Faculty of Manufacturing Engineering

UTILIZATION OF INDUSTRIAL WASTE DERIVED ASHES AS FILLER IN ACRYLONITRILE-BUTADIENE-STYRENE COMPOSITE

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DECLARATION

I declare that this thesis entitled "Utilization of Industrial waste Derived Ashes as Filler in Acrylonitrile-Butadiene-Styrene Composite" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Master of Manufacturing Engineering (Manufacturing System Engineering).

Signature :…….

Supervisor Name :…….

Date :…….

DEDICATION

To my beloved parents, wife and daughter

ABSTRACT

Industrial wastes such as fly ashes (FA) and palm oil fly ashes (POFA) can cause environmental pollution if not properly managed. In order to reduce the impacts to the environments, industrial waste can be recycled and used as reinforcing filler in polymer based composite. Acrylonitrile butadiene styrene (ABS) is an interesting polymer that can be used as polymer matrix due to its wide applications in various sectors. Addition of industrial waste as filler into ABS can also reduce the usage of ABS while enhancing the mechanical and physical properties of the composite. The purpose of this research is to assess the mechanical and physical properties of ABS filled with industrial waste filler in dry condition. To fabricate the ABS based composites, melt mixing method was used to compound industrial waste particle, i.e., palm oil fuel ash and fly ash with ABS. The tensile, flexural, impact and physical testing have been performed to assess the effects of FA and POFA addition on the properties of ABS. Scanning electron microscope (SEM) was used to study the surface morphology of the composites as to analyse the effect of different amounts and types of filler toward the behaviour of the ABS composites. It has been found that for mechanical properties, POFA filled ABS gives better result than that of FA, but for physical properties FA addition gives better result than POFA addition.

ABSTRAK

Bahan buangan industri adalah abu terbang (FA) dan abu bahan bakar kelapa sawit (POFA) boleh jadi penyumbang kepada pencemaran alam jika tidak diuruskan dengan baik. Unuk mengurangkan kesan kepada alam semulajadi, bahan buangan ini akan digunapakai sebagai pengukuh dalam komposit polimer. Acrylonitrile butadiene stirrene (ABS) adalah polimer yang menarik untuk digunakan sebagai matriks polimer kerana aplikasinya yang luas dalam pelbagai sektor. Penambahan bahan buangan industri sebagai pengisi ke dalam ABS juga dapat mengurangkan penggunaan ABS sambil meningkatkan sifat mekanikal dan fizikal komposit. Tujuan kajian ini adalah untuk menilai ciri-ciri mekanikal dan fizikal ABS yang diisi dengan pengisi dari bahan terbuang industri dalam keadaan kering. Untuk menghasilkankan komposit berasaskan ABS, teknik campuran cairan telah digunakan untuk mengukuhkan dua jenis zarah semulajadi iaitu abu bahan bakar kelapa sawit (POFA) dan abu terbang (FA) ke dalam ABS. Ujian tensil, kelenturan, pelanggaran dan fizikal dibuat untuk menilai kesan penambahan FA dan POFA pada komposit ABS. Mikroskop imbasan elektron (SEM) telah digunakan untuk mengkaji morfologi permukaan untuk menganalisis kesan jumlah dan jenis pengisi yang berbeza terhadap sifat komposit yang telah hasilkan. Dalam penemuan kajian, penambahan 20% peratusan berat POFA dan FA memberikan prestasi yang lebih baik daripada komposisi yang lain. Seperti keseluruhannya, bagi sifat mekanikal, POFA memberikan hasil yang lebih baik daripada FA, tetapi untuk sifat fizikal, tambahan FA memberikan hasil yang lebih baik daripada POFA.

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LIST OF ABBREVIATION

AASTHO	-	American Association of State Highway and Transportation Officials
ABS	-	Acrylonitrile-Butadiene-Styrene
ASTM	-	American Society for Testing and Materials
FA	-	Fly ashes
POFA	-	Palm oil fuel ash
TPE	-	Thermoplastic Elastomer

CHAPTER 1

INTRODUCTION

1.1 Background of study

Increasing environmental concerns and awareness are the driving force which have pushed manufacturers all over the world to develop alternative materials such as composites based on renewable resources. The areas of applications of composite materials have grown rapidly and have even found new markets. Modern day composite materials consist of many materials in day to day use and also being used in sophisticated applications while composites have already proven their worth as weight saving materials the current challenge is to make them durable in tough conditions to replace other materials and also to make them cost effective. This has resulted in development of many new techniques currently being used in the industry. The composite industry has begun to recognise the various applications in industry mainly in the transportation sector.

Acrylonitrile butadiene styrene (ABS) (chemical formula $(C_8H_8)_x \cdot (C_4H_6)_y \cdot (C_3H_3N)_z$) is a common thermoplastic polymer. Its glass transition temperature is approximately 105 °C (221 °F). ABS is amorphous and therefore has no true melting point. ABS is a polymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15 to 35% acrylonitrile, 5 to 30% butadiene and 40 to 60% styrene. The nitrile groups from neighboring chains, being polar, attract each other and bind the chains together, making ABS stronger than pure polystyrene. For the majority of applications, ABS can be used between −20 and 80 °C (−4 and 176 °F) as

its mechanical properties vary with temperature. The properties are created by rubber toughening where fine particles of elastomer are distributed throughout the rigid matrix.

In this research, locally available industrial wastes, i.e.,fly ashes (FA) and palm oil fuel ashes (POFA) are added as filler into acrylonitrile butadiene styrene (ABS), and the mechanical and physical properties are determined to evaluate and compare the effects of each type of ashes on the ABS composite.

1.2 Problem Statement

ABS is an important material that is widely used as primary material for strength and durability in plastic industry. In today situation, there is a need for polymer manufacturers to move towards more sustainable materials. One of the ways to achiece this is by reinforcing thermoplastic material with sustainable materials such as natural fibers or industrial wastes. The bio-based composites have already started to replace the petroleum based fiber reinforced polymer composites due to its sustainability and biodegradability in nature and have increase the interest in materials science in perspective of ecological and environmental (Shalwan et al, 2013). By using bio-based or waste-derived materials the dependence on petroleum resources can be reduced, thus decrease the negative impacts on the environments.

Malaysia has a large industrial sector with abundance of industrial wastes produced. These wastes can harm the environment thus can affect the health quality of the citizen. One of the alternatives to overcome this problem is by reusing this waste by compounding with other material. By utilizing these wastes, we can reduce the waste and contribute to the preservation of environment and nature.

In this study, ABS polymer is reinforced with fillers derived from locally available waste materials such as palm oil fuel ashes (POFA) and fly ashes (FA). By utilizing the

wastes, it will eventually give added value to the wastes and reduce the usage of ABS, thus decrease the total cost of the composite. As ABS is a strong and durable polymeric material, addition of these industrial wastes may jeopardize its mechanical properties. Thus, it is vital to study the effects of these industrial wastes addition to the ABS composite, to evaluate the worthiness of the addition.

1.3 Aims and Objectives

For future research development in the idea of combining material with industrial waste is finding the best mixing parameter and suitable composition in order to create better composite. Therefor in order to achieve this aim, the objectives of this study are:

i) To develop acrylonitrile-butadiene-styrene (ABS) reinforced with fly ash and palm oil fuel ash.

ii) To determine the effect of the type and amount of industrial waste filler on mechanical and physical properties for different composition.

iii) To analyze the properties of different type filler and different composition by observing the microstructure of the produced composite.

1.4 Research Scope

With the idea of developing a new material that aims for sustainable development and environmental friendly material, industrial wastes such as fly ash (FA) and palm oil fuel ash (POFA) are mixed with acrylonitrile-butadiene-styrene (ABS) to create a more sustainable polymer composite. In this study, the type and amount of the waste-derived ashes used as filler are varied in order to study their impact on the properties of the ABS composites.

The ABS composites reinforced with industrial waste filler are prepared by compounding them together using internal mixer. The different formulation of the ABS and filler used will give different effect to physical and mechanical properties. The total composition of FA and POFA does not exceed 40% by total weight of composite. The studies on mechanical properties cover tensile, flexural and impact test, while the physical tests consist of water absorption and thickness swelling of each mixture. Finally, the specimens are analysed using the scanning electron microscope (SEM) to determine the microstructure composition of ABS/FA and ABS/POFA composites.

1.5 Importance of Study

Fly ashes (FA) and palm oil fuel ash (POFA) are industrial waste that are currently disposed by agriculture industries without realizing their potential uses in other situation for example as filler or reinforcement in polymeric material. This study is significant as it positively contributes to the environmental cause through the utilization of the industrial wastes such as FA and POFA. It also provides potential benefits for plastic manufacturing industry by reducing the production cost of the ABS based products as well as highlighting the green factor of their products.. Thorugh the study on mechanical and physical properties of the composite, it is hoped that the best mixture of material that able to withstand unexpected extreme load or blast load can be found and this will be useful in the ABS manufactured application. Moreover, this study also will contribute to the future research development on industrial waste based material.

1.6 Research Planning

Gantt chart for the research is shown in Appendix A

CHAPTER 2

LITERATURE REVIEW

2.1 Composite Material

Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix, or binder (organic or inorganic) maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone. (Saira Taj et al, 2007).

Wood is natural three-dimensional polymeric composite and consists primarily of cellulose, hemicellulose and lignin. In addition, wood is an original and natural composite. The biological world offers other examples of composites in bone and teeth, which are essentially composed of hard inorganic crystals in a matrix of tough organic collagen. Significant examples include the use of reinforcing mud walls in houses with bamboo shoots, glued laminated wood by Egyptians (1500 BC) and laminated metals in the forging of swords (1800 AD). In the 20th century, modern composites were used in 1930s, where glassfibers reinforced resins. Boats and aircrafts were built out of these glass composites, commonly called fiberglass. Since the 1970s, the application of composites has widely increased due to development of new fibers such as carbon, boron and aramids, and new

composite systems with matrices made of metal and ceramics. Figure 2.1 shows the types of composites.

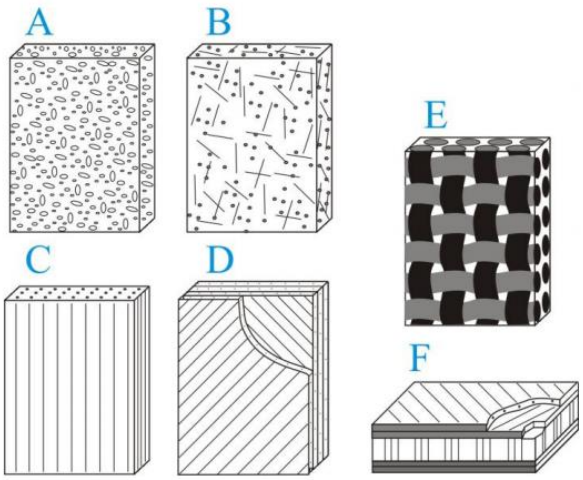

Figure 2.1: Various types of composites; A) reinforced by particles; B) reinforced by chopped strands; C) unidirectional composites; D) laminates; E) fabric reinforced plastics; F) honeycomb structure.

Modern composite is highly selected compare to other material. It is because they are stronger and lighter than its matrix compound. Based on the proper mixing of matrix and reinforcement of materials, new materials can be made to meet the requirement needed based on various applications. Regardless of its advantages, the cost of this material is usually expensive.

2.1.1 Application of polymer based composites

There are various application of composite that have been utilised around the world such as furniture, construction, and automobiles. In automobiles application, there are many parts of the cars, generally in Mercedes-Benz E-class, use composite and natural

fibers such as rear parcel shelf, door trim panels and seat cushion parts (Bajpai et al., 2012). The automotive parts that used natural fiber composites are shown in Table 2.1.

Table 2.1: Automotive parts produced from natural materials (Bajpai et al., 2012).

Vehicle parts	Material used
Glove box	Wood/cotton fibers molded, flax/sisal
Door panels	Flax/sisal with thermoset resin
Seat coverings	Leather/wool backing
Seat surface/backrest	Coconut fiber/natural rubber
Trunk panel	Cotton fiber
Floor panels	Flax mat with PP
Trunk floor	Cotton with PP/PET fibers

There are various applications of jute-reinforced polymer composite such as door panels, seat backs dash boards and trunk liners for automobile, ceiling floor and windows for building components table, kitchen cabinet and chair for furniture (Das S., 2009).

Hong et al, (2004) established a new dielectric constant material suitable to electronic material uses via hollow keratin fibers and chemically adjusted soybean oil. Or plastic/wood have been utilised heavily in various application in docks, window frames and decks. Ghavami, 2005 suggested to reinforce bamboo fiber in structural concrete elements. Composite that have been reinforced with natural fiber is preferable in construction application compare to other materials. Some parts in building construction that use this type of materials are fencing, bridge and door in building applications.

Asbestos- cement composites that hazardous for human and animal health can be replaced by sisal cement composites (Golbabaie, 2010).

In Figure 2.2, a car door panel assembly that made of polyester/jute composite. The excellent mixture of the composite can give the new material the ability to replicate the texture as same as high quality plastic products.

Figure 2.2: Car door panel assembly.

2.2 Acrylonitrile Butadiene Styrene (ABS)

Acrylonitrile butadiene styrene (ABS) plastics are modified with excellent performance, dimensionally stability, easy to shape and are widely used in various types of communications, digital, office equipment, household appliances, automotive component and other fields. Figure 2.3 shows the granule size of ABS in market.