PERFORMANCE ANALYSIS OF MINERAL FIBRE REINFORCED POLYPROPYLENE

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This report submitted in accordance with requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering (Department of Process)

By

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process). The member of the supervisory committee is as follow:

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PROF. MADYA IR. DR. SIVARAO SUBRAMONIAN

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ABSTRACT

The matrix and filler used are polypropylene and stone wool. Stone wool is a natural material that is formed from one of earth's most abundant material. It become a mass of fine, intertwined fibres with a typical diameter of 6 to 10 micrometers after an advance process. The main purpose of using stone wool is because of its very good properties such as an insulator, ease of control, lightweight, consistently high quality and sterile production under extreme temperature and etc. By using stone wool, a new improvement in material world will happen especially in PMC. The investigation of mechanical properties of stone wool composite compared with virgin material, Polypropylene (PP) carried out as a new research. The filler had been prepared by cleaned and dried before mix with PP in four weight ratio, which are 10wt%, 20wt%, 30wt%, and 40wt% by internal mixer. The compounded composite then compressed into sheet and cut into size as 45 samples for tensile test, hardness test, flexural test and SEM. The result showed that the filler had improved the tensile strength and yield strength up to 20wt% stone wool reinforced PP and decreased after that ratio. 20wt% also showed the lowest for tensile modulus. Addition of filler had improved the flexural modulus but not for flexural strength and flexural strain. The pure PP showed the best flexural strength and strain when compared with the stone wool reinforced PP. The hardness test results showed that the hardness improved with the increase of the filler weight ratio.

ABSTRAK

Matrix dan pengisi yang digunakan adalah polipropelina (PP) dan stone wool. Skop untuk kajian ini memfokuskan tentang kajian analisis sifat mekanikal tentang Stone wool yang dikukuhkan dengan campuran bahan PP untuk PP asli dengan menggunakan variasi stone wool dengan komposisi 10wt%-40wt%. Stone wool merupakan sebuah bahan yang asli yang dihasilkan daripada tanah dan ia merupakan bahan yang paling senang didapati. Ia menjadi benda yang halus dan dililitkan dengan fibre yang mempunyai diameter sebanyak 6 hingga 10 micrometer selepas tahap pemprosesan yang lebih tinggi. Objektif utama menggunakan stone wool adalah kerana ia mempunyai sifat yang amat bagus seperti penebat, senang dikawalkan, konsisten dengan kualiti tingginya dan juga kuat dalam suhu yang amat tinggi. Dengan menggunakan stone wool, sebuah bahan baru akan memberikan manfaat yang banyak kepada dunia PMC. Penyiasatan sifat mekanikal dan prestasi komposit stone wool terhadap virgin bahan, PP akan dilaksanakan sebagai kajian yang baru. Stone wool disediakan dengan membersihkan and mengeringkannya dengan oven sebelum bercampur dengan PP. Campuran stone wool dengan PP kemudian dimampatkan ke dalam kepingan dan memotongnya kepada saiz sebagai 45 sampel untuk ujian tengangan, ujian kekerasan, ujian lenturan dan SEM di mana objektif adalah untuk mencari prestasi komposit. Hasil daripada ujian menunjukkan bahawa pengisi telah meningkatkan tensile strength dan yield strength sampai 20wt% kemudian menurun selepas ratio tersebut. 20wt% menunjukkan tensile modulus yang terendah. Penambahan stone wool meningkatkan flexural modulus tetapi bukan untuk flexural strength and strain. Kekerasan material meningkat dengan penambahan stone wool ke dalam PP.

DEDICATION

This report dedicated to my beloved parents, siblings and boyfriend. Thanks for always being there for me. Without their love and support this report would not have been made possible.

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$CaCO_3$	- Calcium Carbonate
CMC	- Ceramic Matrix Composites
iPP	- Isostatic Polypropylene
LDPE	- Low Density Polyethylene
MAPP	- Maleated Polypropylene
MMC	- Metal Matrix Composites
PMC	- Polymer Matrix Composites
PP	- Polypropylene
FKP	- Faculty of Manufacturing Engineering
PP-ES	- Eggshell Reinforce Polypropylene
SEM	- Scanning Electron Microscope
Wt%	- Weight Percent Solution
Eq.	- Equation
$>$	- more than
$<$	- less than
%	- Percent
℃	- Degrees Celsius
±	- Plus or Minus
ρ	- Density
σ	- Stress
ϵ	- Strain
g	-Gram

t/h	- Thickness
L_f	- Final Length Gauge
L_o	- Original Length gauge
A_o	- Area of Specimen
σ_p	- Flexural Strength
P_p	- Load Applied to the Surface of the Specimen
L	- Length of Lower Support
B	- Width of Specimen
In	- Inches
Kg	- Kilogram
m	- Mass
V	- Volume
MPa	- megapascal
GPa	- Gigapascal

CHAPTER 1

INTRODUCTION

1.1 Background

The matrix and filler used for preparing polymeric composite is polypropylene (PP) and stone wool respectively. Several of testings were carried out in order to investigate the mechanical properties of stone wool reinforced polypropylene.

Stone wool is a natural material that formed from one of the earth's most abundant material and this material are spun into wool from rock at a temperature of about 1600 ℃ followed by stream of air or steam. Some of the rock wool produced by some advanced techniques that spinning molten rock on high speed spinning wheels like the process prepared cotton candy. The final product is a mass of fine, intertwined fibres with a typical diameter of 6 to 10 micrometers. Heat temperature that stone wool can withstand is in the range between 700 ℃ - 850 ℃.

Stone wool itself has some very good properties. Stone wool can act as insulator and means in build fire protection. Stone wool also has an open fibrous structure making it able to absorb and regulate noise. This properties enable stone wool to be used in products which reduce ear-deafening noise from machines or activities of people and allow provide ambient situations with normal conversation. The use of stone wool offers many advantages. It is consistently high quality and sterile production under extreme temperature ensures that the stone wool is clean and sterile. Stone wool is also very easy to control. Stone wool shows that it has yield per square meter high and energy consumption per unit of product low. It is easy to use due to it lightweight. Besides that, it also can be easily re-used. All that characteristics have proved that stone wool is a sustainable and environmentally-friendly product.

It has been known for many years that the existence of composite materials has existed. A composite material is clearly defined as a constituent material which is consists of two or more of them. Small quantities of additives, inert fillers and adhesives can usually be found in PMC. A thermoplastic or thermoset resin are also usually found with PMC or also known as the polymer matrix in composite. Polymers are usually defined as high molecular weight compounds which usually have many repeated small segments within it. The block result of a polymer is usually resulted from the factual characteristics of a chemical reaction with the usage of the smallest building block. All of these blocks results in a polymer. Polymers these days can me made using two different methods. These two are known as condensation and also poly-addition. The main bonds that are being formed between the molecules are covalent bonds which have very strong strength in their bonds. It is known that these bonds are actually caused by the forces of Van der Waal. All of these are able to produce branched or linear polymers. Even though so, the molecules also has a tendency to form secondary bonds which actually holds a magnitude of lower power compared to the covalent bonds.

Therefore, stone wool is chosen due to its ability to withstand high temperature, soundproof and also waterproof. Several of testings will be done in order to investigate the mechanical properties of stone wool reinforced polypropylene.

1.2 Problem Statement

It was rarely found that a fibre would contain the three main characteristics of stone wool, which are waterproof, soundproof and also the ability to withstand high temperature. Therefore, there are researches that have been conducted on the uses of different filler for polymer. One of the examples is eggshell reinforced PP. Result shown that composite has higher tensile modulus compared to the original PP. On the other hand, there are just few of them research about the stone wool as reinforced fibers. From their researches, they were stone wool reinforced CMC but not PMC. Thus, this research was aim to investigate the mechanical properties and performance analysis of stone wool reinforced PMC where matrix is PP. Tensile test, flexural test, hardness test and scanning electron microscopy (SEM) are used to analysis performance of stone wool reinforced PP.

1.3 Objectives

The objectives of this study are to:

a) Characterize the stone wool reinforcement PMC.

b) Propose the potential application product.

1.4 Scope

The research will mainly focus on the investigation of mechanical properties performance analysis of stone wool reinforced PP for pure PP and PP with various stone wool composition which are between 10% - 40%. Other ratio of stone wool and test will not be discussed. The composites are manufactured using hot press moulding technique. Tensile test, flexural test, hardness test and scanning electron microscopy (SEM) were carried out in this study. Tensile and flexural test were carried out to determine the mechanical properties. Their microstructure were observed using SEM.

1.5 Composite

Composites are a combination of two materials in which one of the materials, namely reinforcing phase, is in the form of sheets, particles or fibres. All of these are embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can usually be metal, ceramic or also polymer. Typically, reinforcing materials are strong with low densities while the matrix is usually a touch material with ductile properties. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties which is not available or found in any single conventional material.

Composites are produced to optimize material properties, chemical and/or physical as well as mechanical properties. In composites, materials that have been combined in such a way as to enable us to make better use of their virtues and minimizing to some extent the effects of their deficiencies. Composites are usually used for their structural properties, where the most commonly used composite is used in reinforcing components in fibrous or particulate form. Hence, the definition above can be restricted to such systems that contain a continuous/discontinuous fibre or particle reinforcement, all in a continuous supporting core phase, the matrix.

Reinforcement phases usually exist with volumes of substantial fractions, usually 10% or more. Therefore, three common types of composites can be described as: continuous fibre reinforced composites, particle strengthened composites, and discontinuous fibre reinforced composites. Main functions of each component can actually appear to be different: in particle-strengthened composites, the matrix bears the main load and small dispersed particles obstruct the motion of dislocations in the matrix; and the load is distributed between the matrix and particles. On the other hand for fibre reinforced composites (FRC), the fibres bear the main load and the function of the matrix is mainly to load distribution and its transfer to the fibres.

There also exist another group of composites which are the laminar composites. These composites has reinforcing agents with the form of sheets bonded together and are often impregnated with more than a single continuous phase within the system.

In composites, matrices usually have a very low modulus, while they ability to reinforce elements into it are typically twenty to a hundred and fifty times stiffer and also stronger by fifty times. Composites can also be described as having reinforcements of materials which are embedded into a matrix. To incorporate dispersed phase into the matrix is the effective method to increase the strength and to improve overall properties of the composites. The matrix can be an engineering material, for example metal, polymer or ceramic. Thus, ceramic matrix composites (CMC), metal matrix composites (MMC), and polymer matrix composites (PMC) are obtained. MMC and CMC structures was developed to give a rather high temperature applications, for example being greater than 360 °C, where PMC are usually inadequate. Since metals are more conductive thermally and electrically, MMCs are also used in heat dissipation and electronic transmission applications.

1.5.1 Ceramic Matrix Composite (CMC)

Ceramics matrix composites (CMC) are known to be a subgroup of composite materials and also a subgroup that belongs to technical ceramics. All of these consist of ceramic fibers which are embedded into a ceramic matrix, which thus forming a ceramic fiber reinforced material. The matrix and also fibers are able to consist of any ceramic material, in which carbon and carbon fibers could also be categorized as a ceramic material.

It is also known that the fabrication processes of ceramic-matrix composite is actually a complex process and needs to be carefully planned and also optimized because of the high sensitivity of material properties to microstructures which are controlled by interactions and processing conditions. With comparisons of early