

**The effect of rice husk additive on physical properties and applicability of Low  
Density Polyethylene**

by

Shahrul Ahmizan Bin Musa

Dissertation submitted in Partial Fulfillment of  
The requirement for the  
Bachelor of Engineering (Hons)  
(Mechanical Engineering)

© Copyright 2004  
by  
Shahrul Ahmizan Musa

Universiti Teknologi PETRONAS  
Bandar Seri Iskandar  
31750 Tronoh  
Perak Darul Ridzuan

## **CERTIFICATION OF APPROVAL**

**The Effect of Rice Husk Additives on Physical Properties and Applicability of Low  
Density Polyethylene.**

By

Shahrul Ahmizan Bin Musa

A project dissertation submitted to the  
Mechanical Engineering Programme

Universiti Teknologi PETRONAS

In partial fulfilment of the requirement for the  
BACHELOR OF ENGINEERING (Hons)

(MECHANICAL ENGINEERING)

Approved:



[Mr. Sia Chee Wee]  
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS  
TRONOH, PERAK

May 2004

## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgement, and the original work contained herein have not been undertaken or done by unspecified sources or persons.



SHAHROL AHMIZAN BIN MUSA

## ACKNOWLEDGEMENT

First, I would like to take this opportunity to express my deepest gratitude to my Final Year Project supervisor, Mr. Sia Chee Wee, who spends his time and effort giving guidance to me throughout the year. He is committed in providing valuable information and suggestion, showing excellent support and explaining every single detail. This project might not have proceeded well without his kindness and support.

Besides that, I would like to thank to all University Teknologi Petronas Final Year Project committee members and the coordinators whom had gave a continuous support, guidance and provide all the facilities needed towards the achievement of the aim of the project.

In addition, thanks to all lecturers and technicians especially from Mechanical Engineering Department for their help and guidance throughout my studying period in UTP and during this phase of the project accomplishment.

Finally, I would like to express my appreciation to all personnel who have involved directly and indirectly especially to my parents in helping me to materialize the objective of this project.

May God bless you all.....

## ABSTRACT

In this particular project, a polymer composite called polyethylene-rice husk (RH-LDPE) were produced by using lignocellulosic materials such as rice husk flour as the reinforcing fillers and low density polyethylene as the matrix or polyols. From this material, a particle-reinforced composite will be used to determine testing data for the mechanical properties of the composite as the filler's volume and size are varies. The properties investigated are tensile modulus and impact strength. These properties are investigated according to the standard testing, namely the ASTM (American Society for Testing and Materials) standard. The effect of percentage of rice husk (by weight), and rice husk size on the tensile and impact properties were investigated. For most tests, the properties increased as the weight percentage of rice husk (RH) and sizes were increased. However, after exceeding a threshold value, the properties started to decrease. This phenomenon was attributed to two factors, which is percentage of rice husk (by weight) and percentage of rice husk OH groups. As the weight percentage of rice husk (RH) increased, the absorption and swelling decreased thus making the mechanical properties decreased. the size of rice husk (RH) also played a significant role in the properties, where smaller size rice husk produced composites with higher strength. This is due to greater surface area for interaction between the two materials. The result of the project shows that the possibility of using lignocellulosic materials as reinforcing fillers in the thermoplastic polymer composite is high. By using low density polyethylene (LDPE) as the matrix and rice husk as the reinforcing filler, a better particle-reinforced composites are managed to be produced in order to determine testing data for the physical and mechanical properties of the composite.

## TABLE OF CONTENTS

<b>CERTIFICATION OF APPROVAL</b>	<b>iv</b>
<b>CERTIFICATION OF ORIGINALITY</b>	<b>v</b>
<b>ACKNOWLEDGEMENT</b>	<b>vi</b>
<b>ABSTRACT</b>	<b>vii</b>
<b>CHAPTER 1: INTRODUCTION</b>	<b>1</b>
1.1 Background of study	1
1.2 Problem statement	3
1.3 Objective and Scope of Study	4
<b>CHAPTER 2: LITERATURE REVIEW AND THEORY</b>	<b>5</b>
2.1 General polymer processing	5
2.2 General polymer testing	6
2.3 Properties of rice husk	7
2.4 Properties of LDPE	8
<b>CHAPTER 3: METHODOLOGY</b>	<b>13</b>
3.1 Literature research	13
3.2 Material preparation	14
3.3 Sample preparation	14
3.4 Determination of rice husk density	14
3.5 tensile testing	15
3.6 Izod impact testing	15

<b>CHAPTER 4: RESULT AND CALCULATION</b>	.	<b>16</b>
4.1 Determination of rice husk density calculation	. .	<b>16</b>
4.2 Graph and analysis	. . . . .	<b>19</b>
<b>CHAPTER 5: DISCUSSION</b>	. . . . .	<b>26</b>
<b>CHAPTER 6: CONCLUSION AND RECOMMENDATION</b>	.	<b>28</b>
<b>REFERENCES</b>	. . . . .	<b>30</b>
<b>APPENDIX</b>	. . . . .	<b>31</b>

## LIST OF FIGURES

Figure 1: The covalent bonding of ethene molecules

Figure 2: The graph of load versus elongation for LDPE polymer and RH filled polymer composites at various filler loading.

Figure 3: The graph of ultimate tensile strength versus filler loading capacity for RH filled polymer composites at various filler loading.

Figure 4: The graph of modulus of elasticity versus fillers' loading capacity for RH filled polymer composite at various filler loading.

Figure 5: The graph of maximum elongation versus fillers' loading capacity for RH filled LDPE polymer at various filler loading.

Figure 6: The graph of modulus of elasticity versus filler sizes at 8%wt filler loading

Figure 7: the graph of tensile strength versus filler sizes at 8%wt filler loading

Figure 8: The graph of maximum elongation versus filler sizes at 8%wt filler loading



## **LIST OF TABLE**

Table 1: Representative value of thermal transitions for semicrystalline polymers.

Table 2: Mechanical properties of representative polymers

Table 3: Value of notched-Izod impact strength for some representative polymer

Table 4: The list of mass of rice husk and LDPE for injection molding.

# CHAPTER 1

## INTRODUCTION

### 1.1 BACKGROUND OF STUDY

Globally, many lignocellulosic fiber options exist for the production of composite products. A literature search was conducted at the USDA Forest Service, Forest Products Laboratory to survey the worldwide use of agricultural fibers in composite building products. A total of 1,039 citations were selected from the vast number available. Among the material that have the potentials are rice husk, corn stalk, cotton stalk, bagasse, coconut coir, jute and kenaf.

In a broad sense, a composite can be defined as any combination of two or more resources, in any form, and for any use [2]. For the purposes of this discussion, the term composite describes two situations. The first is when the lignocellulosic serves as the main ingredient in the composite. The second is when the lignocellulosic serves as a reinforcing filler or aggregate within a matrix material. Whatever scenario is used, the objective of composite development is to produce a product whose performance characteristics combine the beneficial aspects of each constituent component.

The study of polymer additives is not a relatively new subject; in fact, quite a lot of information could be obtained from books, journals and the Internet. However, it is considered quite a challenge to discover new material that is cheap and applicable to be used in polymer industries. Due to its availability in our local community, rice husk is considered the best material that can be used for this objective. In order to do this, a project need to be carried out to discover the effect of variation of rice husk filler additives to the physical properties and applicability of low density polyethylene (LDPE). Thus, at the end of the project, the results and data collected can be the answer whether or not this idea is applicable to be commercialised.

Before the project can be carried out, the study on the properties of rice husk and the low density polyethylene (LDPE) is essential. Therefore, the author needs to find out the properties of rice husk and how it can improve the properties of low density polyethylene (LDPE) composite. In this project, the effects of rice husk properties like its texture, size and mixture percentage (by weight) will be investigated. In this case, the author needs to study the effect of rice husk properties on the flexural, tensile and impact strength of polyethylene. Theoretically, the physical properties of polyethylene increased as the percentage of rice husk are increased. However, after exceeding a threshold value, these properties started to decrease. The size of the rice husk filler can also affect the findings where smaller rice husk size produced composites with a better and increased mechanical properties.

## 1.2 PROBLEM STATEMENT

As the polymer composites is widely used in the various engineering products especially in plastic industry, the study of rice husk as an additives is indeed very important.

Currently, most of the additives used in the commercial polymer industries are expensive and rare. Such additives are mica, silica and fibres. Therefore, the study to replace these additives with a new material is essential. The problem faced by the author is that the existing study on the rice husk is quite little that make the project have limited resources. It is the author's interest that this project would ascertain that rice husk is a good material that can be used as additives in polymer industries.

Recently, utilization of biomass resources has been the subject of various studies. In Malaysia, rice husk is one biomass materials that is a by-product from the rice industry. Many studies have been carried out on the utilization of biomass such as particle board, medium density fiberboard, pulp and composites [8]. In general, utilization of biomass in lignocellulosic composites have several advantages such as low density, greater deformability, less abrasiveness to equipment, biodegradability and low cost. However, in producing a good lignocellulosic composite, the main obstacle to be resolved is the compatibility of the fiber and matrix. The properties of the lignocellulosic composites are dominated by the interfacial interaction between the lignocellulosic filler and polymer matrix.

As such, the problem statement for this project is to prove that rice husk can be used to change and improve the physical properties such as tensile and impact strength of low density polyethylene (LDPE) as the filler's volume fraction and size varies.

## **1.3 OBJECTIVES AND SCOPE OF STUDY**

### **1.3.1 Objectives**

The objectives of the project are as follows:

- To study the effect of weight percentage and size of rice husk on the physical properties of low density polyethylene (LDPE). These physical properties are tensile modulus and impact strength.
- To prove that rice husk is an applicable new material that can be used as additives in commercial polymer industries.
- To run an experiment to collect results and investigate truth behind the theoretical fact on the rice husk.

### **1.3.2 Scope of study**

The scope of this project would evolve around conducting the experiment in order to investigate the effect of weight percentage and size of rice husk on the physical properties of low density polyethylene (LDPE). In order to do this, the author required to grind the rice husk into the desired size and allow to mix with the polymers under certain procedures. The properties of the mixtures are then investigated.

The calculation and measurement of the physical properties of the mixture would be conducted using the most readily available appliances, most probably using the mechanical procedures.

## **CHAPTER 2**

### **LITERATURE REVIEW AND THEORY**

Recently, utilization of biomass resources has been the subject of various studies. In Malaysia, rice husk is one biomass materials that is a by-product from the rice industry. Many studies have been carried out on the utilization of biomass such as particle board, medium density fiberboard, pulp and composites. In general, utilization of biomass in lignocellulosic composites have several advantages such as low density, greater deformability, less abrasiveness to equipment, biodegradability and low cost.

Therefore, various synthetic polymers are being prepared combined with various reinforcing fillers in order to improve the mechanical properties and obtain the characteristics demanded in actual application. Studies are ongoing to find ways to use lignocellulosic fibers in place of synthetic fibers as reinforcing fillers. These natural fillers are especially being sought since the production of composites using natural substances as reinforcing fillers is not only inexpensive but also able to minimize the environmental pollution caused by the characteristic biodegradability, enabling these composites to play an important role in resolving future environmental problems.

#### **2.1 GENERAL POLYMER PROCESSING**

Polymer processing can be divided into five basic processing operations – extrusion, molding, spinning, calendering, and coating. As for this project, the polymer processing required is injecting molding.

Molding is normally a batch process where it is run through various ways. These are includes compression, injection, transfer, blow and rotational molding. In the molding polymer processing, a mold is used to create the desired plastic parts. Example of a simple molding process is compression molding where the resin is placed in the bottom half of an open heated mold. Then, the top half of the mold is placed over the bottom half. Next, the pressure is applied to cause the resin to completely fill the cavity, while

the excess resin is forced out of the mold as flash. Where else, in injection molding, the reciprocating screw is used to melt a measured volume of feed introduced through the hopper. After a sufficient time has elapsed to form a homogenous melt, the rotation of the screw ceases, and the melt is rammed into a mold under high pressure by a hydraulically driven thrust of the screw. The amount of resin that can be molded may vary with a particular machine from a few grams to few kilograms, with clamping forces up to 5000 tons.

Injection molding is used extensively for the manufacture of polymeric items. A reciprocating/rotating screw both melts polymer pellets and provides the pressure required to quickly inject the melt into a cold mold. The polymer cools in the mold and the part is ejected. Injection molding machines are sized primarily by the force available in the mold clamping unit; ranging from 20 tons in laboratory machines to over 5000 tons in large commercial machines.

## **2.2 GENERAL POLYMER TESTING**

The properties of the polymers can be determined through different kind of testing under different variety of loading condition. These testing can be classified as static (tensile and shear), transient (creep and stress relaxation), impact (Izod and Charpy) and cyclic (fatigue testing).

Tensile tests are used to measure the force response when a sample is strained, compressed or sheared at constant rate. This provides a means to characterize the mechanical properties of a polymer in terms of modulus, strength and elongation to failure.

Impact testing measures the energy expended up to failure under conditions of rapid loading. There are a number of different types of impact tests. This includes the widely used Izod and Charpy tests in which the hammerlike weight strikes a specimen and the energy to break is determine from the loss in the kinetic energy of the hammer. Other

variations include the falling-ball or dart test, whereby the energy-to-break is determined from the weight of the ball and the height from which it is dropped. Values of impact strength may also be calculated from the area under the stress-strain curve in high-speed tensile test.

Information obtained from the impact test may be used to determine whether a given plastic has sufficient energy-absorbing properties to be useful for a particular application such as plastics for beverage bottles or window replacement. In such cases, it is important that the material be tested at temperatures and impact conditions close to those of actual use because impact strength will decrease with decreasing temperature and increasing rate of deformation. The presence of defects that act as stress concentrators will also reduce impact strength. In order to standardize impact results or to study the effect of cracks and other defects on impact properties, samples with inscribed notches of specified dimensions are often used.

### **2.3 PROPERTIES OF RICE HUSK**

Rice husk is an agricultural waste that available in fairly large quantities in Malaysia. Trees “store on the stump” and with rare exception other lignocellulosics do not share this luxury. Rice husks are a notable exception because they are stored on the grain. The grain is stored to be milled year round, making the availability of rice husks reasonably uniform. Rice usually comes to the mill at about an 8% moisture content level. Rice husks are quite fibrous by nature and little energy input is required to prepare the husks for board manufacturer. To make high-quality boards, the inner and outer husks are separated and broken at their “spine.” This can be accomplished by hammer milling or refining. Rice husks have a high silica content, and present the same cutting tool problems. The density of the rice husk is calculated at the methodology section to be at about 0.7252 g/cm<sup>3</sup>.



Rice husks are generated during the first stage of rice milling, when rough rice or paddy rice is husked i.e. husk is separated from the rest of the grain.

- In general, 100 kg of paddy rice will generate 20 kg of husks. Short grain varieties produce slightly more hull than medium or long grain varieties.
- Moisture content of rice husk is around 10%; the equilibrium moisture content is lower than that of paddy or rough rice.
- Bulk density of rice husks is 100 to 150 kg/m<sup>3</sup>. If rice husks are ground, bulk density increases to 200 to 250 kg/m<sup>3</sup>.
- Rice husk contains 16 to 22% ash, and 90-96% of the ash is composed of silica. Therefore, rice husk ash can be considered a slightly impure form of silica.
- The ash composition and structure give rice husks an abrasive character. Metal surfaces in frequent contact with rice husks will wear out and eventually puncture.
- The calorific value of rice hull is 14-16 MJ/kg on a 10% moisture content basis. In comparison, most dry woods contain 18-20 MJ/kg, and coal contains 25-30 MJ/kg. The higher the ash content of rice husks, the lower the calorific value.
- The main carbohydrate components of rice husks are cellulose and lignin.
- Rice husks contains only minor levels of potassium and chlorine, and therefore ash melting temperatures of rice hull are much higher than those of rice straw.

The size of rice husk also played a significant role in the properties, where smaller size rice husk produced composites with higher strength. This is due to the greater surface area for interaction between the rice husk and the polymers, which could be detected by scanning electron microscope (SEM) analysis. The rice husk must be grinded to the desired size and dried at 100 °C for 24 h before conducting the experiment. This is to ensure that the rice husk flour is at best condition for the experiment.

## 2.4 PROPERTIES OF LOW DENSITY POLYETHYLENE (LDPE)

Low density polyethylene (LDPE) is the low density version of polyethylene (PE). This has less hardness, stiffness and strength compared to high density polyethylene (HDPE), but better ductility. It is opaque and only thin foils can be transparent.

LDPE is used for packaging like foils, trays and plastic bags both for food and non-food purposes. Used as protective coating on paper, textiles and other plastics, for instance in milk cartons. LDPE can be categorized as thermoplastic. The products that can be used from LDPE are wrapping foil for packaging, plastic bag (soft type that does not crackle), garbage bag and tubes. Used PE plastic can be recycled through remelting although there is a quality loss. Incineration is straightforward and comparable to oil, since PE is only consist of hydrogen and carbon atoms. LDPE has excellent resistance to water, moisture and most organic solvents and chemicals except ones with aromatic or chlorine content.

Polyethylene is one of the simplest and most inexpensive polymers. It is a waxy, chemically inert plastic. It is named thus because it is obtained by the polymerization of ethylene (ethene). It is also known as polythene, a contraction of the name and even more simply as PE.

The ethene molecule (known almost universally by its non-IUPAC name ethylene),  $C_2H_4$  is  $CH_2 = CH_2$ , Two  $CH_2$  connected by a double bond, thus:

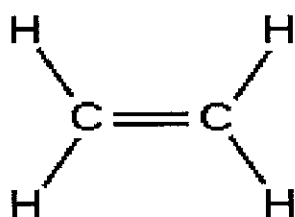


Figure 1: The covalent bonding of ethene molecules

In the polymerization process of ethene, the double bonds of the monomers are broken to allow additional single bonds to form amongst the carbon atoms, thus a macromolecule is created.

Polyethylenes are classified according to their density, which in turn depends on the extent and type of branching present in the material.

- HDPE (high density PE)
- MDPE (medium density PE)
- LDPE (low density PE)
- LLDPE (linear low density PE)

LDPE has many more branches than HDPE, which means that the chains do not "fit well" together. It has therefore less strong intermolecular forces as the instantaneous-dipole induced-dipole attraction is less. This results in a lower density and tensile strength, increased malleability and faster biodegradation. LDPE is created by free radical polymerization.

History has recorded that Polyethylene was first synthesized by the German chemist Hans von Pechmann, who prepared it by accident in 1898 while heating diazomethane. When his colleagues Eugen Bamberger and Friedrich Tschirner characterized the white, waxy substance he had created, they recognized that it contained long  $-CH_2-$  chains and termed it *polymethylene*.

The first industrially practical polyethylene synthesis was discovered (again by accident) by Eric Fawcett and Reginald Gibson at ICI Chemicals in 1933. Upon applying extremely high pressure (several hundred atmospheres) to a mixture of ethylene and benzaldehyde, they again produced a white waxy material. Since the reaction had been initiated by trace oxygen contamination in their apparatus, the experiment was at first

difficult to reproduce, and it was not until 1935 that another ICI chemist, Michael Perrin developed this accident into a reproducible high-pressure synthesis for polyethylene that became the basis for industrial LDPE production beginning in 1939.

For some polymers crystallized from the melt or from concentrated solution, crystallites can organize into larger spherical structures called spherulites. Each spherulite contains arrays of lamellar crystallites that are typically oriented with the chain axis perpendicular to the radial direction of the spherulite. In a few cases, such as occurs in the crystallization of polypropylene, chain folding will occur with the chain oriented along the radial direction [1].

Since no polymer is completely crystalline, even for most crystalline polymer like high-density polyethylene have lattice defect regions that contain unordered, amorphous material. Crystalline polymers may exhibit, therefore, both a  $T_g$  corresponding to long-range segmental motions in the amorphous region and a crystalline-melting temperature, or  $T_m$ , at which crystallites are destroyed and an amorphous, disordered melt is formed. For many polymers,  $T_g$  is approximately one-half to one-third of  $T_m$ . Below is the representative value of  $T_g$  and  $T_m$  for some semicrystalline polymer [2].

<b>Polymer</b>	<b><math>T_g</math>, °C</b>	<b><math>T_m</math>, °C</b>
Polypropylene	-15	176
<b>Polyethylene (LDPE)</b>	<b>-120</b>	<b>115</b>
Polycaprolactone	-60	61

Table 1: Representative value of thermal transitions for semicrystalline polymers.

Below is the theoretical value of mechanical properties of representative polymers [2].

Polymer	Elastic modulus, GPa	Yield strength, MPa	Ultimate strength, MPa	Elongation to break, %
Polypropylene	1.0-1.6	23	24-38	200-600
Polystyrene	2.8-3.5	-	38-55	1-2.5
Polycarbonate	2.4	55-69	55-69	60-120
Polyethylene (low-density)	0.14-0.28	6.9-14	10-17	400-700

Table 2: Mechanical properties of representative polymers

Typical values of notched-Izod impact strength for several important polymers are given in the table below [2];

Polymer	Impact strength, $\text{Jm}^{-1}$
Polystyrene	13 – 21
Poly (vinyl chloride)	21 – 160
Polyethylene(LDPE)	27 – 107
Polyethylene (HDPE)	27 – 1068

Table 3: Value of notched-Izod impact strength for some representative polymer

## **CHAPTER 3**

### **METHODOLOGY/PROJECT WORK**

#### **3.1 LITERATURE RESEARCH**

As the matter of a fact, most of the literature researches are conducted throughout the whole project timeframe. In order to gain as much information as possible, various books, journals and websites have been the important sources of finding. The researchers covered the finding for the basic concept of polymer processing and testing. This approach of work's outcome can be clearly concluded as follows:

1. Theoretical facts and information about rice husk and low density polyethylene.
2. Standard test and procedures involved.
3. Theoretical facts and information about properties to be investigated.

By doing research also, standard test and procedure involve in this project also can be identified. The standards are listed according to the specific sample's testing to be done. The standards identified for this project is as follow:

1. For tensile testing: ASTM D 638, standard test method for tensile properties of plastic.
2. For impact testing: ASTM D 256, standard test method for determining the izod pendulum impact resistance of plastics.

### **3.2 MATERIAL PREPARATION**

LDPE pellets was supplied by The Polyolefin Company (Singapore) Pte. Ltd. With density of  $0.917 \text{ g/cm}^3$  were used as the binder material. Meanwhile, the rice husk is obtained from the Bernas rice factory located in Sungai Manik, Perak.

### **3.3 SAMPLE PREPARATION**

RHF will be dried in an oven at  $100 \text{ }^\circ\text{C}$  for 24 h to adjust it to a moisture content of 1–2% to achieve ideal moisture of rice husk for interaction and then stored over desiccant in sealed containers. The rice husk is then grinded to the desired sizes by using mechanical grinder. The rice husk particle is separated according to size by using Endecotts sieve. There are six levels of particle sizes in this experiment. The sizes are 2000, 1180, 600, 425, 300 and 212 Micron. The separated rice husk particle is then stored in separate trays in an oven at  $25 \text{ }^\circ\text{C}$  for moisture maintaining. Seven levels of filler loading (2, 4, 6, 8, 10, 25 and 40 wt.%) will be used in the sample preparation. Tensile and Izod impact test specimens is prepared using an injection molding machine at  $169 \text{ }^\circ\text{C}$ , an injection pressure of 1200 psi, and a device pressure of 1500 psi. After molding, test specimens will be conditioned before testing at  $23 \text{ }^\circ\text{C}$ , 50% RH for at least 40 h according to ASTM D 618-99.

### **3.4 DETERMINATION OF THE DENSITY OF RICE HUSK**

The mass of LDPE is weighted in a beaker by using electronic beam. Meanwhile, the mass of the rice husk is also weighted in a beaker by using electronic beam. The two materials are then mixed together by using mechanical stirrer. The mixture is molded by using internal mechanical mixer. The polyethylene will be blended with rice husk flour in a two-roll mechanical mixer. Mixing is continued at  $200 \text{ }^\circ\text{C}$  for 15 min at a rotor speed of 20 rpm. A laboratory-size, twin-screw extruder is employed to compound the rice husk with the polyethylene as a matrix polymer. The extruded strand is pelletized and stored in sealed packs containing desiccant. The resultant composite was collected and the weight

and the volume of the specimen were determined. Finally, the density of the rice husk was determined from the formula.

### **3.5 TENSILE TESTING**

Tensile tests were carried out according to ASTM D638 on a **Monsanto tensometer T10**. Dumbbell specimens of 2 mm thick were clamped at both ends to perform tensile test. Two crosshead speeds of 50 and 100 cm/min was used and the test was performed at the temperature of 26°C. Five specimens were tested and the average was calculated in each cases.

### **3.6 IZOD IMPACT TESTING**

Notched izod impact strength tests will be conducted according to ASTM D 256-97 [6] at room temperature. The composites produced were cut into the required dimension proposed by the standard testing. The dimension of the test specimen was cut to be 6.5 cm x 1.2 cm x 0.8 cm (length x width x thickness). The test was carried out on notched a sample using a Zwick Impact Pendulum Tester Model 5101.



## CHAPTER 4

### RESULTS AND CALCULATION

#### 4.1 DETERMINATION OF THE DENSITY OF RICE HUSK

Mass of beaker = 172.0750g

Mass of beaker + LDPE = 590.6443g

Mass of LDPE = 590.6443 – 172.0750g

$$= \mathbf{418.5693g}$$

Mass of beaker = 162.4321g

Mass of beaker + rice husk = 194.0210g

Mass of RH = 194.0210 – 162.4321g

$$= \mathbf{31.5889g}$$

**Calculation of rice husk density by using the formula,**

From,

$$\rho_c = \rho_h v_h + \rho_{PE} v_{PE}$$

But

$$v_h + v_{PE} = 1$$

$$m_c / V_c = (m_h / V_h) v_h + \rho_{PE} v_{PE}$$

and

$$\rho_{PE} v_{PE} = (m_{PE} / V_{PE}) \times (V_{PE} / V_c) = m_{PE} / V_c$$

Therefore,

$$\rho_{PE}(1 - v_h) = m_{PE} / V_c$$

The value calculated was substituted in  $m_c / V_c = \rho_h v_h + \rho_{PE} v_{PE}$

Mass of composite,  $m_c = 418.5693g + 31.5889g = \mathbf{50.1582g}$

Volume of composite,  $V_c = \mathbf{500 \text{ cm}^3}$

Substitute,

$$\rho_{PE}(1 - v_h) = m_{PE} / V_c$$

The list of mass of the rice husk and LDPE are tabulated in the table below;

<b>%RH</b>	<b>Mass of RH (g)</b>	<b>Mass of LDPE (g)</b>
2	7.25	449.33
4	14.50	440.16
6	21.75	430.99
8	29.00	421.82
10	36.25	412.65
25	90.63	343.88
40	145.00	275.10

Table 4: The list of mass of rice husk and LDPE for injection molding.

## 4.2 GRAPH AND ANALYSYS

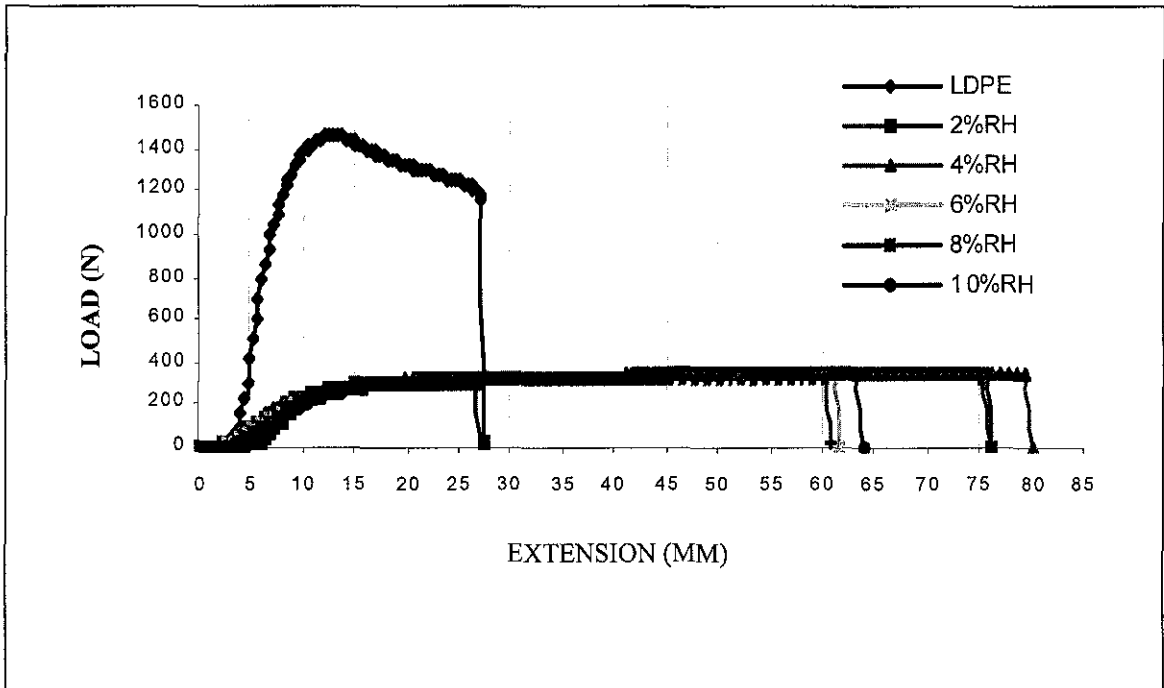


Figure 2: The graph of load versus elongation for LDPE polymer and RH filled polymer composites at various filler loading.

Figure 2 shows the effect of filler loading on the elongation strength of the RH-LDPE composites and the pure LDPE. As shown in the graph, the pure LDPE polymer shows more strength but less ductility. This is proven when the break happened at only 27 mm extension where else, the RH filled LDPE polymers breaks at a longer extension which is around 60-80 mm extension. This is because the RH filled LDPE polymers are more ductile if compared to the pure LDPE polymers. Toughness, from the graph of load versus elongation, can be quantified from the area under the graph. Referring to figure 2, the plain LDPE polymer is tougher compare to RH filled LDPE polymer composites.

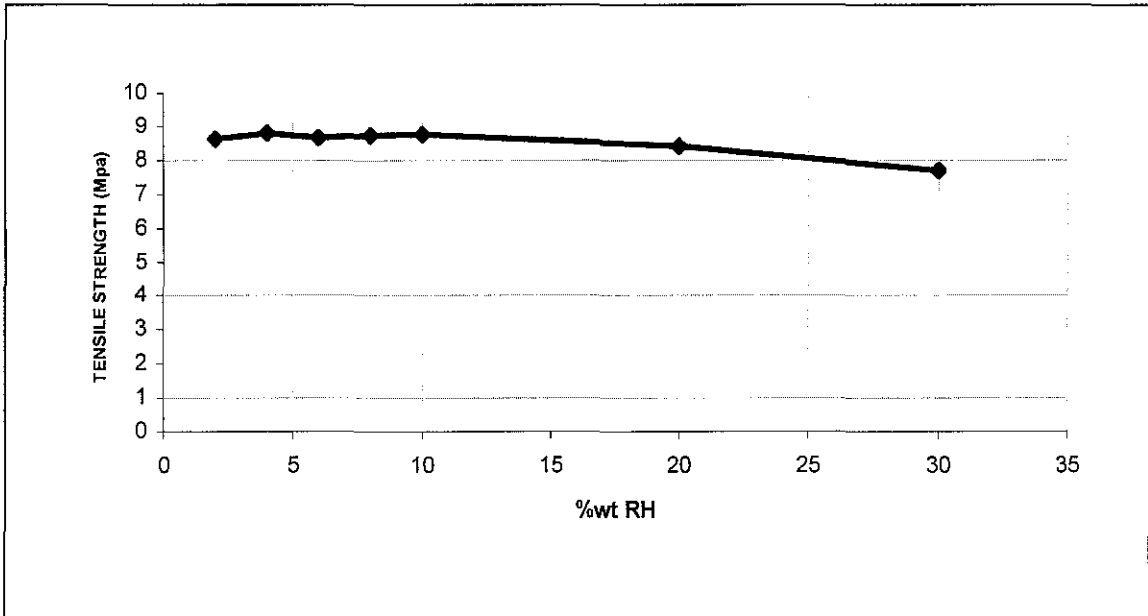


Figure 3: The graph of ultimate tensile strength versus filler loading capacity for RH filled polymer composites at various filler loading.

The tensile strength of LDPE polymer is significantly higher compares to the tensile strength of RH filled LDPE at various volumes fraction. At a big scale, the later are lingering in the range of 7.5 to 8.5 MPa. The tensile strength of the former pure LDPE polymer exceeds 36 MPa. With the introduction of RH as filler, the composites loose its strength. As the loading of the RH increases, the RH filled LDPE polymer composites' strength is degrading (Figure 3). No regular relationship that can tie the tensile strength and the RH loading.

By looking at figure 3, it can be seen that the tensile strength is higher at 4-10% of RH filler loading. After this threshold value, the tensile strength is decreasing. However, the enhancement of the properties is only observed for composite with 4% RH by weight, exceeding which, the strength decreases as the percentage RH (by weight) are increased.

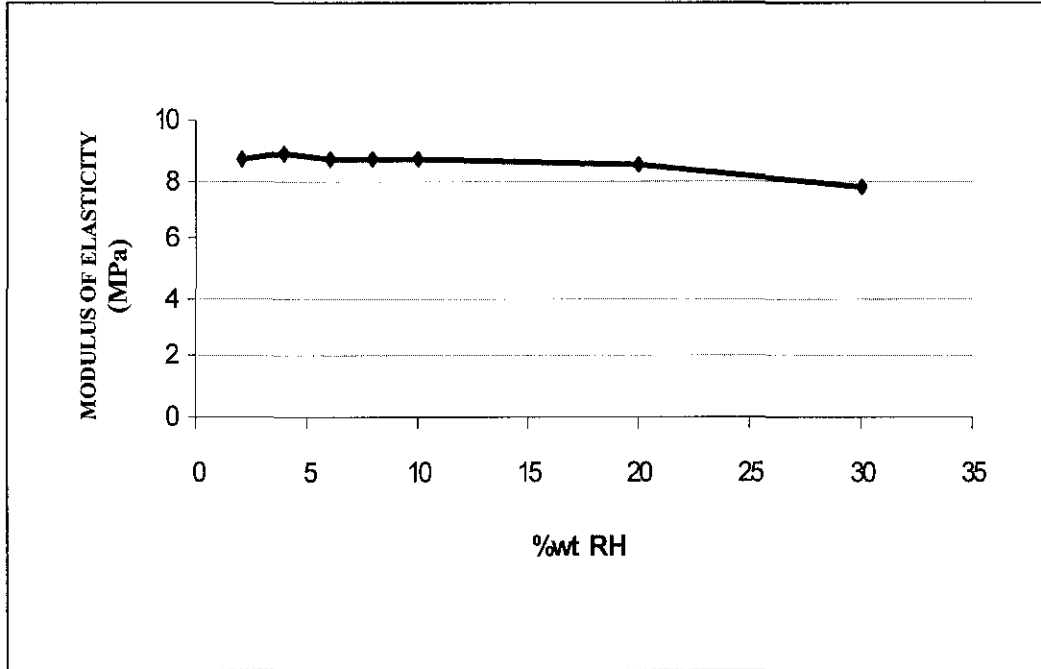


Figure 4: The graph of modulus of elasticity versus fillers' loading capacity for RH filled polymer composite at various filler loading.

The modulus of elasticity of the RH filled LDPE polymer composites are almost the same as the loading capacity varies (Figure 4) and as they are observed in the bigger scale (Figure 2), compares to the LDPE polymer, the ratio of the former to later is approximately 1:8. The RH filled polymer composites have the average of modulus of elasticity of 340 N/mm as the volume fractions of the fillers are varied up to 30%. Looking at the effect of the variation of the RH loading capacity, as they are increased the modulus of elasticity also increased

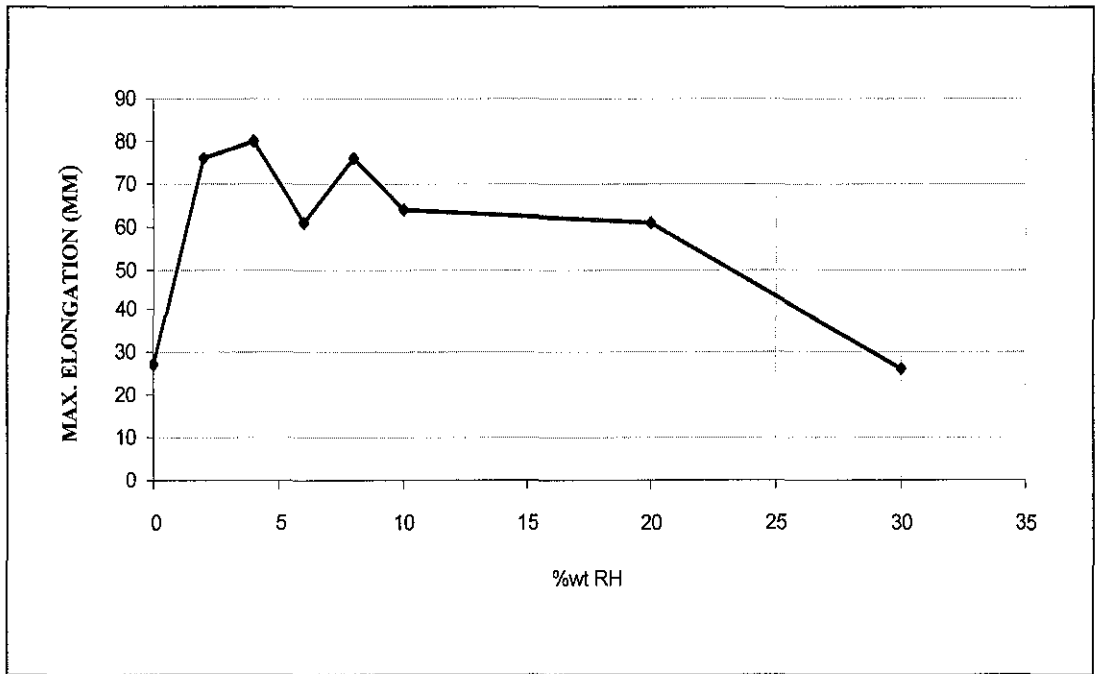


Figure 5: The graph of maximum elongation versus fillers' loading capacity for RH filled LDPE polymer at various filler loading.

LDPE polymer registers maximum elongation before failure of less than 30 mm. Meanwhile, the RH filled LDPE polymer composites are far more ductile than LDPE alone. As the percentage of volume of filler increases, the ductility of the composite is improved tremendously. (Figure 5). Nonetheless, at 30% of volume fraction of the filler, the composite get brittle. No regular relationship between ductility and loading capacity of the RH can be established.

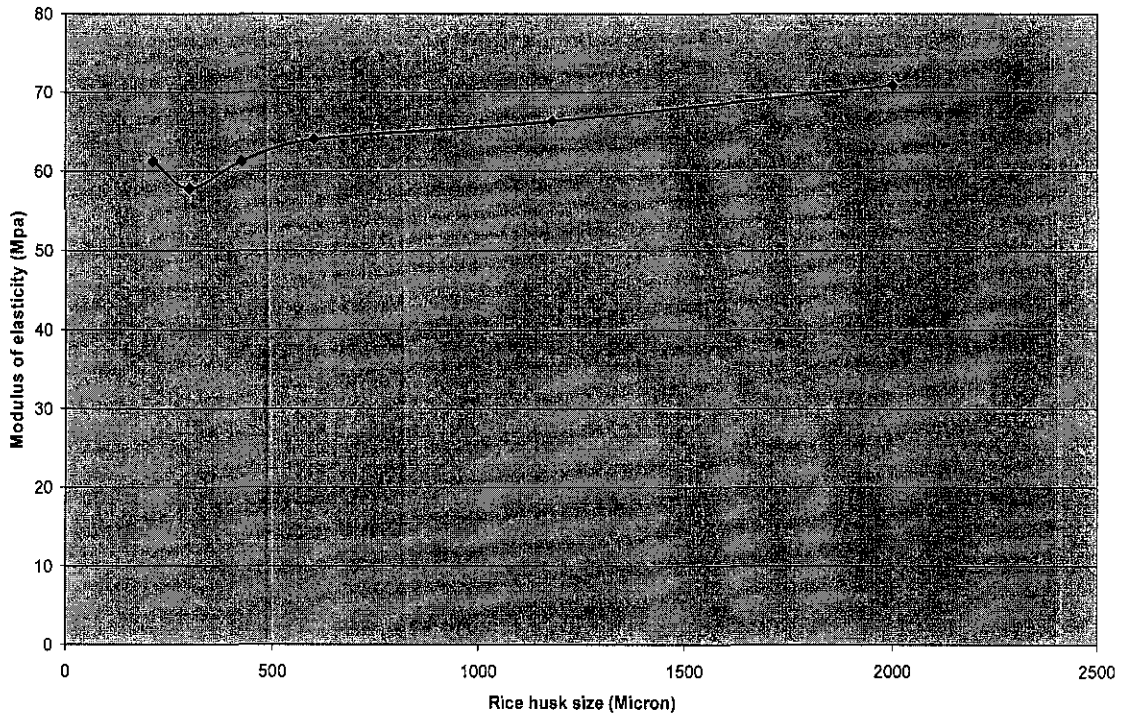


Figure 6: The graph of modulus of elasticity versus filler sizes at 8%wt filler loading

Figure 6 shows that there is a slight decrease in modulus of elasticity at filler size of 300 Micron but it started in increased at filler size of 425 Micron to 2000 micron. This indicates that the modulus of elasticity increase as the filler size increases.

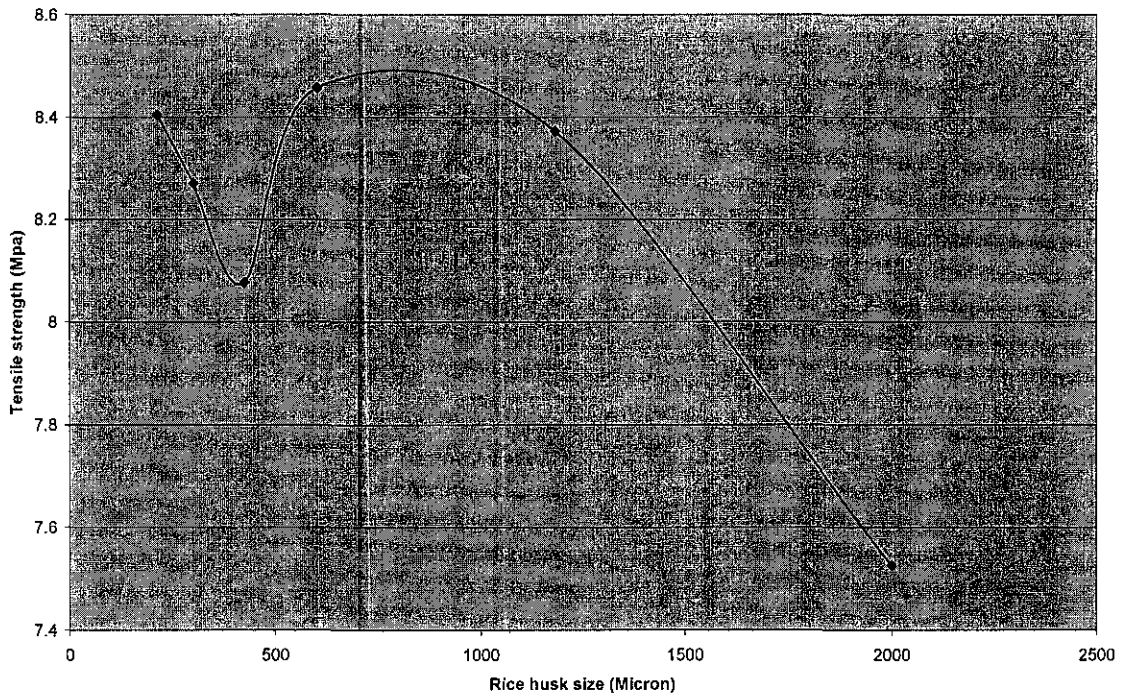


Figure 7: The graph of tensile strength versus filler sizes at 8%wt filler loading

Figure 7 shows that the tensile strength of the RH filled polymer decreases at filler sizes of 300-425 Micron. However, the tensile strength started to increase at filler size of 600 micron and started to decrease back. This indicates that the ideal size for better tensile strength of RH filled LDPE is around 600-1000 micron. This is because composite with smaller size RH displayed higher strength than those with a bigger size filler. This is expected because a smaller size filler gives a larger surface area for the interaction. This result is in agreement with other studies where composites with smaller size fillers produced higher tensile strength than those of larger size.



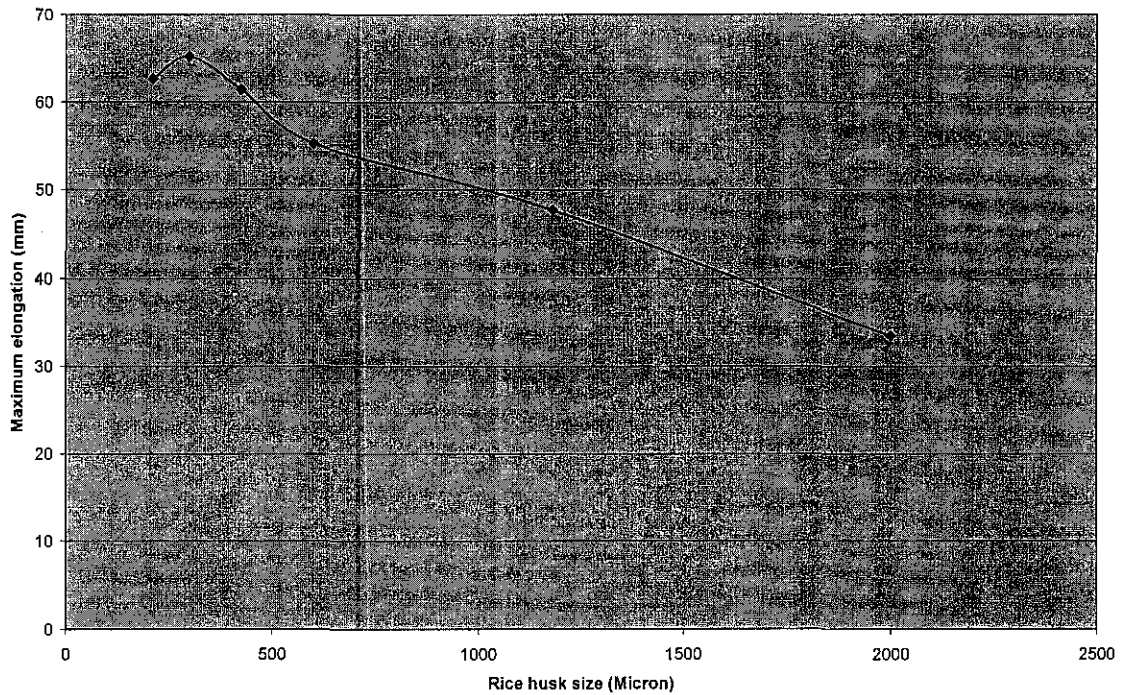


Figure 8: The graph of maximum elongation versus filler sizes at 8%wt filler loading

Figure 8 shows the maximum elongation versus filler sizes at 8%wt filler loading. It can be seen in the graph that the maximum elongation at break happened at filler size of 300 micron. However, after this threshold value, there is the reduction as the percentage of RH filler size increases at 425 micron. Again, it is believed that the deciding factor is the reduction of LDPE content, which resulted in the reduction of the matrix material in the composites to sustain elongation.

## CHAPTER 5

### DISCUSSION

Low density polyethylene as the matrix and rice-husk flour as the reinforcing filler were used to prepare a particle-reinforced composite in order to determine testing data for the physical, mechanical and morphological properties of the composite according to the filler loading in respect to thermoplastic polymer, low density polyethylene. In the sample preparation, seven levels of filler loading (2, 4, 6, 8, 10, 25 and 30 wt.%) were designed. For the filler size, there are six level of filler sizes were introduced (212, 300, 425, 600, 1180 and 2000 micron). In the tensile testing, there are two level of crosshead speed (50 and 100 mm/min) were designed. Tensile strengths of the composites slightly decreased as the filler loading increased. Tensile modulus improved with increasing filler loading. Notched Izod impact strengths were lowered by the addition of rice-husk flour.

The tests will be conducted at room temperature. Generally, fiber-reinforced composites have higher tensile strength than particle-reinforced composites. Tensile strengths of RH-LDPE composites slightly decreased with increasing filler loading. As the filler loading increased, thereby increasing the interfacial area, the worsening interfacial bonding between filler (hydrophilic) and matrix polymer (hydrophobic) decreased the tensile strength, which nevertheless remained within acceptable levels.

Tensile modulus improved with increasing filler loading. For irregularly shape fillers, the strength of the composites decreases due to the inability of the filler to support stresses transferred from the polymer matrix while poor interfacial bonding causes partially separated micro-spaces between filler and matrix polymer, which obstructs stress propagation when tensile stress is loaded and induce increased brittleness.

As the filler loading and crosshead speed increased, the composite became more brittle. As the filler loading increased, the fraction of thermoplastic polymer decreased and interfacial area increased, which increased the brittleness as described above. As the crosshead speed increased, the frictional resistance between filler matrix polymer

decreased, and this increased the brittleness. The nonlinearity in the curves is mainly due to the plastic matrix deformation.

For the impact testing, the tests were performed at room temperature. The notched Izod impact strength of the composites slightly decreased as the filler content increased. In the case of notched samples, the impact strength decreased with increasing amounts of RH added until a plateau was reached at a filler content of about 8 wt.%. Poor interfacial bonding induces micro-spaces between the filler and matrix polymer, and these cause numerous micro-cracks when impact occurs, which induce crack propagation easily and decrease the impact strength of the composites. The notched tip, which is the stress concentrating point, causes relatively low impact strength in the notched sample, thereby allowing the crack to propagate easily, and the same effect appeared at the filler-matrix interfacial area in the filler contained unnotched sample.

The unnotched Izod impact energies were considerably larger than notched Izod impact energies. This is due to the different fracture process for notched and unnotched samples. The unnotched impact behavior is controlled to a considerable extent by fracture initiation processes that, in turn, are controlled by stress concentrations at defects in the system. Notched impact behavior, meanwhile, is controlled to a greater extent by factors affecting the propagation of fracture initiated at the predominating stress concentration at the notched tip. In other words, unnotched Izod impact energies are not only a measure of crack propagation but also of crack initiation.

Based on the analysis, the data or results obtained are considered not 100 percent accurate. However, the results obtained can be considered as acceptable since the testing conducted is accordance to the ASTM standard. The results of this properties testing can be more elaborated and more accurate if examination into the microscopic level can be made. Due to time constraint and some technical problem faced, the microscopic level examination cannot be done in this project. Furthermore, if there are sufficient facilities, test according to ASTM standard can be done accordingly thus giving more accurate and better results.

## **CHAPTER 6**

### **CONCLUSION AND RECOMMENDATION**

Tensile strengths of the composites slightly decreased while the tensile modulus improved as the filler loading and crosshead speed increased, but the composites had an acceptable strength up to a filler loading of 30 wt.%. RH could be utilized as a biodegradable filler at end-of-use in polymeric materials to minimize environmental pollution rather than produce strong reinforcing filler. As the filler loading increased, the tensile property became more ductile, and the poor interfacial bonding between filler and matrix polymer caused decreased tensile and impact strength of the composites. Nevertheless, this problem could be reduced by using a compatibilizing or coupling agent, and further extended research is suggested.

Agricultural fibers have been successfully utilized in a variety of composite panels, most notably conventional composite panels and inorganic-bonded composites. Lignocellulosic/thermoplastic composites are a newer area of lignocellulosic utilization. It is anticipated that interest and commercial development will continue in this area. More than enough agricultural fiber residues are available to support composite manufacturing needs, although the agro-based materials may not have a suitable geographical distribution to provide an economically feasible endeavor. Lignocellulosics are attractive material sources for composites because they are lightweight, economical, and require low amounts of energy for processing. In addition, their growth, use, and disposal are generally considered environmentally friendly. As renewable materials, they can be used to replace or extend non-renewable materials such as those based on petroleum.

This report is a conclusion of student's Final Year Project accomplishment. The author has accomplished the objective of the project within the student's scope of study. However, there are some areas that could be improved in terms of accomplishment and achievement. The obvious one is the achievement of producing good dumbbell RH-LDPE composite specimens during injection molding. This is because the entire project is dependent on the accuracy of the sample prepared.

Nevertheless, due to some technical and non-technical problem faced, this investigation is conducted in a very simple way but still managed to meet the project requirement. As for others properties investigated, the aimed objectives are considered had been achieved since the test is conducted in accordance to specified ASTM standard.

This project can be continued further because some of the tests cannot be done due to the time constraint. This is because a lot of time is required during the sample preparation. If there are more test conducted, there must be more analysis can be performed and hence provide better results. It is highly recommended that this project will be continued for further testing with higher sophisticated equipment. Finally, it is recommended that the university can provide the facilities and more sources of technician available. This is because the university have only two technicians that are shared among number of student at the same time. The technician provided is essential to guide the student especially during conducting of a machine. I would recommend that the technicians are committed and only specialized in final year project so that they are available every time needed.

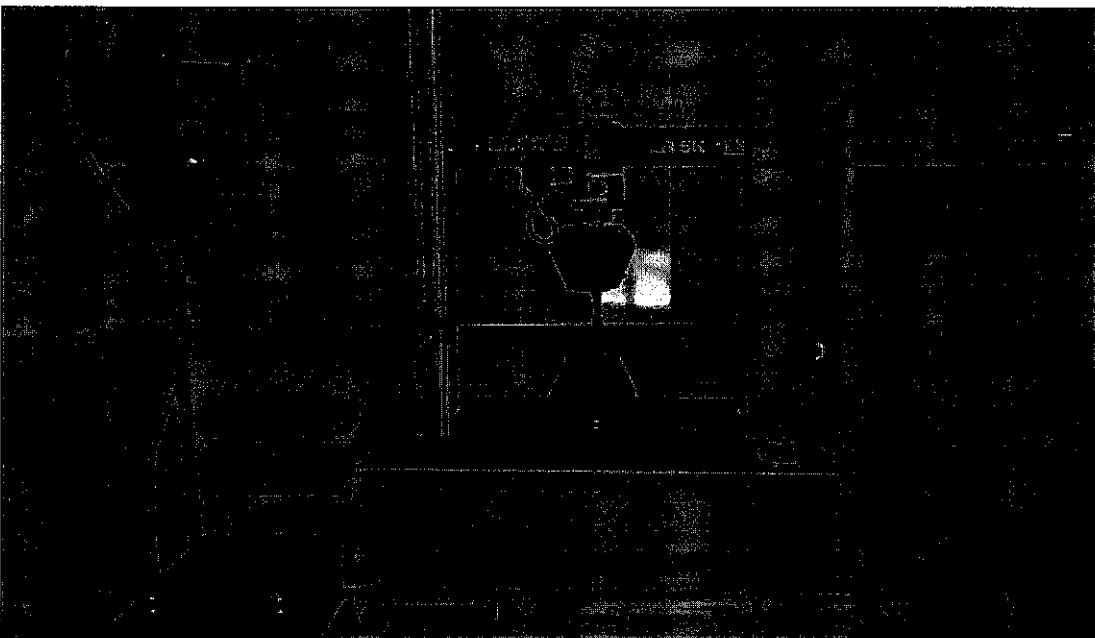
## REFERENCES

1. *Polymer science and technology*, Joel R. Fraid, Prentice Hall PTR, 1995.
2. *Comprehensive Polymer Science-The Synthesis, characterization, Reactions And Application Of Polymers*, Sir Geoffrey Allen, John C. Bevinton, Pergamon Press, volume 7, 1989.
3. *Polymer handbook*, J. Brandrup, E.H Emergat, E.A. Grulke, Wiley interscience, 4<sup>th</sup>. Edition, 1999.
4. *Engineering materials, properties and selection*, Kenneth G. Budinski, Prentice Hall international edition, 1999.
5. *ASTM D638-98*, standard test methods for tensile properties of plastics, West Conshohocken, American Standard for Testing and materials.
6. *ASTM D256-97*, standard test methods for determining the izod pendulum impact resistance of plastics, West Conshohocken, American Standard for Testing and materials.
7. <http://www.google.com>
8. *New type of polymers derived from lignocellulose and saccaharides*, K. Hatakeyama, H.Hirose, S.Nakamura, Ellis Horwood, New York, 1999.

## APPENDIX



**APPENDIX 1.1: The injection molding machine**



**APPENDIX 1.2: The Monsanto tensometer T10 machine**

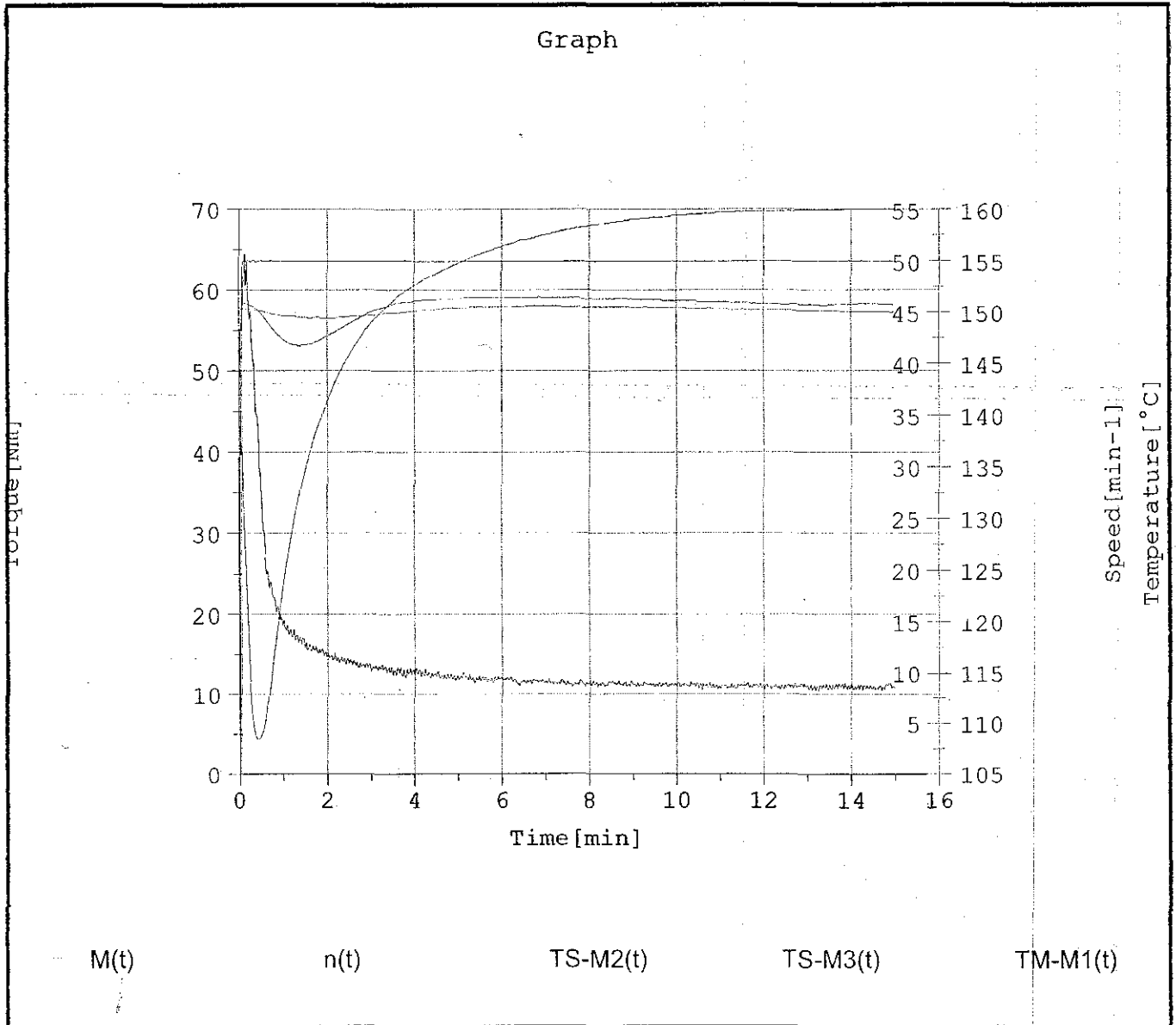


**APPENDIX 1.3: The internal mixer machine**



Filename: C:\PROGRA~1\THERMO~1\POLYLA~1\SEKAM3.MCM  
Company Mixer Rheomix3000p  
Operator  
Customer Rotor Roller-Rotors R3000  
Sample number  
Material  
Compound  
Conditions  
Density 0.00 g/cm<sup>3</sup>  
Mass 0.000 g

Date/Time March 11, 2004 / 17:11:52

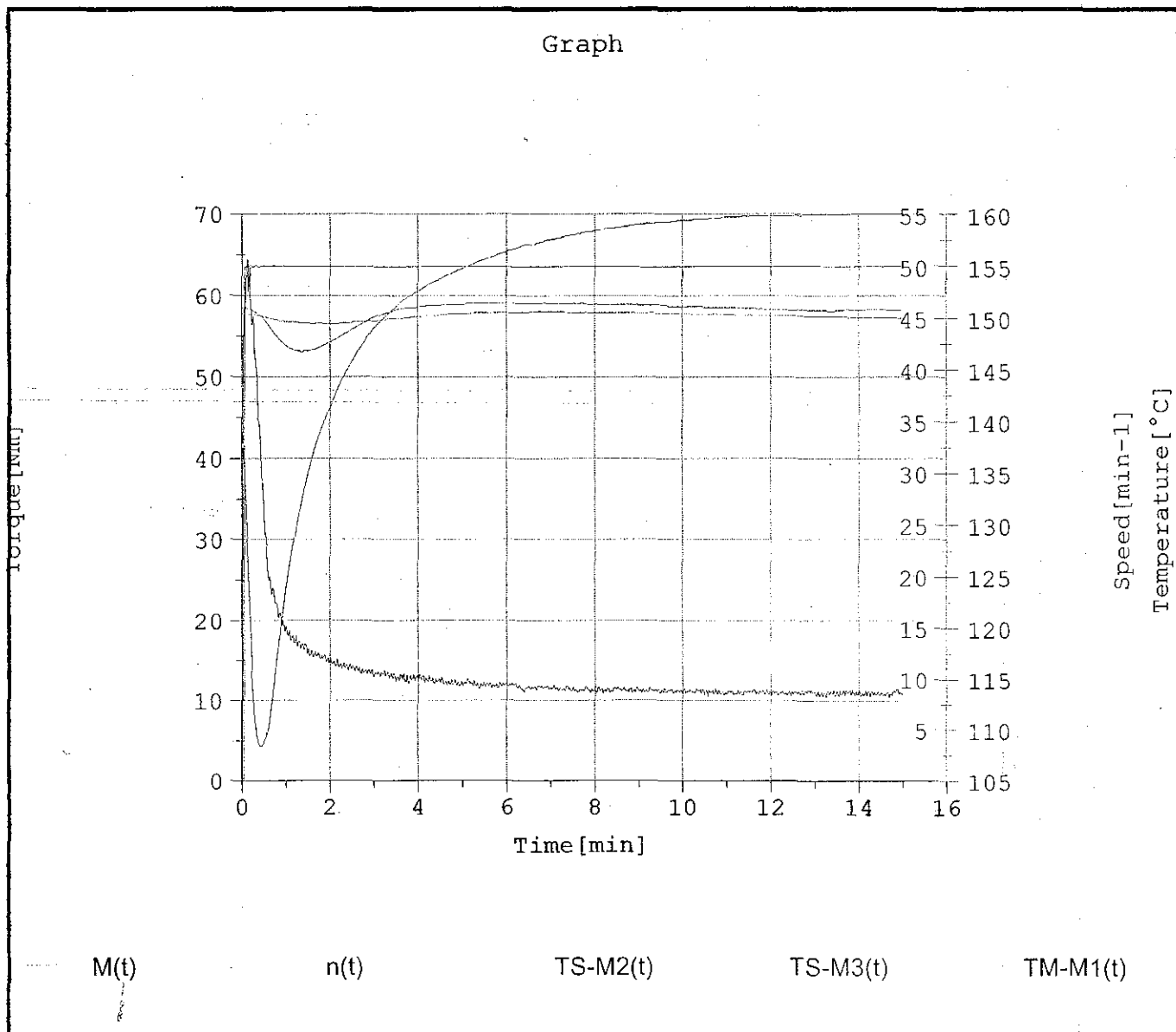


Worksheet 1

T: 150.0 / 150.0 / 150.0 °C

Filename: C:\PROGRA~1\THERMO~1\POLYLA~1\SEKAM3.MOM  
Company Mixer Rheomix3000p  
Operator  
Customer Rotor Roller-Rotors R3000  
Sample number  
Material  
Compound  
Conditions  
Density 0.70 g/cm<sup>3</sup>  
Mass 0.000 g

Date/Time March 11, 2004 / 17:11:52



Filename: C:\PROGRA~1\THERMO~1\POLYLA~1\SEKAM2.MOM  
Company Mixer Rheomix3000p  
Operator  
Customer Rotor Roller-Rotors R3000  
Sample number  
Material  
Compound  
Conditions  
Density 0.00 g/cm<sup>3</sup>  
Mass 0.000 g

Date/Time March 11, 2004 / 16:10:12

