UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MECHANICAL PROPERTIES OF ACRYLONITRILE - BUTADIENE STYRENE-(ABS) FILLED WITH COCKLE SHELL POWDER(CSP)

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Material) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Material) (Hons.). The members of the supervisory committee is as follow:

…….

(Dr.Mohd Eddeerozey Bin Abd Manaf)

ABSTRACT

In plastic Industry, the mineral filler are usually be used in order to alter the properties of the thermoplastic material for various application. In this study, cockle shell powder (CSP) derived from biomass waste is used as organic filler of $CaCO_3$. The main reason to use this organic filler instead of the inorganic filler is to give an added value to the waste material such as cockle shell. This study will be carried out by mixing between the two main materials i.e, Acrylonitrile Butadiene Styrene (ABS) and cockle shell powder (CSP) to produce composite material. Then from the composite material produced, a few mechanical testing such as tensile, flexural and impact tests are carried out in order to determine the effect of the different composition loading of organic $CaCO_3$ filler on the mechanical properties of the new composite material. The loading compositions for the filler loading are 5wt%, 10 wt%, 15wt% and 20 wt%. The results show that, as the addition of filler is increases the stiffness of the material also increases. However, in terms of particle size factor there is no significant effect that was observed through this research although it involves two different particle sizes. Lastly, the fracture surfaces of the tensile test samples were observed using the scanning electron microscope (SEM) for fracture morphological analysis. From the SEM observation CSP can be consider as a potential filler in replacing inorganic filler since on the SEM images, it show that CSP were well distributed and well mixed with the thermoplastic matrix.

ABSTRAK

Dalam Industri plastik, pengisi mineral biasanya akan digunakan untuk mengubah sifat bahan termoplastik untuk pelbagai aplikasi. Oleh itu, disebabkan oleh pencapaian yang telah dicapai oleh pengisi mineral seperti calsium carbonat $CaCO_3$, penyelidikan terhadap pengisi $CaCO_3$ yang dalam bentuk organik telah dijalankan untuk meningkatkan sifat mekanik bahan termoplastik. Pengisi organik ini iaitu $CaCO_3$ yang akan digunakan dalam penyelidikan ini akan diperolehi daripada bahan biomass yang dihasilkan daripada sumber utama yang pada asalnya datang dari serbuk kerang shell (CSP). Antara sebab utama untuk menggunakan pengisi organik ini berbanding pengisi bukan organik yang boleh didapatkan di pasaran ialah sebenarnya disebabkan oleh untuk memberi nilai tambah kepada bahan buangan seperti kerang shell. Kajian ini akan dijalankan melalui proses pencampuran antara kedua-dua bahan utama yang akan diwakili oleh Akrilonitril Butadiena stirena (ABS) dan serbuk kerang shell (CSP) untuk penghasilan bahan komposit. Setelah itu, daripada bahan komposit yang telah dihasilkan, beberapa ujian mekanikal seperti tegangan, lenturan dan ujian kesan akan dijalankan untuk menentukan kesan loading komposisi berbeza pengisi $CaCO_3$ organik terhadap sifat mekanikal bahan komposit yang telah dihasilkan. Komposisi loading yang akan digunakan untuk memuatkan pengisi akan diwakili oleh beberapa komposisi iaitu 5wt%, 10wt%, 15wt% dan 20wt%. Berdasarkan proses ujian yang telah dijalankan, keputusan yang diperolehi menunjukkan bahawa, semakin penambahan berlaku pada komposisi pengisi meningkat ia akan menyebabkan kekukuhan bahan juga menjadi bertambah. Walau bagaimanapun, dari segi saiz zarah tidak ada perubahan ketara yang dapat dilihat melalui kajian ini walaupun ia melibatkan dua saiz zarah yang berbeza iaitu 63μm dan 90μm. Kemudian, melalui kajian ini juga, permukaan patah yang diperolehi melalui ujian tegangan juga akan diperhatikan di bawah mikroskop imbasan elektron (SEM) untuk menganalisis morfologi bagi struktur kawasan yang patah. Melalui pemerhatian yang dijalankan di bawah SEM ia menunjukkan bahawa pengisi organik ini sebenarnya boleh dianggap sebagai pengisi yang berpotensi untuk menggantikan pengisi bukan organik kerana berdasarkan pandangan SEM, ia menunjukkan bahawa pengisi ini bergaul rata dengan bahagian termoplastik yang digunakan dalam pencampuran ini.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

ABS – Acrylonitrile-Butadiene-Styrene
ASTM- American Society for Testing and Material
CMC- Ceramic Matrix Composite
CSP – Cockle shell powder

FKP- Fakulti Kejuteraan Pembuatan

GPa- Giga Pascal

MMC- Metal Matrix Composite

MPa - Mega pascal

mm- milimeter

μm – micronmeter

PMC-Polymer Matrix composite

PP-Polypropylene

UTeM- Universiti Teknikal Malaysia Melaka

UTM- Ultimate Tensile Machine

SEM – Scanning Electron Microscopy

Wt%- Weight Percentage

CHAPTER 1
INTRODUCTION

1.1 Research Background

Nowadays due to the increased awareness in sustain development, peoples especially those in manufacturing industry start to concern regarding the types of material that need to be chosen. Composite material is the one of best selection of material for substituting conventional material such as metal and alloy. The common properties of composite material such as lighter in weight, cheaper in price and as well as good in performance, making this kind of material to be more preferable.

In this research the type of composite material that will be formed is polymer matrix composite (PMC). This type of composite material fabricate in this study is a combination of Acrylonitrile –Butadiene- Styrene (ABS) and cockle shell powder (CSP).

1.2 Problem Statement

Acrylonitrile Butadiene Styrene or commonly known as ABS is the common thermoplastic material that being used in variant application due to the toughness of this material which much higher compare to other thermoplastic material such as Polyproplene (PP). The example of application of ABS material is such as internal and external automotive part, toys and head gears. The main reason of this ABS material be able to use in variant application is due to the unique properties of this

material itself where this unique properties is actually originated from the structure that made up this ABS materials. The structure such as acrylonitrile that presents in ABS will bring heat stability and surface hardness, while butadiene adds toughness and impact resistance, and styrene provides rigidity and processability. However, this ABS material also have a limitation where in terms the cost of producing, ABS is actually required the cost which is twice the cost of producing the other thermoplastic material such as polystyrene. So, one of the best solutions on overcoming this problem will by adding the filler to the pure or virgin ABS material. In previous research the study have be made by using $CaCO_3$ as the filler but for the type of $CaCO_3$ material which come from inorganic source. The using of filler which come from inorganic source will actually lead to increasing cost for the manufacturing of the product and causes the ABS product to be inconvenient for marketable due to higher price.

So, in order to maintain the current filler that being used in previous study which is $CaCo_3$, the alternative method have be choose whereas by do the replacement on the inorganic $CaCo_3$ with the $CaCo_3$ that come from the organic or natural source. The natural or organic source of $CaCo_3$ may be obtained from the cockle shell (anadara granosa). Cockle shell is type of biomass derived material that contains about 95-99% of $CaCo_3$. Besides that, the used of $CaCo_3$ that being derived from the cockle shell also will give an added value to the cockle shell waste since before it just being dumped without treated and cause unpleasant smell.

This study is carried out in order to investigate the suitability of these two materials to perform as composite, where the ABS acts as matrix and cockle shell powder (CSP) as filler. To achieve this, evaluation of mechanical properties of the composite materials will be performed based on the results of tensile, impact and flexural tests. Besides that, the effect of particle size of the filler to the mechanical properties is also investigated. Finally, the comparison between the virgin ABS tensile fracture micrograph and different composition of ABS/CSP composite composition is also presented.

1.3 Objective of Research

The purpose of this research is to determine the effect of mechanical properties of the Acrylonitrile Butadiene Styrene (ABS) filled with cockle shell powder (CSP). This kind of research has been carried out based on the certain objective as be stated on below:

- To investigate the effect of cockle shell powder (CSP) loading on the mechanical properties of Acrylonitrile- Butadiene -Styrene (ABS) composite.
- To study the effect of CSP particle size on the mechanical properties of CSP filled ABS composite.
- To characterize the fracture morphology of cockle shell filled ABS composite.

1.4 Scope of Research

The main scope of this research is to study the mechanical properties of the Acrylonitrile-Butadiene-Styrene (ABS) composite (ABS/CSP). In order to investigate the mechanical properties of the composite material, in this study, a few type of testing will be carried out and the type of testing involved are impact, flexural and tensile testing. Lastly, fracture surface are examined for microscopic observation using Scanning Electron Microscope (SEM) and the fracture sample will came from the tensile testing samples.

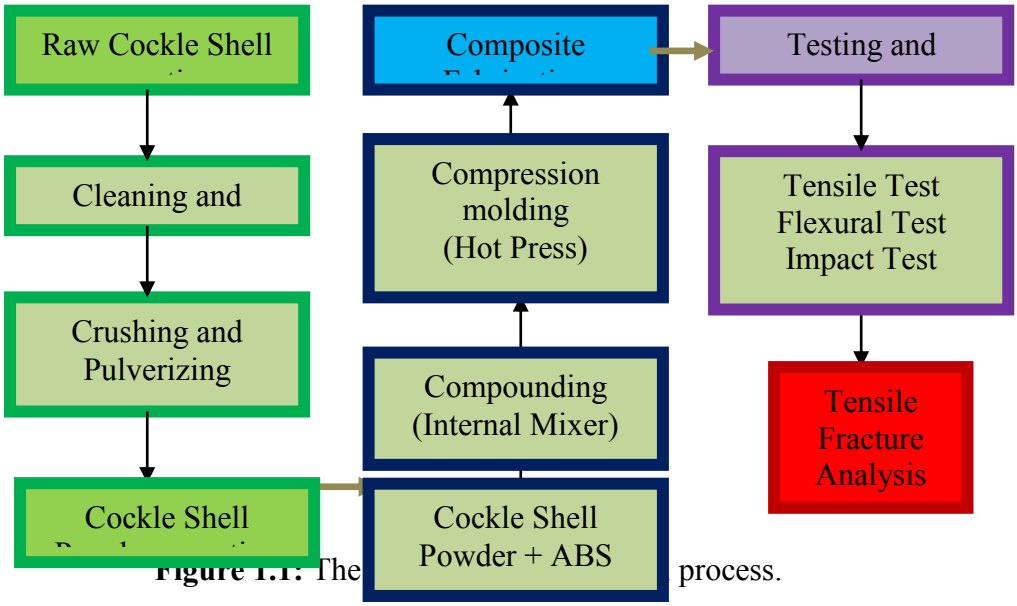

Figure 1.1: The process.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction on Composite

Composite material is made up by combining two or more materials that usually come from the different group of material. Other than different in term of group, the type of material that undergoes this composite process also usually will haves different properties and also come from the different group of material. This two materials will work and blend together in order to give the composite material produce, a new unique properties. Usually, the new properties that will be present by this composite will be much better in enhanced the performance of the material. Although, the composite material will provide the improvement in terms of the properties, but through the composite processing, it also will provided the information which either the composite material that want to produce will be either well dissolve or blend together or not.

2.1.1 Definition and Mechanism

Composite material is the combination of two or more materials (reinforcing elements, fillers and composite binders), differing in form or composition on a macro scale. Normally, the physical state of this kind of material can be physically identified and exhibit an interface between one another. In composite, there is variety type of filler and matrix that will mix together in order for producing the new type of composite. Callister Jr. and Rethwisch, (2011) stated that, composite is produced to achieve a combination of properties that is not display by any single material, and also to provide improvement for each of component material.

From the general definition of composite we known that composite consist of two (or more) chemically distinct phases on a microscopic scale, separated by a distinct interface, and it is important to be able to specify a constituents. The type of constituent that is continues and present on the greater amount in composite is known in term of *matrix.* In composite, this *matrix* will play a really important role as the one that will be improve in term of properties by incorporating with other constituent for producing the composite. This *matrix* can be divided into three type of matrix which is ceramic, metallic or polymeric *matrix*.

Besides that, for the second constituent in the composite, it will referred to the phase that known as reinforcing phase, or reinforcement. This second constituent in the composite will play an important role in order to complete the formation of composite material as it will enhances or reinforces the mechanical properties of the *matrix.* In most cases the reinforcement will have a performance in terms of properties such as harder, stronger and stiffer than matrix in the composite.

2.1.2 Classification and Benefit of Composite

Text Composite can be divided into the several group of classification. The first group of composite that will classify the composite will be known as the reinforced based matrix composite(synthetic composite), where this kind of composite can be divided into three main group. The three main group of composite will referred to the Polymer Matrix composite (PMC), Ceramic Matrix Composite (CMC) and Metal Matrix Composite (MMC). All of this type of composite is be name based on the base of matrix that being used which is metal, ceramic or polymer. The most important thing will to be considering regarding the composite material will be the application of the composite which relate to mechanical and physical properties of the composite.

Besides that, the other group of composite is known as natural composite or commonly be known as bio composite. This natural composite is the kind of composite that made up from the blend of material that origin from the nature source. Composite will consider as the bio composite when one of the matrix or filler is represent by the natural material or both of the material is made up from nature source. In present, usually the source of this type of composite will come from waste that obtained by renewable sources. Figure 2.1 below show the classification of composite.

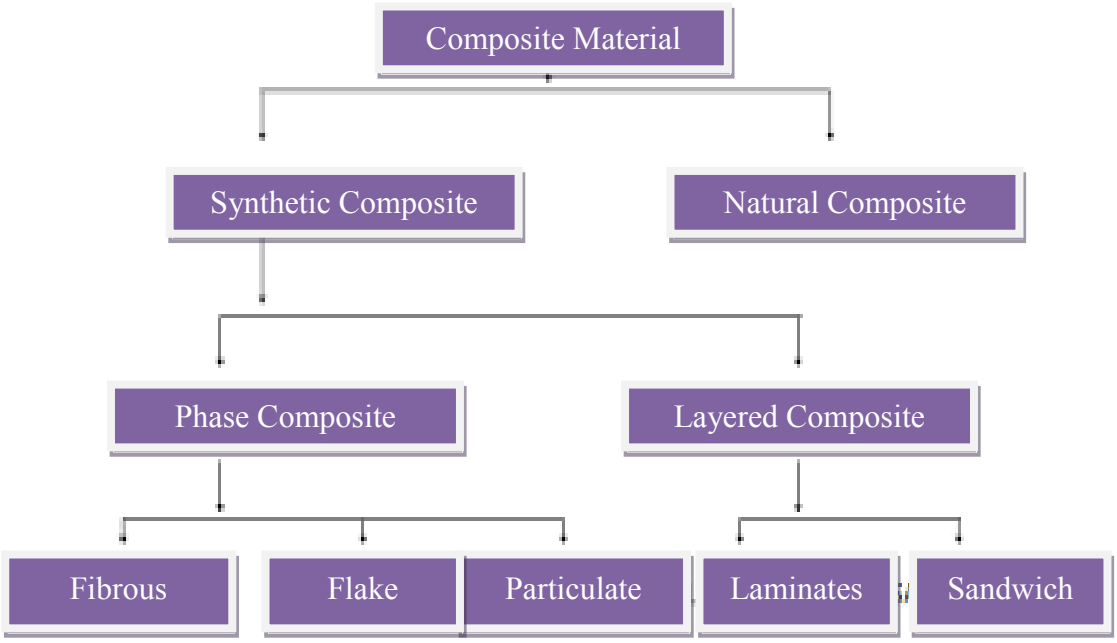

Figure 2.1: Classification of composite

Furthermore, the various feature of composite also have lead to the widespread adoption especially through many different industries. The reason of this composite material to become so important is of course due to the benefit that being provided by this material. The first feature of composite material that provides benefit is because of the light weight of the material. Composites are incredibly lightweight, especially in comparison to materials like concrete, metal, and wood. Often a composite structure will weigh 1/4 that of a steel structure with the same strength. That means, a car made from composites can weigh 1/4 that of a car made from steel. This equates to serious fuel savings.

Then, the other feature of composite is the composite material has a high strength. This composite material is extremely strong, especially per unit of weight compare to other material. Then, composite material also has a highly corrosion and chemical resistance. As this composite material have this kind of feature, it will actually give the advantage of using composite material instead of other material because by using composite the material will not undergoes rusty process

2.2 Polymer Matrix Composite (PMC)

Polymer Matrix Composite is composed of a matrix from thermo set or thermoplastic. This PMC's are the most commonly composite that usually be used on the industry compare to the others classification group of composite. Usually, this PMC composite are involving on fiber reinforced polymer or plastic (FRP). Sergio Nerves (2009) stated that, the industrial application of natural fiber as an alternative for synthetic fiber in polymer composite has already occurred on marketable product.

Besides that, the reason of PMC to become a preferable compare to the other group of composite classification especially on producing a product in industry is also due to the process that being used by this PMC itself. PMC have a processing process which is much easier compare to the other type of composite preparation

such as the one's that involving metal or ceramic. The reason of this polymeric material to become much easier to be prepare is due to the properties that present by the polymer itself, which is polymer material have a good properties in terms of low in service temperature and density. Therefore, due to this reason or condition, it will actually make the composite material that is produce through this process will not involving or require a high pressure as well as high temperature in order for it to be processes.

Furthermore, for the problem regarding the associated with degradation of the reinforcement during manufacture are also less significant for PMCs than for composite with other matrices (Matthews and Rawlings, 2002). So based on the advantage that is provided by PMCs, it actually makes this polymer matrix composite to be developed rapidly and soon accepted for structural application.

Although PMCs have a lot of good and useful properties that make this type of composite to become marketable in industry, but this PMCs material also have present some of limitation in terms of it application. The main limitation or disadvantages that will be representing by these PMCs is this kind of material is having a low service temperature. In the condition within high coefficient of thermal expansion, it will lead to the instability of dimensional and sensitivity to radiation and moisture.

Besides that, the absorption of water from environment also may provide a harmful effect to the PMCs material which is through this condition it will actually be able to degrade the mechanical performance, including swelling, formation of internal stresses and lowering the glass transition temperature. However, there is also type of composite that can be categorised as exceptional for example like carbon

fibre reinforced polymer that may be designed to have very low coefficient of thermal expansion and another material will be epoxies as that act as radiation resistant (F.L Mathews and R.D Rawling, 2002)

2.2.1 Matrix

Matrix is also known as binder. This matrix is actually refers to the phase that receives the inserts in the phase composition which in the kind of continuous phase. This matrix can be from metal, ceramic or polymer.

2.2.2 Thermoplastic

Thermoplastic is a part of the polymer classifications type. In PMCs this thermoplastic is define as the plastic part that made from polymer resins in order to become a homogenized liquid when heated and hard when cooled. This thermoplastic also has properties where it will readily flow under stress at elevated temperature (R.D Matthews and R. D Rawling, 2002). So due this nature condition, it will actually allow this thermoplastic material to be fabricated into the required components and become solid as well as retain their shape when cooled to room temperature. Furthermore, these types of polymer are also normally fabricated by simultaneous application of heat and pressure. Thermoplastic materials are easy to process due to its weak van der Waals forces which allow the molecules to slip.