Pascal
g	-	gram
v	-	Volume
ms^{-1}	-	Meter per second
Hz	-	Hertz
N/mm^2	-	Newton per millimeter square
J	-	Joule
J/cm^2	-	Joule per centimeter square

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, natural fiber composites (NFCs) are humongous used in many applications, interest area of scientific research and product development due to it exhibition with combined behavior of low density, stiff and strong fibrous reinforcement. In additional, natural fiber reinforced composites also give the benefits such as environmental friendly, corrosive resistance, chemical resistance, high mechanical performance and thermal properties. These natural fibers included sisal, pineapple, jute, banana, oil palm, kenaf and coir fibers (Geethamma *et al*., 1998). Polymer is categorized into three classes which are elastomer, thermoplastic, and thermosetting. Besides, these polymers used as matrix to bind together with natural fiber into form natural fiber reinforced composite. The tensile properties of the natural fiber reinforced polymer will be affected by the interfacial adhesion between fiber and matrix. Therefore, better interaction between the matrix and fiber must be takes in the consideration to produce reinforced composite (Ku *et al*., 2011). According to Salman *et al*. (2015) epoxy resin had the higher performance application compared to other thermoset resin. Hence, the epoxy resin is selected for further explored in this research.

According to Akil *et al*. (2015), kenaf fiber is one of the type of natural fiber which brings many advantages and it has high potential as a reinforcement in composite material fields. Because each component of it plant is usable such as stalks, leaves, and seeds. Moreover, it can easily to be harvested in one year. Kenaf fiber-reinforcement has become common natural fiber used in various application such as automotive, construction, electrical,

marine, aircraft, and transportation. Kamal (2014) also agreed with this statement because kenaf is a fast-growing property which it able to produce large volume of raw material within a short period. It has become high demand for many industrial due to it has high environmental sustainable which able to reduce the use of fossil fuels, low density, cost effective, and great performance in term of physical and mechanical. Therefore, kenaf fiber is chosen as reinforcement for this research instead of other natural fiber.

Epoxy resin is one of the family member of thermosetting. It has better properties than other resin as it can provide low shrinkage, high adhesive strength and chemical resistance. It has high service temperature which is up to 175 °C and most of the epoxies are less affected by water and heat. The moisture absorption must be takes in the consideration. This is because it will detrimental effect the mechanical properties of the composite material. When epoxy resin serviced at high temperature, the water gain will be lowered. This can be explained it behaviors more brittle with low elongation, low toughness, and weak resistance to crack. Mainly application used in the aircraft industries such as adhesive for aircraft honey comb structure, airframe and missile applications (Barbero, 2010).

Stitching is a process to bind two components together by using thread and needle. In the modern technology, it can be performed advanced from sewing machine. Lock stitch, modified lock stitch and chain stitch are the common stitching types used by many researchers on the composite material. The use of stitching in the composite is to join the composite structure to improve through-thickness strength and interlaminar fracture toughness and impact damage tolerance (Mouritz *et al*., 1997). According to Pingkarawat and Mouritz (2015), stitching will cause fiber breakage in the composite. They highlighted that stitching on mendable composite reduced mechanical properties due to the increasing of areal density or the size of stitched. Furthermore, the stitch density and stitch size will influence the performance of the composite. Suhaimi *et al*. (2018) also agreed with this