DYNAMIC BEHAVIOUR OF BIOCOMPOSITES

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DECLARATION

I declare that this report entitled "Dynamic Behaviour of Biocomposites" is the result of my own work except as cited in the references

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Date : 24/6/2016

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

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DEDICATION

To my beloved father and mother

Ahmad Suhaimi Bin Hassan

Kamisah Binti Asmoni

ABSTRACT

This research project focuses on the dynamic behavior of pineapple leaf fiber reinforced poly lactid acid biocomposites, with limited resources currently available in the literature. In terms of fabrication of the biocomposites, the pineapple leaf fibre was pre-treated with natrium hydroxide prior to fabrication of the composite via a compression moulding process, with the aim to improve adhesion between the fibres and the matrix, leading to enhancement in the mechanical properties of the biocomposites. This research project considered both quasi static and dynamic loading condition. The quasi static indentation test was run using an Instron 5585 model Universal Testing Machine at crosshead displacement rate of 1 mm/min and 2 mm/min, simply supported in between the two support using a hemispherical steel indentor and centrally loaded during testing. As for the dynamic loading condition, an Instron Dynatup model 9250 HV dropweight impact test was used to conduct a low velocity impact test using a 10 mm diameter hemispherical steel indentor, simply supported and impacted at the centre of the square-sided test specimens with dimensions of 50 mm x 50 mm x 3 mm, using impact velocities of 1 m/s, 1.5 m/s, 2 m/s, 2.5 m/s, 3 m/s and 3.5 m/s. From the experimental results obtained from quasi static indentation test, it was observed that the specimens exhibit much higher maximum force and maximum stress, with the values of 2713.74 ±38.07 N and 36.19 ± 0.51 MPa, respectively when subjected to 1 mm/min, in comparison to that of the test results obtained for the 2 mm/min crosshead displacement rate. The corresponding damage for all the specimens can be classified as barely visible, limited to the contact loading radius. Meanwhile, as for the dynamic behaviour of the composites, from a series of dropweight impact test at impact velocities between 1 – 3.5 m/s, it was found that the maximum force increased with increasing impact velocity, from 1 to 2.5 m/s, with the highest value obtained at this impact velocity. From this point, there is a decrease in the maximum force when subjected to 3 m/s and 3.5 m/s. These observations can be correlated with the failure mechanism or damage mechanism present in the composite system. From visual observations on the specimens as well as morphological study via Scanning Electron Microscopy (SEM), it was found that the specimens underwent higher degree of damage when subjected to the dynamic loading conditions at different impact velocities. Cleary, significant damage is found starting from impact velocity of 1.5 m/s, as evident in the images captured.

ABSTRAK

Penyelidikan ini memfokuskan terhadap kesan dinamik atas bahan komposit polilaktid acid (PLA) diperkuat serat/gentian daun nanas., dengan sumber literatur yang terhad.Untuk fabrikasi biokomposit ini, serat/gentian nenas di rawat terlebih dahulu dengan natrium hidrosikda untuk megukuhkan lagi lekatan antara fiber dan matrik.Komposit ini terhasil dengan menggunakan proses pengacuan mampatan Rawatan in juga meningkatkan lagi sifat-sifat mekanik biokomposit tersebut.Terdapat dua ujian yang dilakukan dalam penyelidikan ini iaitu ujian takukan 'quasi' statik dan ujian hentaman dinamik. Ujian takukan 'quasi' statik ini dijalankan dengan menggunakan mesin Intron 5585 model Universal Testing Machine manakala ujian hentaman dinamik dijalankan menggunakan mesin Dynatup model 9250 HV.Ujian takukan 'quasi' static ini dilakukan menggunakan dua kelajuan hentamant iaitu 1 mm/min dan 2 mm/min dengan diameter pemberat sepanjang 10 mm.Ujian hentaman dinamik juga menggukan pemberat berdiameter sepanjang 10 mm dan dimensi bagi spesimen yang akan dijalankan ialah 50 mm x 50 mm x 3 mm dengan kelajuan hentaman 1 m/s, 1.5 m/s, 2 m/s, 2.5 m/s, 3 m/s dan 3.5 m/s.Keputusan eksperimen daripada ujian seakan statik mendapati bahawa daya maksimum dan tegasan bagi spesimen dengan nilai 2713.74 ±38.07 N and 36.19 ± 0.51 MPa ialah daripan kelajuan permberat sebanyak 1 mm/min berbanding dengan kelajuan pemberat sebanyak 2 mm/min.Kerosakan di spesimen-spesimen selepas ujian dilakukan tidak boleh dilihat dengan mata kasar. Manakala bagi ujian pembebanan dinamik, bagi kelajuan pemberat sebanyak 1 hingga 3.5 m/s, daya tekanan menujukkan menaik dari kelajuan 1 hingga 2.5 m/s dengan mencapai daya tekanan maksimum di tahap ini.Selepas kelajuan ini iaitu kelajuan 2.5m/s terdapat pengurangan nilai dalam daya tekanan maksimum di kelajuan 3 m/s dan 3.5 m/s. Pemerhatian daripada ujian pembebanan dinamik ini dapat dikaitkan dengan kegagalan mekanisme yang berlaku dalam sistem bahan komposit.Melalui pemerhatian visual dan juga kajian morfologi menggunakan mesin Scanning Electron Microscopy (SEM), spesimen mengalami kerosakan yang tinggi apabila dikenakan ujian pembebanan dinamik dengan kelajuan pemberat yang berbeza sangat jelas. Kerosakan ketara boleh dilihat pada spesimen yang dikenakan kelajuan sebanyak 1.5 m/s dan ini boleh ditunjukkan dalam gambar yang ditangkap.

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CHAPTER 1

INTRODUCTION

1.0 Background

Composites has widely use in today technology such as in aerospace industry and automotive industry [1]. This composite is made up from reinforcement and matrices. However majority of composites industry uses fiber-glass reinforced with plastic materials which are both expensive and harmful to the environment because the composites is not biodegradable [2].

Biocomposites concept is the same as composite, the difference between this two is biocomposites has environmental benefits. Both of it is renewable resource and good in biodegradability. Natural fibres reinforced into bioplastics are a good example of green composites, which is easily degradable by bacteria and enzyme [3]. Natural fibers has widely developed in the biocomposites industry nowadays such as Bamboo, Kenaf, Pineapple, and Jute as a reinforcement with plastic materials in the mechanical properties,molding condition, and interfacial bonding. Uses of these natural fibers as reinforcement are different if to compare with composite reinforcement such as fiber-glass and carbon-fiber. The mechanical properties, molding condition and interfacial bonding of natural fibers are depends on its shape, size and strength. It may vary depends on cultivation environment and other characteristics [4].

Pineapple is a plant that is widely grown in Malaysia as well as Asia. After banana and citrus, pineapple is one of the most essential tropical fruits in the world. Commercially pineapple fruits are very important and its leaves are considered as waste materials of fruit which is being used for producing natural fibres. PALF contains holocellulose (70–82%), lignin (5–12%), and ash (1.1%). Pineapple (PALF) has tremendous mechanical properties and can be applied in making of reinforced polymer composites [5]. A pineapple leaf fiber which is the subject present study is a waste product of pineapple cultivation. Thus PALF can be obtained for industrial purpose without any additional cost [2].

Polymer had been replaced many of the metals or materials in various applications in the past decades. Polymer has advantages which its ease of processing, productivity, and cost reduction. Most polymers are modified using filler and fibers to suit the high strength requirements. Fiber reinforced with polymer shows advantages over other conventional materils when its specific properties are compared. The polymer that researcher always use with natural fiber are polypropylene (PP) and Polyactic acid (PLA) [1].

Chemical treatment is used to provide strong bond between two materials otherwise the surface of these two materials will incompatible. If the reinforcement which is natural fiber and its matrices which are plastics have a strong or stable bond then the composites will show result in high strength of composites. Chemical treatment is usually to modify fiber surface and improve its interfacial adhesion. Chemical treatment such as alkaline treatment, Silane treatment and acetylazation are usually used on natural fibers [6].

1.1 Objectives

The objectives of this research are:

1. To characterize the quasi-static behavior of PALF reinforced PLA biocomposites.
2. To study the strain rate effect on the dynamic mechanical behavior of PALF reinforced PLA biocomposites.

1.2 Scopes

The scopes of this project are listed as below:

i. Selection of materials and chemicals for the composites.
ii. Fabrication of biodegradable polymer composites test panels.
iii. Mechanical testing.
iv. Surface morphology

1.3 Problem Statement

Composites is suitable in manufacturing industry in this world because it easily degradable but nowadays, government all over the countries is very concern about environment and for the sake of environment, scientist has found sustainable method and low energy consumption needed which is biocomposites [1].

Many research shows result of Pineapple Leaf Fiber (PALF) reinforced with polypropylene (PP) but there are not many study of dynamic behavior of PALF reinforced with Polyactid Acid (PLA) [2]. Thus this research is to characterize biocomposites of PALF reinforced with PLA and compare the result with other study result.

1.4 Plan And Execution

There are 15 weeks given to finish PSM 1. A GANNT chart is made from week 1 to week 15. Briefing is held on the first week and follows by weekly meeting the next week till week 14. Flow chart is mad on week 6 and GANNT chart is made on week 4. While for fabrication process, most of the process such as fabrication of PLA, short fiber PALF, and long fiber PALF will be make from week 5 till week 12. The characterization and testing for the composites will be done on week 9 till week 13. Data analysis and report writing will be done on week 11 till week 15. Next, poster presentation which will be on week 7.Lastly, report submission and PSM 1 seminar will be on week 15. Table 1.1 shows GANNT chart from week 1 to week 15.

Table 1.1: Gannt Chart for PSM 1

CONTENT	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
MEETING															
BRIEFING		■													
WEEKLY MEETING			■	■	■	■	■	■	■	■	■	■	■	■	■
DESIGN OF EXPERIMENT															
FLOW CHART						■									
GANTT CHART				■											
FABRICATION															
PLA (PLAIN)					■	■	■	■	■	■	■	■			
COMPOSITES (SHORT FIBER)					■	■	■	■	■	■	■	■			
COMPOSITES (LONG FIBER)					■	■	■	■	■	■	■	■			
CHARACTERIZATION/TESTING															
PHYSICAL									■	■	■	■	■		
THERMAL									■	■	■	■	■		
MECHANICAL									■	■	■	■	■		
DATA ANALYSIS											■	■	■	■	■
REPORT WRITING											■	■	■	■	■
POSTER							■								
REPORT SUBMISSION															■
PSM 1 SEMINAR															■

Table 1.2 below shows the gannt chart for PSM 2. Material review will be on week 1 till week 3. Experimental work and fabrication for PALF-PLA composite were carried on week 3 till week 11. The mechanical tests were carried on week 9 till week 13 while the result will be discussed on week 12 to week 14. Submission of PSM 2 final report is on week 14 and PSM 2 seminar is on week 15.

Table 1.2 Gannt Chart for PSM 2

CONTENT	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
Material review	■	■	■												
Design test model			■	■											
Experimental work		■	■	■	■	■	■	■	■	■	■				
Fabrication		■	■	■	■	■	■	■	■	■	■	■			
Mechanical test										■	■	■	■		
Analysis												■	■		
Result & discussion												■	■	■	
Submission of PSM II report														■	
PSM 2 seminar															■

CHAPTER 2

LITERATURE REVIEW

2.0 Composites

People have been making composites for many thousands of years. One early example is mud bricks. Mud can be dried out into a brick shape to give a building material. It has good compressive strength and it has poor tensile strength. Another ancient composite is concrete. Concrete is a mix of aggregate (small stones or gravel), cement and sand. It has good compressive strength (it resists squashing). In more recent times it has been found that adding metal rods or wires to the concrete can increase its tensile (bending) strength. Concrete containing such rods or wires is called reinforced concrete [7].

Composite is defined as the combination of two or more materials to become one material. One of the materials has very different properties. Each combination of the two material gives varies and unique properties. However, if the material did not dissolve or blend to each other, it cannot be call as composites [8]. Basically, composites are made up of matrix which is continuous and surrounds the other phase that is called dispersed phased [9] or binder that combines together with fibers or fragments of the other material that is called reinforcement [7]. Composites reinforcement is classified into three parts which are particle-reinforced, fiber reinforced and structural [9].

2.0.1 Fiber-Reinforced Composites

Fiber-reinforced composites can be divided into two parts which are continuous (aligned) and discontinuous (short). As shown in figure 2.1, Discontinuous type is divided into aligned and randomly oriented [9].

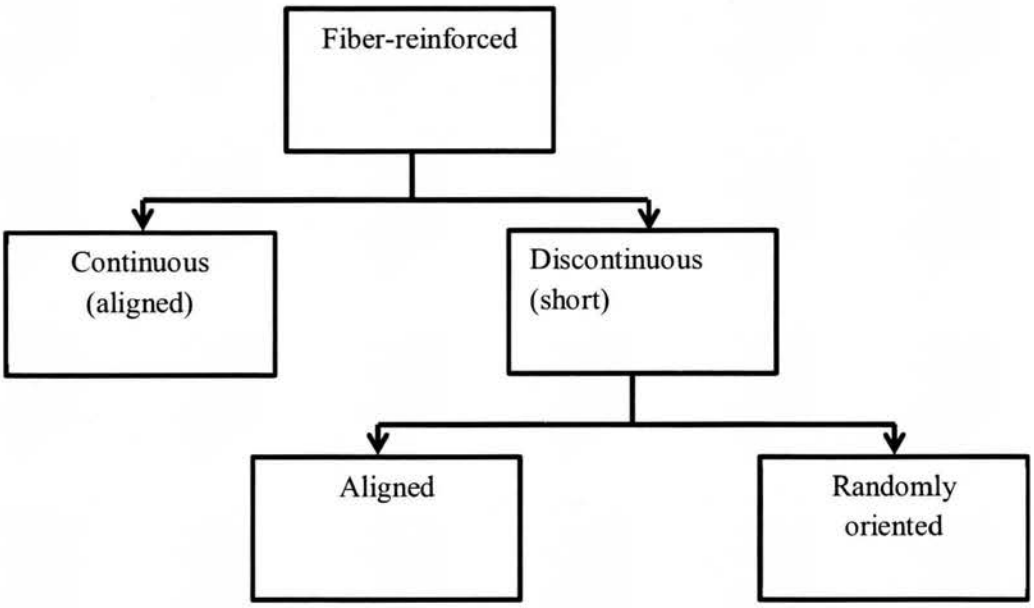

Figure 2.1 Classification of Fiber Reinforced [9]

Fiber-reinforced composites are composed of axial particulates embedded in a matrix material. The purpose of these fiber-reinforced composites is to obtain a material with high specific strength and high specific modulus. To obtain the strength, the applied load is transmitted from the matrix to the fibers. Thus, interfacial bonding is very important in fiber-reinforced composite [10]. There are three types of orientation in fiber-reinforced composite. These are continuous and aligned fibers, discontinuous and aligned orientation and discontinuous and random orientation as shown in figure 2.2 below.

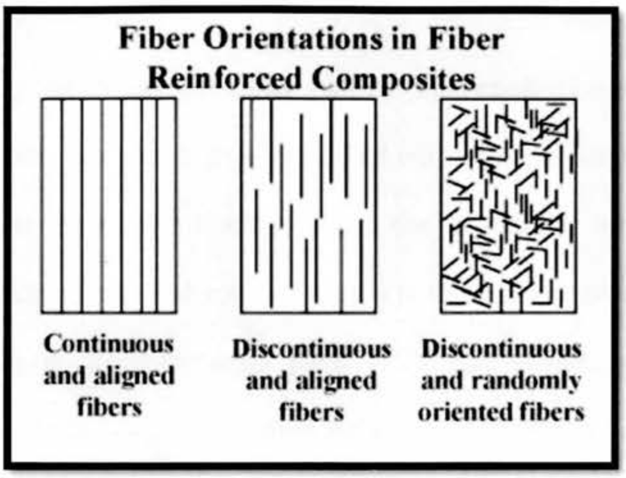

Figure 2.2 Fiber Orientations in Fiber-Reinforced [10]

For aligned orientation, the properties of the composite material are highly anisotropic. The longitudinal tensile strength will be high whereas the transverse tensile strength can be much less than even the matrix tensile strength. It will depend on the properties of the fibers and the matrix, the interfacial bond between them [10]. For discontinuous and random orientation, the strength will be not as high as with aligned fiber; however the advantage is that the material will be isotropic and much cheaper.

2.0.2 Polymer-Matrix Composites

Organic-matrix composites (OMC) are basically included polymer-matrix composites and carbon matrix-composites. Over the past 30 years, OMCs have won increasing mass fraction of aircraft and spacecraft structure because it can produce materials with high strength and stiffness values compare to existing structural material [11].

Polymer matrix composites are consists of a variety of short on continuous fiber combined together by an organic polymer matrix. The reinforcement in polymer-matrix composites which is fiber provides high strength and stiffness. The polymer-matrix composite is designed so that the mechanical loads to which the structure is subjected in service are supported by the reinforcement. The matrix function in these composites is to bond thè fibers together and to transfer loads between them [12]. The advantage of polymer-matrix composites is its lightweight coupled with high stiffness and strength along the direction of the reinforcement. This advantage is applied on aircraft, automobiles and other moving structures. The matrix phase can be divided into two parts which are thermoplastics or thermosets [12].

2.0.3 Thermoplastics

Thermoplastic is a material based on polymer which can be shaped, in a liquid state at a temperature either higher than its glass transition temperature or higher than its melting temperature. To shape thermoplastics composites, it is necessary to melt them by a processing machine such as an extruder or in an injection moulding press [13]. Thermoplastic is also easy to recycle [8]. Example of thermoplastics that are widely used in polymer-matrix composites are Polypropylene (PP) , Polyethylene (PE),and Polyvinyl Chloride (PVC) [12] .

2.0.4 Thermosets

Thermosets is a type of polymer plastics that are synthetic materials that strengthen during being heated but cannot be shaped, remolded or reheated after the early heat-forming. It is suitable production that is permanent and large in size. It has good strength although it is