MECHANICAL PROPERTIES OF WOOD PLASTIC COMPOSITE (WPC) MADE OF RECYCLED HIGH DENSITY POLYETHYLENE (HDPE) AND RECYCLED WOOD FLOUR (RWF)

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Mechanical Properties of Wood Plastic Composite (WPC) Made of Recycled High Density Polyethylene (HDPE) and Recycled Wood Flour (RWF)

Thesis submitted in accordance with the requirements of the
Universiti Teknikal Malaysia Melaka for the Degree of
Bachelor of Manufacturing Engineering
(Engineering Material)

By

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Sukacita dimaklumkan bahawa tesis yang tersebut di atas bertajuk ***"Mechanical Properties of Wood Plastic Composite (WPC) Made of Recycled High Density Polyethylene (HDPE) and Recycled Wood Flour (RFW)"*** mohon dikelaskan sebagai terhad untuk tempoh lima (5) tahun dari tarikh surat ini memandangkan ia mempunyai nilai dan potensi untuk dikomersialkan di masa hadapan.

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"BERKHIDMAT UNTUK NEGARA"

Yang benar,

INTAN SHARHIDA BINTI OTHMAN
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DECLARATION

I hereby, declared this thesis entitled "Mechanical Properties of Wood Plastic Composite (WPC) Made of Recycled High Density Polyethylene (HDPE) and Recycled Wood Flour (RWF)" is the results of my own research except as cited in references.

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APPROVAL

This Thesis submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Material). The members of the supervisory committee are as follow:

……

(Pn. Intan Sharhida bt Othman)

ABSTRACT

The goal of our research was to value add the waste material, to compare the mechanical properties and to find the best optimum ratio between the PE and wood flour. In this study, Wood Plastic Composite (WPC) fabricated using virgin material and post-consumer high density polyethylene (PE) and wood flour using a twin-screw extruder and hot compression machine. The tests of composite based on wood flour at three different ratio filler content, 20%, 30% and 40%, were carried out using universal tensile machine and impact tester according to ASTM D 3039, ASTM D 790 and ASTM D 6110 respectively and their result were presented. To improve the interfacial adhesion between the wood fiber and the HDPE, silane was used in same quantity level as modifiers to treat wood fiber and the results are presented. The experiment results showed that tensile and flexural properties of the composite increased with the increase of the wood flour particles. This result is totally opposite for the impact test. The effects of different material used and wood fiber length on the mechanical properties of WPC were investigated and presented. Tensile fracture surfaces of tested WPC samples were examined by using SEM and the fracture mechanism of WPC was also analyzed in this research. From the research done we identified that the better tensile strength is (19.24 MPa) for recycled WPC, flexural strength (50.75 MPa) for non-recycled WPC and impact energy is (1.45 KJ/$m^{2)}$ for recycled WPC. As a conclusion regarding the mechanical properties, it is shown that 30% is the optimal filler content for both type of WPC. As overall observation the result shows that recycled WPC has better mechanical properties compared to non-recycled WPC.

ABSTRAK

Matlamat kajian kita adalah megkaji dan menambah nilai bahan buangan serta mencari formulasi optimum terbaik diantara serbuk kayu dan plastic. Dalam kajian ini, komposit panel yang berasaskan kayu dihasilkan dengan mengunakkan mesin penyempritan skru berkembar dan mesin penekan. Ujian panel komposit berasaskan serbuk kayu ini dilakukan pada tiga komposisi gentian kayu yang berlainan, iaitu 20%, 30% dan 40%, dimana dengan menggunakan mesin penguji tegangan dan mesin penguji kesan daya menurut piawaian ASTM D 3039, ASTM D 790 dan ASTM D 6110. Keputusan ujian ini turut dibincangkan dalam kajian ini. Untuk mengukuhkan pelekatan antara gentian kayu and plastik (HDPE), "silane" telah digunakan dalam kuantiti yang sama untuk semua komposisi bagi merawat serbuk kayu dan keputusannya juga dibincangkan. Hasil kajian ini menunjukkan bahawa ciri-ciri kekuatan lenturan dan tegangan selari meningkat apabila partikel serbuk kayu meningkat. Keputusan ini adalah terbalik bagi ujian hentaman. Kesan pengunaan bahan dan gentian kayu yang panjangnya berlainan dalam ciri-ciri mekanikal, komposit panel kayu dikaji dan dibincang dalam kajian ini. Permukaan bahagian patah pada sampel ujian lenturan dikaji dengan menggunakan mikroskop elektron pengskanan dan mekanisma retak turut dibincangkan dalam kajian ini. Hasil daripada kajian ini, kita dapat tahu bahawa kekuatan tegangan yang baik adalah 19.24 MPa untuk komposit panel kayu yang dikitar semula, kekuatan lenturan yang baik adalah 50.75 MPa untuk komposit panel kayu semula jadi dan Kekuatan hentaman yang baik adalah 1.45 KJ/m^2 untuk komposit panel yang dikitar semula. Kesimpulan daripada ciri-ciri mekanikal, nilai optimum gentian untuk serbuk kayu adalah sebanyak 30%. Secara pemerhatian keseluruhan hasil kajian ini menunjukkan sampel yang menggunakan bahan kitar semula mempunyai ciri-ciri mekanikal yang baik apabila dibandingkan dengan bahan asli.

DEDICATION

For my beloved mother and father also to my family who always give me support

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By the Grace of God, finally I have completed my thesis based on the knowledge and experience that I got during my entire project. Here I would like to take this opportunity to thank the people for their utmost help and guidance given to me. I sincerely appreciate the following people for their utmost cooperation to me during my project flow.

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This project is dedicated to everyone who was involved while I am doing the project because without his or her help and support, I would not have been able to create this project successfully.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

WF	-	Wood Flour
HDPE	-	High Density Polyethylene
RWF	-	Recycled Wood Flour
WPC	-	Wood Plastic Composite
PMC	-	Plastic Matrix Composite
PP	-	Polypropylene
PVC	-	Polyvinylchloride
PS	-	Polystyrene
LDPE	-	Low Density Polyethylene
PET	-	Polyethylene teraphthalate
GPS	-	General Purpose Polystyrene
HIPS	-	High Impact Polystyrene
MAH	-	Maleic anhydride
SSE	-	Single Screw Extruder
CTSE	-	Co-Rotating Twin Screw Extruder
CRTSE	-	Counter Rotating Twin Screw Extruder
MSW	-	Municipal Solid Waste
SPI	-	Society for the Plastic Industry
SEM	-	Scanning Electron Microscope
UTM	-	Universal Testing Machine
MOR	-	Modulus of Rupture
MOE	-	Modulus of Elasticity
RPM	-	Rotational per Minute

CHAPTER 1
INTRODUCTION

1.1 Project Background

In today's modern age, there has been a large leap in development of mankind from the beginning of this race. Due to this rapid improvement, the needs of human increases from day to day in order to improve the quality of life. Regarding to this, many product or equipment have been invented to make human life more comfortable and easy. As time passes, all of this equipment wears of due to constant usage or improvement on the product itself causing all of them to be thrown as a waste.

Usually people will ignore the left over or wastage material, for example plastic chairs and wooden table. These things will end up in the dumping site without knowing the real usage or benefits behind them. Besides wastage, this material can cause serious environmental effect since some of the materials produced are non-biodegradedable. Materials such as this will not decomposed even after few years. It is a waste not to recycle these materials since recycling can help to lower the cost of production to so that it can be utilized by every walk of life poor nor rich and in the same time protect the environment.

Realizing its potential, this project will focuses on developing a wood plastic composite (WPCs) from recycled plastic and recycled wood flour. At the same time, this project will also focus on the comparison between the second generation material (recycled

material) and first generation material (non-recycle or virgin material). From the development of this new composite, analysis as well as further research will also be done to determine whether this material can be recycled again.

In our research, we will use both virgin and post consumer materials. The High Density Polyethylene (HDPE) functions as the polymer matrix and wood flour as the filler. The recycled HDPE is obtained from crushed milk bottle and the wood flour gets from post consumer wood products. In order to do a through research, a few testing will be done on the panel itself such as Tensile testing, Flexural testing and Impact testing in order to observe its mechanical properties. From the series of testing the behavior of wood plastic composite (WPCs) will be observe such as tensile strength, yield point and Modulus of Elasticity (MOE). This data will help to determine the capability of the material as well as identify the best formulation in order to commercialize the recycled products.

1.2 Problem Statements

Currently the amount of garbage or waste is increasing day after day as the world's population increases. If we see closely, most of the wastes are from the things that we used daily such as plastic and paper. Due to the increasing number of mankind in the world, more products have to be manufactured to cater the needs of every human being. These cause natural resources such as wood and petroleum to deplete fast.

Realizing this, recycling is introduced as a way to curb the problems that arise. By recycling natural resources can be preserved for future use and in the same time protect the environment such as forest that gives oxygen for human to life. Recycling also reduces amount of waste produce and can help to encounter garbage accumulation problem. Recycling also reduces cost since manufacturing product from raw material to finished product is getting expensive as time passes.

To overcome this problem, this study is done in order to develop composite from recycled material such as wood flour and plastic. So from this combination of wood flour and plastic, it is known as Wood Plastic Composite (WPC). By doing this research, a deeper study on the properties of WPCs can be done in order to develop and improve the usage of this composite in the future.

1.3 Objectives

(a) To find the best formulation of recycled HDPE and WF in order to produce high strength WPC.

(b) To compare the mechanical properties of composites made from non-recycled and recycled waste woods and plastics.

(c) To convert recycled wood fiber and recycled plastic into durable product that is recyclable on.

1.4 Scope of Project

(a) Characterization of non-recycled and recycled wood flour and HDPE.
(b) Grinding and sieving of the recycled wood flour and HDPE in order to get the desired sizes
(c) To find the best formulation of non-recycled and recycled WF and HDPE in order to get high strength WPC.
(d) Fabrication of WPC involving certain process such as compounding, hot etc.
(e) To study the influence of blending formulation to mechanical properties and microstructure of the composite.

1.5 Study Benefit

This research provides vast knowledge and information to all future researchers around the world. Some of the benefits can be acquired through this research are:-

(a) From the experiment and testing done, the result can provide information which answers all or some doubt regarding to the newly developed recycled composite especially in terms of its properties.
(b) By this research, new acquired information can encourage more researchers to keep on going improving the composite produce as well as develop other new form of composite from recycled materials.
(c) This research also acts as a guide line for future researchers to do test as well as develop new composites and testing equipment to aid the study and R&D that will be done in the future.

Hopefully from the benefits listed above, more new minds can be develop in furthering the research that have been done as well as used this research in achieving new breakthrough that can aid human kind in the future to have an even better quality of life.

CHAPTER 2
LITERATURE REVIEW

2.1 Wood Plastic Composite

Wood Plastic composites (WPCs), variously known as wood fiber-plastic composites and green composites are a new group of materials that are generating interest in many applications. WPCs are defined as composite materials that contain wood (in various forms) and thermoplastic polymer and do not include wood flour-thermoset plastics like bakelite and particleboard products such as medium density fiberboard (Andrea Wechsler, 2006). WPC products use a range of polymers such as polyethylene (PE), polypropylene (PP) or polyvinylchloride (PVC) in various proportions along with wood or other natural fibers to produce profiles or molded objects with the structural integrity and workability of wood and the durability of polymers (Figure 2.1). While wood flour or waste wood is mainly used as a cost-cutting alternative to mineral fillers like talc and calcium carbonate, plant fibers like flax, hemp and kenaf are currently being evaluated as environmentally friendly and low-cost alternatives for glass or carbon fibers in engineering composites.