# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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

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

by

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# DECLARATION

I hereby, declared this report entitled “Effect of Stitching on Jute Woven Fabric Embedded Thermoset Binder System in Intraply Composite” is the results of my own research except as cited in references.

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# 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 (Process and Technology) with Honours. The member of the supervisory is as follow:

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## ABSTRACT

Jute fibre is a biodegradable nature and versatility that is good for production of the composite material. its have good properties such as strong, durable, light fibre and environment friendly as well as cost efficient. However, most research did not utilize the jute fibre in the fabrication of intraply polymer matrix composite. Therefore, the purpose of this study is was to investigate the effect on the stitching on jute woven fabric embedded epoxy as a matrix in the intraply composite. The designed lamina composites were fabricated via vacuum infusion process where epoxy was used as the matrix and jute fibre was used as the reinforcement. Mechanical and physical testing such as tensile, flexural, impact, areal density and water absorption were carried out to determine the effect of stitching on jute fibre composite. Furthermore, the failure mode was studied by using the scanning electron microscopy (SEM). Hence, it can be concluded that the effect of stitching on the jute fibre composite have greater effect on tensile strength, flexural and impact compare to jute fibre alone.

## ABSTRAK

Serat jut adalah sifat yang semula jadi dan fleksibiliti yang baik untuk menghasilkan bahan komposit yang mempunyai ketulenan sifat yang baik seperti kuat, tahan lasak, serat yang ringan dan mesra alam serta harga yang amat berpatutan. Walau bagaimanapun, kebanyakan penyelidikan tidak menggunakan serat jut dalam proses menghasilkan campuran gentian polimer yang sempurna secara satu lapisan. Oleh itu, tujuan kajian ini dijalankan adalah untuk mengkaji kesan daripada kepelbagaian kaedah jahitan pada serat jut itu. Selain itu, benang yang siap dijahit akan dicampurkan dengan, epoksi sebagai pengikat dalam satu lapisan komposit. Reka bentuk lapisan dihasilkan melalui proses penyerapan vakum di mana epoksi digunakan sebagai pengikat dan serat jut digunakan sebagai tetulang. Ujian mekanikal dan fizikal seperti tegangan, lenturan, kesan impak, lingkungan kepadatan dan penyerapan air dilakukan untuk menentukan samada ianya memberi kesan keatas jahitan pada komposit jut tersebut. Oleh hal yang demikian, punc-punca kegagalan bahan komposit dikaji dengan menggunakan mikroskop elektron imbasan (SEM). Oleh itu, dapat disimpulkan bahawa kesan jahitan pada komposit serat jut mempunyai kesan yang lebih besar terhadap kekuatan tegangan, lenturan dan kesan impak berbanding serat jute sahaja.

# DEDICATION

*Dedicated to*

*my beloved father, Baharudin bin Hoosen*

*my appreciated mother, Zaithoon bt Syaik Mydin*

*my adored siblings, Nur Hayati, Nazirah and Luqman*

*for giving me moral support, cooperation, encouragement and also understandings.*

*Thank You So Much & Love You All Forever*

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# TABLE OF CONTENTS

## CHAPTER 2: LITERATURE REVIEW



## CHAPTER 3: METHODOLOGY

## CHAPTER 4: RESULTS AND DISCUSSIONS

## CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

## LIST OF TABLES

## LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| ASTM | - | American Society for Testing and Materials |
| 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 |
| wt % | - | Weight Percentage |
| °C | - | Degree Celsius |
| kN | - | Kilo Newton |
| kg | - | Kilograms |
| Pa | - | Pascal |
| v | - | Volume |
| m$s^{-1}$ | - | Meter per second |
| Hz | - | Hertz |
| $W_w$ | - | Wet weight |
| $W_D$ | - | Dry weight |
| $W_f$ | - | Fiber mass |
| $\rho_f$ | - | Kenaf density |
| $\rho_m$ | - | Resin density |

| | | |
|---|---|---|
| $T_f$ | - | Final thickness |
| $T_i$ | - | Initial thickness |

# CHAPTER 1

# INTRODUCTION

## 1.1 Research Background

According to Dehkordi *et al*. (2010) said that hybrid composite is classified as interply hybrid and intraply hybrid composites. In interply hybrid composite, layers of the two or more homogeneous reinforcements are stacked layer wise while in intraply hybrid composite, two or more constituents of fibers are mixed in the same layer. In that study, the researcher was saying that the intraply composites were composed of fabric layers. However, In this study Finley *et al*. (2017) was analyzed that the strength and ductility of aligned intraply composited can be controlled by manipulating the arrangement of different fibre types. He was found that the intraply composited had the better tensile and the impact performance than their interply counterparts. There are several variables affecting the compound such as the type of matrix, type of reinforcement materials, the thickness of layers and number of layers.

As highlighted by Hancock *et al*. (2006) he studies on the hand lay-up process that used woven reinforcements in the advanced composites and considers how much the material is conventionally being used in the process of hand lay-up. However, Yuhazri *et al*. (2011) found that the fibers modification are required and need to improve the mechanical properties of composites product. Basically, it is due to the fibre, matrix and the bonding between these two components. Hand lay-up technique most commonly used due to simple processing

method. Furthermore, Chawla (2012) showed that the result can be enhanced by using the roller to densify the stacked layers. Further improvement process in mechanical properties is possible by using the bag molding or autoclave.

In addition, Alves *et al*. (2010) define that the jute fibers need to be used based on the sustainable system to avoid the deforestation. The finding is consistent with findings of past studies by Rana *et al*. (2003) about the biofibers which are derived from annually renewable resources as reinforcing fibers in the thermosetting matrix composites where it clearly provides positive environmental benefits with respect to the raw material utilization. Sustainable development is an important concept that was underlying many of today's renewable resources policies.

In another study, Birbeck and Mercer (1956) examined the epoxy resin offers remarkable freedom from polymerization damage, with consequent excellent preservation of cellular fine structure and intercellular relationships. The first practical method of embedding in epoxy resin was investigated by Glauert *et al*. (1956). In the different study, the Lutf (1961) examined the advantage of the epoxy resin embedding method is rapid embedding, easy sectioning of the embedded tissue, good contrast in the electron microscope and wide range of hardness. Since epoxy resins as an organic matrix have an excellent heat, moisture, and chemical resistance and good adhesion to many substrates they are mostly applied in the field of the composite and laminate.

A study by the Kang *et al*. (2001) stated that for getting excellent properties of the composite the strong interfaces between components are needed. Besides, other important factors of fillers for affecting composite properties are their contents and size. According to Nakamura (1992) stated that to enhance the properties, the smaller size and the larger amount

of filler are required. It has been already reported that the increase of specific surface area and contents of fillers enhance the mechanical and impact properties of the composite. However, when the size of filler becomes smaller and the content of filler become higher, the viscosity of composite resin will be too high to process. In that case, the interfacial strength will be a more important factor due to their increased surface area of the filler. An early study by Pape and Plueddemann (1991) was saying that one of the most promising solutions enhancing processibility at the high filler loading system is suggested to be the surface modification of filler.

Besides, stitching does not affect or may improve slightly the in-plane properties while others find that the properties are degraded. In contrast, the study by Mouritz *et al.* (1997) indicated that Stitching will improve the in planes properties, the most investigation reports a substantial deterioration due to damage incurred as a result of the stitching process and this phenomenon is particularly serious for prepreg material. However, it was later shown by McConnell (2007) that when it comes to reinforcement fabric, innovative weaving and stitching technology now makes it easy to tell one warp from weft, bias from the gauge, and to capitalize on the best properties of both woven and nonwoven selection that will show the effect of stitching on it.

The research study by the Aktas (2014) stated that textile fabrics such as woven and knitted fabrics have long been known as prime reinforcement for composite application to their attractive intra laminar strength, damage tolerance, lower cost and versatile design potential. However, the study by Haller *et al* (2006) found that the improvement of the load bearing behavior regarding strength, stiffness, and ductility using tailor made textiles adapted to the stress field in the vicinity of a dowel type fastener. The improvement of embedding

characteristics by means of biaxial weft knitted and multiaxial stitch bonded textiles are presented. The orientation of the reinforcing yarns is either vertical (weft) or horizontal (warp) to the production direction.

## 1.2 Problem statement

According to Yamada *et al*. (1978) stated that a lamina is a flat or sometimes curved arrangement of unidirectional or woven fibers suspended in a matrix material. A lamina is generally assumed to be orthotropic and its thickness depends on the material from which it is made. This can be further understanding when the fibers suspended in an epoxy matrix lamina so it will clearly show a modeled as having one layer of fibers through the thickness that has been deciding. Consistent with findings by Yadaw and Chaturvedi (2012) which found that the composites encounter problems can be classified as fiber fracture, matrix cracking, and delamination.

While a laminate is a stack of the lamina, its have an oriented in a specific manner to achieve the desired result. Besides, this is support by Petit *et al.* (1969) found that the individual lamina is bonded together by a curing procedure that depends on the material system used. The mechanical response of a laminate is different from that of the individual lamina that forms it. The laminate response depends on the properties of each lamina, as well as the order in which the lamina is stacked, this statement is agreed by Peterson and Hart Smith (1990). So, to construct a jute as reinforcement and epoxy as matrix base on the composite material its need a lamina composite. These lamina is being held together thanks to the resin that have chosen depending in-service condition of the composite material products.

Many studies focus on jute but not as an intraply concept only but there is more focus in the other form such as the weave designs. According to Yuhazri *et al*. (2016) found that there are six types of lamina composite weave design obtained were plain, twill, basket, satin, leno and mock leno weave. In addition, it was shown that the thickness of the specimens was found that the decrease of thickness increased the tensile strength of lamina or one ply composite due to the fact that there was a weaving structure that had better interlocking between the fiber and sufficient resin to wet all the specimens in the lamina composites.

Further research might investigate the effect of the layer sequence of fabrics revealed improvement in mechanical properties. Similarly, Rajesh *et al*. found that the layered of the composite with relatively strong intraply fabric as the facing layer and relatively weak jute plain fabrics as the core layer has higher tensile and flexural properties. However, there is little study focuses on the composited in the form of the intraply but more focused on synthetic woven fibre. This is consistency with Yuhazri *et al*. (2016) which stated that the natural fibre is proposed to substitute synthetic fiber due to several advantages such as environmentally friendly, low cost, abundant, renewability and good weight. Besides, this is support by Kaddami *et al* (2006) which showed that natural fibre reinforced composites combined good mechanical properties with a low density.

In this study of the effect of the stitching on jute woven fabric embedded thermoset binder system in the intraply composite was analyzed. However, to the best of the author's knowledge, no report has been found so far around the world regarding the stitching technique. In contrast, the study by De Rosa *et al*. (2009) analyzed that stitching offers a potential to increase the impact delamination resistance and improve interlaminar strength and fracture toughness. Numerous studies have also conducted out of plane impacts tests for the