Faculty of Manufacturing Engineering

CHARACTERIZATION OF COMPOSITE TILES FABRICATED FROM RECYCLED POLYPROPELENE (rPP) AND SILICA USING HOT PRESS METHOD

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DECLARATION

I hereby, declared this report entitled 'Characterizations of composite tiles fabricated from Recycle Polypropylenes (rPP) and Silica Using Hot Press Method' is the results of my own research except as cited in the references.

Signature : .....

Author's Name : Samsul Anuar Bin Sulong

Date : 15/8/14

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Manufacturing Engineering (Industrial Engineering).

Signature : .....

Supervisor Name : Dr. Mohd Asyadi Azam Bin Mohd Abid

Date : 20/8/14

DEDICATION

To my beloved wife, Masliza bte Mat Hussin, my lovely sons, Shaza Adelia Putri. Their source of my inspiration and strength in pursuit of excellence. To my mother, Romlah bte Jusoff also father and mother in law who always pray for us happiness. Thanks for all support and encouraged towards the end.

ABSTRACT

The main purpose of this research is to determine the more specific nature of the physical and mechanical properties of a mixture of silica sand and polypropylene material (rPP) recycling in producing composite tile. In this study, rPP is the main ingredient in the binding details of silica through a process of melting and compression using hot press method. There are five weight percent of the composition rPP in producing composite tiles of 30%, 50%, 70%, 90% and 100% and particle size of the silica sand is the fine. After determine the mechanical and physical properties each composition, the results get the composition with better combination in flexural strength, tension, hardness and fire resistant is Sample CT70 which the matrix is 70% and the filler is 30%.

ABSTRAK

Tujuan utama kajian ini dilakukan adalah untuk mengkaji dengan lebih spesifik sifat-sifat fizikal dan mekanikal terhadap campuran pasir silika dan bahan polypropelene (rPP) kitar semula dalam menghasilkan jubin komposit. Dalam kajian ini, rPP digunakan sebagai bahan utama dalam mengikat butiran silika melalui proses pencairan dan pemampatan yang mengunakan kaedah pengacuan pemampatan. Terdapat lima komposisi peratusan berat rPP dalam menghasilkan jubin komposit iaitu 30%, 50%, 70%, 90% dan 100% serta saiz partikel pasir silika yang halus. Setelah diukur sifat mekanikal dan fizikal setiap komposisi, keputusan menunjukan bahawa komposisi yang lebih baik dari segi kombinasi kekuatan lenturan, teganggan, kekerasan dan rintangan api adalah sample CT70 yang mana kandungan matriknya sebanyak 70% dan pengisi sebanyak 30%.

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ASTM	-	American Society for Testing and Materials
Al_2O_3	-	Alumina
APP	-	Ammonium polyphosphate
EDX	-	Energy Dispersion X-Ray
ISO	-	International Organization for Standardization
L	-	Length
MEKP	-	Methyl Ethyl Ketone Peroxide
PC	-	Plastic Composite
PCT	-	Plastic Composite Tile
PE	-	Polyethylene
PET	-	Polyethylene Terephthalate
PER	-	Pentaerythritol
PP	-	Polypropelene
rPP	-	Recycle Polypropelene
SEM	-	Scanning Electron Machine
SiO_2	-	Silicon Dioxide
t	-	Time
UTM	-	Universal Testing Machine
V	-	Volume

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Pollution and solid waste disposal give a big problem for every country in the world including Malaysia. If a country has a proper solid waste management then the pollution problems will not occur thereby reducing global warming. The study conducted in 2007 by Idrus et. al. have stated that the amount of solid waste in Malaysia was about 7.34 million tons per year. As a result of this issue, most countries including Malaysia have encouraged their researchers to study on the method or new product that can be produced from waste residues, in other words, to recycle of renewable resources. Therefore, studies on the use of plastic waste from the Polypropylene (PP) as binding agent or matrix's mix with filler between silica and alumina has a commercial value to study for produce the composite tile.

As we know, the ceramic tiles are hard but brittle. Ceramic tiles are also relatively heavier. In general, the ceramic tile weight with a thickness of 6 mm is between 14.26 kg/m^2 to 18.46 kg/m^2 for every one square meter (Tilersforum, 2013). From this fact, why don't we produce the tiles that lighter, stronger and unbreakable? We also can reduce the problem of solid waste disposal and improve certain properties of ceramic tiles, and then the study to produce composite tiles from plastic waste can be obtained. Ceramic tile ratings are set up in a grading system of 1 to 5, based on the tile's toughness and durability. The rating 1 to 5, the tile applies only one aspect of tile like visible surface abrasion resistance. A tile rating of 5 is the toughest in terms of standing up to scratching, dirt and

traffic, one is the easiest to damage. See below for a quick breakdown of the 1 to 5 ceramic tile ratings systems:

1. Grade 1, this is the weakest of all standard grade ceramic tiles. It's really only suitable as a wall tile.
2. Grade 2, this is best for light traffic areas. Again, a great product for wall tiles, but it will also work in residential bathrooms, where foot traffic is minimal.
3. Grade 3 is most common in residential building, and perfect for light to moderate traffic. This makes it a very sensible choice for residential kitchens, countertops, residential flooring, and all areas that receive lighter wear and tear.
4. Grade 4, this grade is a step up from grade 3 tile grades. It's still a good choice for residential uses, such as tile floors and countertops, but it can also take the heavier abuse of light commercial foot traffic.
5. Grade 5 is built to take a beating. It's mostly used in high traffic commercial areas such as shopping malls and airports.

In this study, the hot press machine used to produce the composite tiles. The material most commonly used in hot press are ceramics, composite and plastic materials. However, in this study, the material used is a mixture matrix composite of plastic granule, silica and alumina powder. The hot press machine is the simultaneous application of temperature and pressure compression to compress the powder or particles to partially or fully sintered components. But in the context to fabricate the composite tiles, the matrix material will melts and solidifies when cooled. Hot press is used to fabricate the composite tiles as same with the original production of ceramic tile using the cold press powder machine. It also used to compress the powder between silica and feldspar. The hot press

machine is also relatively easier to use because the process is not complicated. The main factor why this hot press machine is used because of the composition that can be processed by the machine is unique to produce composite tiles. To view a clear process of hot press, please refer to Figure 1.1.

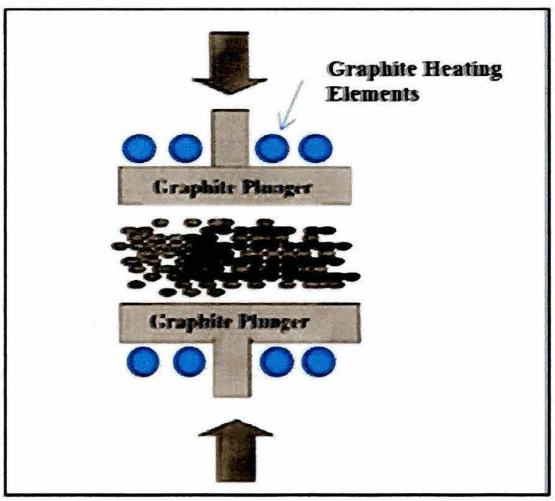

Figure 1.1: Schematic Hot Pressing Technique

1.2 Problem Statement

Generally, we have seen that ceramic tile is a product that can be classified as an exclusive product because of the tedious process which begins with crushing and mixing the silica and feldspar, followed by the cold- press process, then the process of sweeping shiny and lastly is firing process. After conducting the examination and observation, it is true that the production of ceramic tiles is very difficult and complex. In addition, a lot of energy is used in ceramic production to make the ceramic tiles thereby increasing the cost of production. From this we can see that, it is a good idea to produce tiles using a low cost and simpler process. After reviewing some articles on the early researchers, came the idea to produce a composite tile using the hot press process to fabricate the composite tile. The reason why composite tile is selected, is because the mixture of the composite tiles is

similar to the mixture of the ceramic tiles, the only difference is composite tile has matrixes and fillers.

In addition, the weight factor of ceramic tiles also has been a problem for construction labourers, especially during installation and delivery. For example, a ceramic tile with a thickness of 6 mm has a weight of between 14.26 kg/m^2 to 18:46 kg/m^2 for every one square meter (Tilersforum, 2013). This factor also paves the way for composite tiles to replace ceramic tiles, especially in terms of product weight. This is because composite tiles are lighter than ceramic tiles.

Nowadays pollution is very serious and is related to the plastic products. This is due to the fact that plastic takes a long time to decompose. With abundant resources and mechanical properties of thermoplastic, that can be recycled, Polypropylenes waste or recycle Polypropylene (rPP) is chosen for the matrix's to make the composite tiles. After fabricating the composite tiles, it is hoped that the study will reduce the environmental pollution caused by plastic waste.

After using recycled plastic as the matrix in the composite tile, this study becomes more interesting as the general nature of the plastic is flammable. To produce a composite tile based plastic, the product needs to be the fire resistance is very important. After review some previous studies, to make the products based plastic are fire resistant, it is necessary to add flame retardant agent. In this study, the additive flame retardant used is aluminum oxide aided by silica powder.

1.3 Aim and Objectives

The objectives of this study are:

i) To fabricate composite tile-based rPP as a matrix and a mixture of silica and alumina powder as filler.

ii) To identify the best mechanical and physical properties of the fabricated composite tiles.

1.4 Research Scopes

In achieving the objective, this study focuses on the following scope:

For objective 1:

i. Fabricate the composite tile using the hot press method.

ii. Fabricate samples as a percentage of the weight of the rPP 30%, 50%, 70%, 90% and 100%.

For objective 2:

i. Conduct flexural strength test, tensile test and hardness test to identify the mechanical properties of composite tile.

ii. Conduct burning rates test and SEM-EDX analysis of composite tiles to identify the best physical properties.

CHAPTER 2

LITERATURE REVIEW

2.1 Background of Plastic Waste

As we arrived in the 20th century, we are faced with many ecological problems such as pollution which can be attributed to poor solid waste management. Thus, many researchers took the initiative to improve the methods of disposing solid waste more systematically and reuse waste material. Various methods can be done in managing solid waste, either by recycling the material or make new materials or products. Therefore, the uses of plastic waste can increase the recycling technologies will be developed and improved since the early 70's (Allan and Kukacka, 1995). However, the amount of plastic waste has increased throughout the world. Taking into account the needs and too much wasted plastic material, Icduygu et. al. (2012) made a study of the production of polyester composite tiles produced from the synthesis of PET blended with a micro marble arrangement as filler. This shows that plastic waste can be mixed with other materials to produce composite tile. Many researchers such as Choi et. al. (2005), Ochi et. al. (2007), Wong (2010), and Konin (2011) has shown the addition of plastic waste material can be used in various fields not only in tile and plastic products only, but plastic waste can be recycled and used more extensively in the field structure of the buildings and pavements.

2.2 Material

For the fabricated tiles with plastic wastes, the materials properties that are used:

Table 2.1: Typical properties of PP (Boedeker.com)

TYPICAL PROPERTIES of POLYPROPYLENE				
ASTM test	**Property**	**Homopolymer**	**Co-Polymer**	**Flame Retardant**
	PHYSICAL			
D792	Density (g/cm³)	0.905	0.897	0.988
D570	Water Absorption, 24 hrs (%)	<0.01	0.01	0.02
	MECHANICAL			
D638	Tensile Strength (psi)	4,800	4,800	4,300
D638	Tensile Modulus (psi)	195,000	-	-
D638	Tensile Elongation at Yield (%)	12	23	28
D790	Flexural Strength (psi)	7,000	5,400	-
D790	Flexural Modulus (psi)	180,000	160,000	145,000
D695	Compressive Strength (psi)	7,000	6,000	-
D695	Compressive Modulus (psi)	-	-	-
D785	Hardness, Rockwell R	92	80	-
D256	IZOD Notched Impact (ft-lb/in)	1.9	7.5	0.65
	THERMAL			
D696	Coefficient of Linear Thermal Expansion (x 10^{-5} in./in./°F)	6.2	6.6	-
D648	Heat Deflection Temp (°F / °C) at 66 psi /at 264 psi	210 / 99 125 / 52	173 / 78 110 / 43	106 / 41 57 / 14
D3418	Melting Temperature (°C)	164	164	164
-	Max Operating Temp (°C)	82	77	82
C177	Thermal Conductivity (BTU-in/ft²-hr-°F) (x 10^{-4} cal/cm-sec-°C)	0.76-0.81 2.6-2.8	- -	- -
UL94	Flammability Rating	HB	n.r.	V-O
	ELECTRICAL			
D149	Dielectric Strength (V/mil) short time, 1/8" thick	500-660	475	500-650
D150	Dielectric Constant at 1 kHz	2.25	2.2-2.36	2.3
D150	Dissipation Factor at 1 kHz	0.0005-0.0018	0.0017	-
D257	Volume Resistivity (ohm-cm) at 50% RH	8.5×10^{14}	2×10^{16}	10^{15}
D495	Arc Resistance (sec)	160	100	-

2.2.1 Plastic Waste

Plastics are the most common waste item, which represents over 30% of all waste collected over the past 10 years. This includes drink containers, confectionery packets and water bottles, all of which pose a huge threat to wildlife and our environment. Recycling plastic saves energy, valuable resources and helps to protect our environment.

In this study, the polypropylene recycled (rPP) can be used. Polypropylene is an extremely versatile material and used for a wide range of applications. PP is tough and yet flexible and classed as semi-rigid. It is also extremely resistant to heat, chemicals and fatigue. Furthermore, it is translucent and has an integral hinge property. Polypropylene plastics have a high melting point and are also great to prevent the dampness transmission and are almost inert in the face of things such as acids and solvents. To find the polypropylene plastics very easy because it's used for medical tools, food containers, automotive parts and etc. Table 2.1 shows the typical properties of PP. The reasons the rPP are used is as follows:

i. It is a resource of thermoplastic that is easily moulded and become solid when cooled.
ii. This plastics material is the second most widely used type of plastic after polyethylene plastic in the manufacturing and packaging industry.
iii. In addition, the combustion does not emit toxic fumes.

2.2.2 Silica

Dolley and Bolen (2000) cited in their study that there are four types of silica sand in the world, which are quartz crystals, special silica stone products, and tripoli. Most stone are covered by a silica stone called novaculite. The tripoli includes own tripoli and other

fine-grained, porous silica materials that have similar properties and end uses, such as rottenstone.

Industrial sand or stone, often called silica or silica sand with quartz sand, includes sand and gravel with high content of silicon dioxide (SiO_2). Sand is very popularly used in the manufacturing of glass, foundry, abrasive, and hydraulic fracturing (frac) applications and for many other industrial uses. Specifications for each uses vary. But as a resource of silica for most uses is still a lot. In this study, the source silica obtained from Concord Chemical Sdn. Bhd. and size 45μm.

2.2.3 Alumina

In this study, understanding the mechanism and action of flame retardant is important. We need to understand the fire triangle by Emmons as shown in Figure 2.1 because an initial source of heat is the start of a fire requires fuel and oxygen to be sustained and expanded. Polymers provide a continuous flow of fuel pyrolysis and decomposition products as temperature rise as Figure 2.2. Ambient conditions to provide the oxygen needed to continue to decompose and create free radicals that propagate combustion of polymer fragments in the gas phase. To stop the fire, this process can be stopped at one or more levels. Thus flame retardant developed to prevent the process according to the mechanism of action in one or more critical stage. In this study, alumina used as a flame retardant. Source alumina was obtained from Concord Chemical Sdn. Bhd. on equally sized 45μm.