Faculty of Mechanical and Manufacturing Engineering Technology

RESEARCH ON DEVELOPMENT OF COMPOSITE DECK FOR ELECTRIC VEHICLE

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RESEARCH ON DEVELOPMENT OF COMPOSITE DECK FOR ELECTRIC VEHICLE

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in fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology)

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DECLARATION

I hereby, declared this report entitled "Research on Development of Composite Deck for Electric Vehicle" is the results of my own research except as cited in references.

Signature	:	………………
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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka as a partial fulfilment 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:

Signature : ……………………………………………………………………….

Supervisor Name : PROF. MADYA. IR. TS. DR MOHD YUHAZRI BIN YAAKOB

Date : ……………………………………………………………………….

DEDICATION

Dedicated to

My parents, the reason for who I am today

my appreciated father, Tan Hock Meng

my beloved mother, Chan Soo Shyan

my adored siblings, Tan Yi Fang, Tan Rui Jie, Tan Yi Suan

Thank You So Much for All the Support

ABSTRACT

Composite deck is the solution to conventional wood deck due to the weight reduction possibilities during design, excellent durability, resistant to weathering and excellent mechanical strength it provides. Problem statements for composite decking design is the weight and mechanical performance of the composite as well as sustainability issues. The aim of this research is to study the implementation of different type of woods as a core for sandwich panel to tackle the issue. The wood utilized as cores also have hexagonal cells designated onto for weight reduction of the sandwich panels as a whole. Wood cores variation along with hexagonal cell presence is manipulated for studies of mechanical properties. The wood variation utilised in the research are rubber, pine and balsa wood while hexagonal cell parameters are constant with 7 mm diameter and 3 mm wall thickness. The sandwich composite is fabricated with machined wood cores, woven glass fiber and epoxy resin. Fabrication of the sandwich panel is done using hand lay up method followed by vacuum bagging process to ensure quality sample or product. Testing of mechanical properties are done based on reference of ASTM standards. Mechanical tests carried out includes shear tension, flexural and compression tests. Rubber wood with hexagonal cells achieved the highest weight reduction percentage compared to the pine and balsa while also remaining as the core with highest flexural and compressive strength among the hexagonal cell cores. For shear tension strength, the presence of hexagonal cells on rubber wood increased the shear strength by 1.38 % with pine and balsa increasing 18.09 % and 75.75 % respectively. Nonetheless, hexagonal cell rubber wood core have the highest flexural and compressive strength compared to hexagonal cell pine and balsa while losing in terms of shear tension against hexagonal cell pine core. By factoring in the highest density reduction percentage, hexagonal rubber wood core is deemed the optimum design for composite decks in terms of weight reduction and mechanical strength.

ABSTRAK

Dek komposit adalah penyelesaian kepada dek kayu konvensional kerana kemungkinan mengurangkan berat badan semasa reka bentuk, ketahanan yang sangat baik, ketahanan terhadap cuaca dan kekuatan mekanik yang sangat baik yang disediakannya. Pernyataan masalah untuk reka bentuk pengikat komposit adalah berat dan prestasi mekanikal komposit serta isu-isu kelestarian. Tujuan penyelidikan ini adalah untuk mengkaji pelaksanaan pelbagai jenis kayu seperti kayu getah sebagai teras untuk panel lapis. Kayu yang digunakan sebagai teras juga mempunyai sel-sel hexagonal yang ditetapkan untuk pengurangan berat badan panel lapis sebagai keseluruhan. Perubahan teras yang baik bersama dengan kehadiran sel heksagonal dimanipulasi untuk kajian sifat-sifat mekanik. Variasi kayu yang digunakan dalam penyelidikan adalah kayu getah, pinus dan balsa manakala parameter sel heksagon selalunya mempunyai diameter 7 mm dan ketebalan dinding 3 mm. Pembuatan panel lapis dilakukan menggunakan kaedah pemasangan tangan yang diikuti oleh proses pembungkus tekanan untuk memastikan sampel atau produk berkualiti. Ujian sifat mekanikal dilakukan berdasarkan ASTM. Ujian mekanikal yang dijalankan termasuk ujian ricih, lenturan dan mampatan. Kayu getah dengan sel hexagonal mencapai peratusan pengurangan berat badan tertinggi berbanding dengan pinus dan balsa sementara juga kekal sebagai teras dengan kekuatan lentur dan mampatan tertinggi di antara teras sel heksagon. Bagi kekuatan ketegangan ricih, kehadiran sel-sel heksagon pada kayu getah meningkatkan kekuatan ricih sebanyak 1.38 % dengan pinus dan balsa meningkat 18.09 % dan 75.75 % masing-masing. Walau bagaimanapun, teras kayu getah sel heksagonal mempunyai kekuatan lentur dan mampatan tertinggi berbanding dengan pinus sel hexagonal dan balsa manakala kehilangan ketegangan ricih terhadap teras pinus sel heksagon. Dengan pemfaktoran dalam peratusan pengurangan berat badan tertinggi, inti kayu getah heksagon dianggap sebagai reka bentuk optimum untuk dek komposit dari segi pengurangan berat badan dan kekuatan mekanikal.

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LIST OF ABBREVIATIONS

3D	-	3 Dimensional
ASTM	-	American Society for Testing and Material
CATIA	-	Computer Aided Three-dimensional Interactive Application
CFRP	-	Carbon fiber reinforced polymer
CLT	-	Cross laminated timber
CNC	-	Computer Numerical Control
DT	-	Destructive test
GFRP	-	Glass fiber reinforced polymer
HCBW	-	Hexagonal cell balsa wood
HCPW	-	Hexagonal cell pine wood
HCRW	-	Hexagonal cell rubber wood
ISO	-	International Organization for Standardization
KFRP	-	Kenaf fiber reinforced polymer
LBL	-	Laminated bamboo lumber
LVL	-	Laminated veneer lumber
MACM	-	Magnet assisted composite manufacturing
NDT	-	Non destructive testing
NFC	-	Natural fiber composite
PVC	-	Polyvinyl Chloride
SBW	-	Solid balsa wood
SPW	-	Solid pine wood

SRW	-	Solid rubber wood
UTM	-	Universal Testing Machine
WPC	-	Wood plastic composite

LIST OF SYMBOLS

°	-	Degree
cm	-	Centimeter
g	-	Gram
GPa	-	Giga Pascal
kg	-	Kilogram
kg/m^3	-	Kilogram per cubic meter
kPa	-	Kilo Pascal
mm	-	Millimeter
MPa	-	Mega Pascal
kNm/kg	-	Kilo Newton meter per kilogram

CHAPTER 1

INTRODUCTION

1.1 Background

The improvement of technology and the rising awareness of the global environment, the population of electric vehicle user has a rapid growth during the past decade. Electric scooter is one of a type of electric vehicle mentioned which is available in normal type and self-balancing type. As electric scooter is a type of vehicle albeit a vehicle which operates on electricity, its structural design is important. There are variety of parts used to construct electric scooter and a vehicle deck is one of them. Vehicle decks are typically made of woods and lumbers but recent researches shows that composites deck are an excellent alternative to wooden deck. Saba *et al.* (2017) highlighted green composites as a significant environmental key for aerospace, automotive, decking and structural applications due to a high strength to weight ratio compared to metals.

Composite deck are deck fabricated by using composite different from that of traditional or conventional deck which typically uses variety of lumber and woods. Composite deck can come in different forms but typical composite deck are made using wood plastic composites (WPCs) in the form of laminates. WPCs offers better durability, better bending stiffness, corrosive and chemical resistance followed by good mechanical performance compared to conventional lumbers. WPCs which is considered natural fiber composites (NFCs) are one of the hot topics for researching interests, product development and applications trending over the decades among industries and researchers. Mazzanti *et al.* (2015) introduced WPCs as a thermoplastic polymer reinforced natural fibers from lignocellulosic origin to substitute conventional lumbers and plastic in terms of mechanical properties. As a matter of fact, Sanjay *et al.* (2016) mentioned that the efficiency of NFCs as composites are better than that of synthetic composites due to its lower density and better energy conservation in applications.

WPCs are typically fabricated in the form of composite laminates which is layers of fibers embedded in thin matrix known as lamina bonded surface to surface in a stacking sequences as stated by Birman and Genin (2018). Composite laminates with different fiber orientations and materials composition offers excellent properties in strength to weight ratio and stiffness to weight ratio compared to homogeneous and isotropic materials counterparts. Fiber volume fractions and fiber orientations can be utilized as design variables to minimize mass in composite laminate according to Liu and Paavola (2016).

Another structure of composite which offers excellent stiffness to weight ratio are sandwich panels which is fabricated from two strong and stiff faces separated by a low density core as mentioned by Vitale *et al.* (2016). The sandwich core increases the flexural stiffness of the sandwich panel with increased moment of inertia under bending. Typical core used in sandwich panels are PVC foams, balsa wood and honeycomb core with the more prominent one in research being honeycomb core. Honeycomb cores demonstrates good compressive strengths which are affected by wall thickness and the core height as mentioned by Sun *et al.* (2016).

Laminated bamboos are a fine example of NFC with excellent mechanical properties which can serves as a good reference for composites development. The physical and mechanical properties of bamboo are generally better than conventional timber species making engineered bamboo in industry increases as mentioned by Xiao (2016). Applications of bamboo laminates can be found in laminated panels, fiberboards, particle boards, furnitures and floor panels as stated by Varma (2016).

Other NFCs such as kenaf, jute, and flax also serve as a possibilities to be applied into composite development research due to excellent mechanical properties and low density characteristics. Ramesh (2016) quoted that substitution of synthetic fibers composites with NFCs is possible due to advantages such as biodegradability, renewability, recyclability, abundant, permeability, corrosion resistance, non-toxicity, reduced energy consumption, excellent mechanical properties and minimum waste disposal problems. Chemical treatment towards natural fibers also helps to increase the overall mechanical properties of the fibers where researches on this particular area is increasing, contributing to a stronger NFCs development trend.

Fabrications of both laminates and sandwich structures in composites typically involves processes such as hand lay-up, vacuum bagging or resin infusion which requires manual handling with care and are design dependent. Lozano *et al.* (2015) stated that design and manufacturing in composite are dependent where design influence manufacturing efficiency and quality whereas manufacturing process limits design with constraints.

There are significant amount of researches regarding the utilization of natural fibers in composites structures including laminates and sandwich panels. Examples of the applications of natural fibers in sandwich panels includes flax fiber made honeycomb core researched by Riccio *et al.* (2018) and rice husk fiber reinforced polymer as honeycomb core which is fabricated by Zaini *et al.* (2018) using mould injection process. As far as the researches of natural fibers for composites go, there are still natural materials which is left out such as other types of wood based core excluding balsa core which is to be explained in this research. This creates a foundation for the development of new composites deck for this