Physical Properties of Rice Husk Packaging Material

by

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Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons.)
(Mechanical Engineering)

MAY 2013

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Mechanical Engineering Programme
Universiti Teknologi PETRONAS
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BACHELOR OF ENGINEERING (Hons.)
(MECHANICAL ENGINEERING)

Approved by,

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(Dr. Mohamad Zaki bin Abdullah)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2013

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 acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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NOR HAZWANI BINTI ANUAR

ACKNOWLEDGEMENT

First and foremost, my utmost gratitude to ALLAH for giving me strength, ideas and health to successfully complete the Final Year Project, **Physical Properties of Rice Husk Packaging Material**. This program would not be completed without the guidance and help of several individuals who in one way or another contributed and extended their valuable assistance in preparation and completion of the project.

I am highly indebted to my Final Year Project supervisor, Dr Mohammad Zaki bin Abdullah and my co-supervisor, Dr Azmi Abdul Wahab, for the guidance and constant supervision as well as for providing me necessary information of the project, work and all the task. With their supervision, I am able to keep the progress of the project in track and on time.

I would like to express my gratitude to our FYP coordinators for their kind co-operation and encouragement which help me completing the project. Special thanks to my lectures, laboratory technician and seniors who help me a lot during the fabrication of the project and also give me ideas for improvement.

My thanks and appreciations also go to my colleagues and family for their support. Information and moral support from my friends and family really give me a big momentum to complete the project.

Last but not least a special gratitude and thanks to all the examiners and judges who give me the experience to present the project. All the experience that I gain from the project is very meaningful to me.

ABSTRACT

The discharged of the rice husk from the rice mill all over the world causes a very serious environmental problem. Burning of the rice husk to dispose it emits dangerous gas such as CO_2 and methane which have adverse effects on the ozone layer and health. Presently, several attempts have been made to transform the natural material such as rice husk into other product for example packaging material. The compositions of the rice husk are almost similar to wood, suggesting a great possibility for paper making and packaging product. This project aims to study the tensile strength and moisture absorption of rice husk packaging material. The strength and moisture absorption properties of paper box and polystyrene foam box were used as the benchmark.

Alkali treatment and grinding process were done on the rice husk. The treatment was done by using Sodium Hydroxide (NaOH). Paper making and packaging making process was performed based on a small scale prospect. A simple tensile test and water absorption test were done as the project target is to produce a packaging product. Results from the testing shows that packaging from rice husk seems to have the strength similar to polystyrene foam. Moisture absorption behaviour of packaging from rice husk is also comparable with existing packaging product which is paper box.

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CHAPTER 1

INTRODUCTION

1.1 Background

Most of the waste produces from many sources go into landfills, increasing the burden on the landfill loading and operation. Farm waste is usually burned and as a result the soil and air are polluted [1]. Some of the wastes like plastics and glasses can be recycled into the same product for re-use or other usable products. Other waste such as farm waste and municipal waste can be used to generate electricity [2]. Instead of discarding tons of wastes from farms, some part of it could be used for packaging material. This will help achieving “waste reduction” and move one step closer towards sustainable environment.

To achieve “waste reduction”, packaging material is the most suitable way to recycle farm waste as its composition is quite similar to wood. Packaging is the name given to the containers in which products are wrapped, sold and transported. Packaging can be ranged from cardboard boxes and wooden pallets to plastic bottles and aluminium drink cans. Packaging also can be a protection of the goods during handling and transportation.

The purpose of the project is to investigate an alternative source of material to produce packaging material. Due to its availability and renewability, rice husk was chosen as the based material to produce packaging material to replace wood. According to the statistics compiled by the Malaysian Ministry of Agriculture, 408,000 metric tonnes of rice husk are produced in Malaysia each year [3]. This is quite a huge quantity, suggesting the wide availability of the rice husk.

By using rice husk as the alternative source, the abundance of the farm waste can be reduced and number of tree employed for packaging material can be cut off.

The composition of the rice husk that is quite similar to the composition of wood makes it suitable to replace the existing wood packaging materials. The using of farm-based natural resources can also reduce the usage of plastic based resource like polystyrene. The project theme is using the concept of "waste to wealth" which means transforming something that has no value into something that is useful.

1.2 Problem Statement

Rejected agricultural materials in the form of straw, leaves, husk and other by-products, which are burned, dumped and disposed, account for tonnes of waste produced. Most of farm wastes are burned, causing pollution to soil and air. Rice husk is an example of agricultural waste generated with quite a large quantity. Packaging material can be one of the solutions to overcome the abundance of such waste.

1.3 Objectives

The objectives of the project are:

1. To study the tensile strength and moisture absorption of packaging material from rice husk.
2. To assess the appearance of rice husk prototype packaging material.

1.4 Scope of Study

The rice husk used in this project is MR220 type. The rice husk was grind into fine particle using mortar grinder. The average size of the rice husk after grinding is 600 micron. MR220 is categorized as medium size grain rice which is a typical size of rice cultivated in Malaysia. Surface treatment on the rice husk was done using sodium hydroxide (NaOH). A prototype of packaging material was produced. The production of packaging material was based on the neutral-alkaline papermaking. The variable of the study is the ratio of the rice husk and binders. Two binders were employed for this project which were corn starch and recycled paper. Tensile strength and moisture absorption test were carried out and compared with that of common paper box and polystyrene foam.

CHAPTER 2

LITERITURE REVIEW

2.1 Environmental Problem and Pollution

According to the World Health Organization (WHO), environmental health addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviours [4]. It encompasses the assessment and control of those environmental factors that can potentially affect health. The problem comes from the generation of the large amount of wastes from industrial and agricultural areas. Some materials can be recycled to be a new product and some can be reused to function like the original products. Unfortunately, recycling requires the material to be processed again and normally it is not economically feasible unless the processing facility is located nearby.

Farm waste is abundant and most wastes are burned. The burning process causes air pollution. Getting rid of the farm waste like rice husk is a problem as the amount of the waste is increasing. The quantity of the rice husk keeps on increasing as the world population increases. The global production of rice is approximately 580 million tons a year and it is rising as the world population and the consumption of rice increases [5]. Figure 2.1 shows the harvesting of rice calendar in Malaysia which indicates that the rice production has continuous schedule throughout the year.

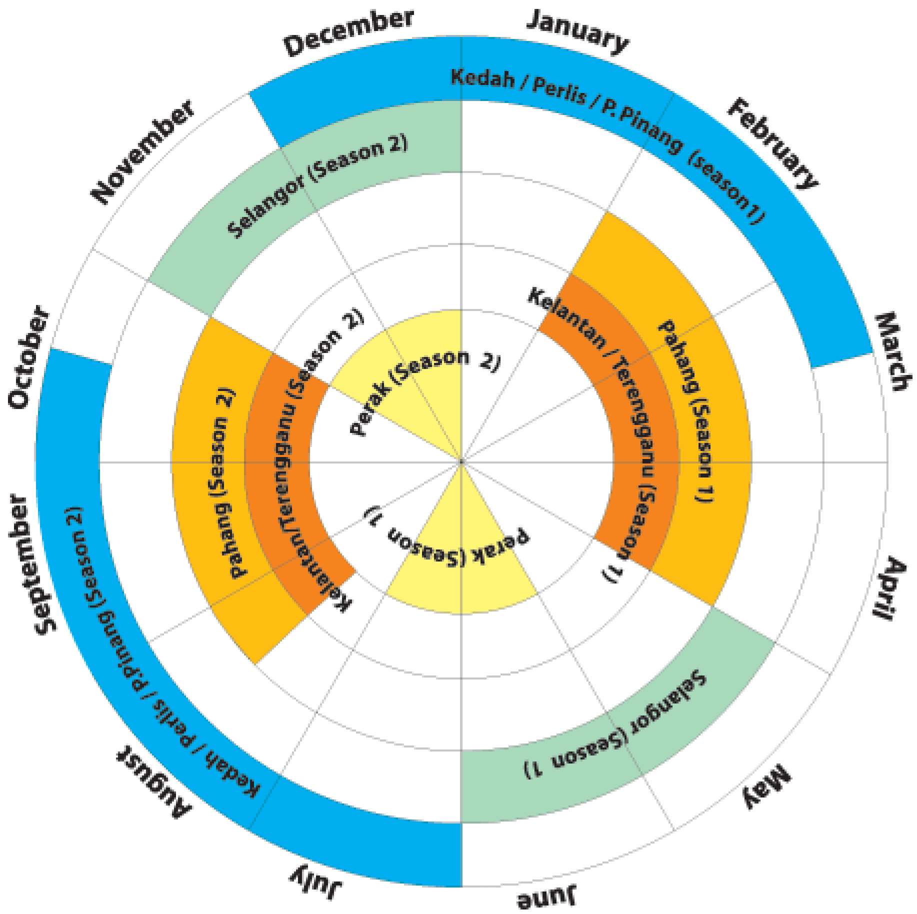


Figure 2.1: Harvesting calendar in Malaysia [6]

Research done by Weiting et al. [7] suggested that a huge amount of rice husk ash obtained after burning is which has no use. Even to dispose the ash is a problem. To solve such problem, a new concept known as Green Technology was introduced over the last two decades. This concept encompasses a continuous evolution of methods and materials, from techniques for generating energy to non-toxic clean products [8]. This concept also deals with using the environmental wastes to produce a useful product.

2.2 Composition of the Rice Husk

Figure 2.2: Rice husk

Rice husk makes about 20% of the total rice weight. Almost 70% of the rice husks are not commercially used. Figure 2.2 shows samples of rice husk. The main components of the rice husk are silica, cellulose and lignin. The reason for using the rice husk in paper industry are because of its availability, low bulk density (90-150kg/m^3), toughness, abrasive in nature, resistance to weathering and unique composition [9]. The same composition also found in the wood making the rice husk suitable to replace wood in paper making process [10]. Lignocellulose fibre in the rice husk can make final product light, biodegradable and absence of residues or toxic by-products. The physicochemical characteristic of rice husk is shown in Table 2.1.

Table 2.1: Physicochemical characteristic of rice husk [3]

Characteristic	Unit	Value
Bulk density	g/ml	0.73
Solid density	g/ml	1.5
Moisture content	%	6.62
Ash content	%	45.97
Particle size	Mesh	200-16
Surface area	m^2/g	272.5
Surface acidity	Meq/gm	0.1
Surface basicity	Meq/gm	0.45

Rice husk is a good insulating material because it is difficult to burn and less likely to allow moisture to propagate mildew or fungi [3]. The characteristic of not allowing moisture to penetrate easily into it make the rice husk suitable for packaging material. The need for materials that are non-toxic to the human body and have appropriate characteristic for specific purpose is increasing [11].

2.3 Lignocelluloses Fibre as Reinforcing Fillers

Studies are on-going to find ways to use lignocellulose fibres in place of synthetic fibres as reinforcing fillers. Composites using natural substances as reinforcing fillers are not only low in cost but also able to minimize the environmental pollution due to their biodegradability [11]. Lignocellulose fibre as reinforcing material also lightweight product offers a less wear of the machinery low production cost and no residues or toxic by-products [12].

Lignocellulose materials contain cellulose, hemicellulose, and lignin in various amounts and chemical compositions. Cellulose, the most abundant biological macromolecule, is an extracellular, linear polymer of glucose molecules. It is a natural polymer containing many hydroxyls groups. It has the ability to form hydrogen bonds which governs the physical properties of cellulose [13]. The bonding between cellulose, hemicellulose, and lignin is very important to the mechanical properties of the material. Hemicellulose has the structure of the hydrophilic properties where water can be easily absorb by hemicellulose. On the other hand, lignin is totally amorphous and hydrophobic.

Table 2.2: Chemical components of used lignocellulose materials [14]

	Holocellulose (%)	**Lignin (%)**	**Extractives (%)**	**Ash (%)**
Beech bark	66.1	16	3.7	14.2
Rice Husk	48.7	30.1	12.6	8.6

Table 2.2 shows chemical components of used lignocellulose materials in beech bark and rice husk. Beech bark has higher holocellulose (cellulose + hemicellulose) and lower lignin contents than rice husk, resulting in higher water absorption compared to rice husk. The higher amount of lignin in rice husk made the rice husk has less water absorption compared to the beech bark. Water absorption is

due the hydrogen atoms in the water molecules is attracted to the free hydroxyl groups present in the cellulosic cell wall materials, resulting in diffusion of water molecules into the filler-matrix interface [14].

2.4 Neutral-Alkaline Papermaking

Paper fibre is made up of cellulose and hemicellulose which have a very strong tendency to absorb and interact with water. Instead of using acidic sizing, many mills have moved to neutral-alkaline sizing to satisfy the requirement of higher strength and increased longevity of the paper papers [15]. Other research found that the advantages of neutral-alkaline system over acid system include improvement in the sheet strength, paper stability on aging, reductions of energy consumption, increase of productivity, and reduces corrosion [16]. A study done on abaca fibre showed that moisture absorption capability of abaca fibre was reduced by alkali treatment [17].

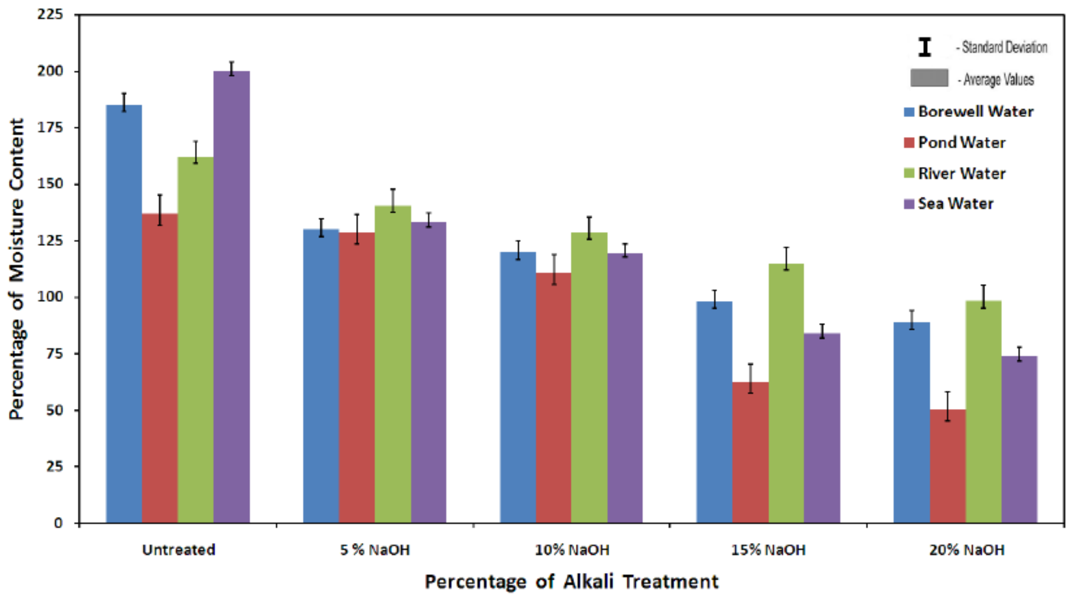


Figure 2.3: Comparative study of water absorption of untreated and alkali treated fibre [17]

The moisture absorption of the treated fibre decreases with an increase of alkali concentration [17]. It is due to the removal of lignin and hemicellulose component of fibre by alkali treatment. The hydrophilic nature of fibre had changed into hydrophobic nature by alkali treatment. Although the cellulose fibre that contain in rice husk is high, the absorption of water can be controlled by neutral-alkaline sizing.

A study done on the effect of fibre alkali treatment on mechanical properties of natural fibre found that, the alkali-treated fibre composite improved the tensile strength by 8%, tensile modulus by 2%-8%, and percentage elongation by 2%-6% at break with 20% fibre content [18]. The increasing of the mechanical properties could be due to better interfacial bonding between matrix and fibre. Similar findings were observed by another group of researchers [19]

2.5 Effect of Grinding on Properties of Rice Husk Ash

The size of the rice husk particles does affect the properties of the materials. This is because a change in grain size affects the strength due to the displacements interacting with the grain boundary as they move. The boundaries act as obstacles, obstructing the dislocation glide along the slip planes. As subsequent dislocations move along the same slip plane the dislocations which happen at the grain boundaries.

The dislocations repel each other, so as the number of dislocation increases as the stress on the grain boundary increases. In a larger grain there will be more dislocations within the grain, so there will be more dislocations in the happen. Therefore, a lower applied stress is required to produce a local stress great enough to cause the grain boundary to collapse.

Rice husk ash has high potential to develop into a good pozzolanic material if it is in a fine particle form [20]. The fine particle of pozzolans had a greater pozzolanic reaction and could fill the voids of the mixture, thus increasing the compressive strength of the mortar.

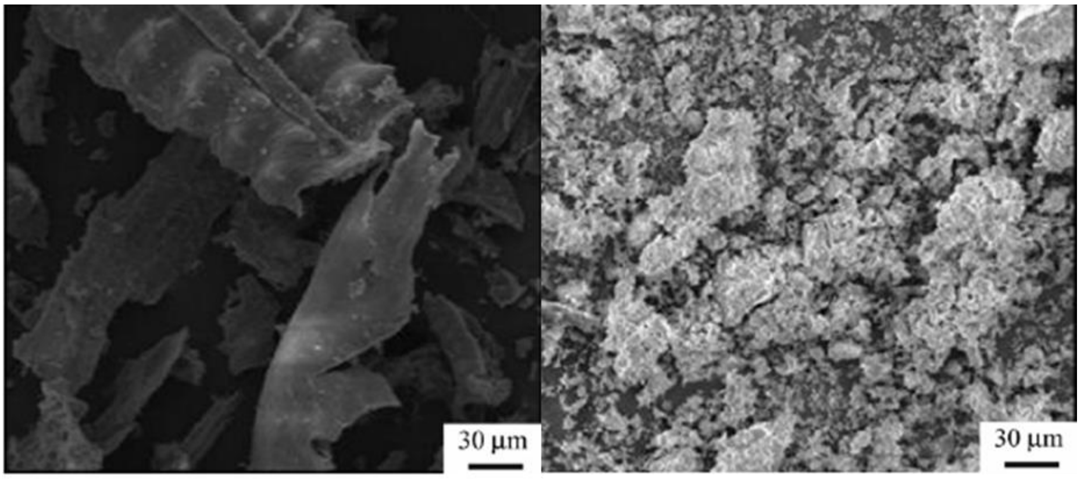


Figure 2.4: SEM images of unground rice husk and ground rice husk [20]

A study on mortar concrete mix with rice husk particles suggested that fine particles of pozzolanic had a greater pozzolanic reaction and could fill the voids in the mixture, improving the compressive strength of the mortar. Scanning Electron Microscope (SEM) in figure 2.4 shows the image of the small particles fill in the voids of the mixture. In the article wrote by R. Hamid et al, the author said in general, compressive strength increased as the grinding time of the rice husk increased [5].

CHAPTER 3

METHODOLOGY

3.1 Research Methodology and Procedure

Many studies have been done on the topic of lignocellulose fibre and packaging material, making the process of data collection for this project easier. Table 3.1 shows how the rice husk packaging material has been made.

Table 3.1: Rice husk packaging material process

1. Preparation of materials	Material and tool procurement
2. Preparation of mould and deckle	Mould and deckle construction for paper making process
3. Producing mould for prototype	The production of rice husk packaging material using the mould
4. Alkali treatment and neutralization process	Removing the lignin from the fibre
5. Grinding	Grind the rice husk into small particle
6. Specimen preparation	Testing specimens are made
7. Testing	Tensile strength and water absorption test were done on the specimens
8. Data analysis	Testing result were analysed

3.2 Project Activities

PART 1: Preparation of Mould and Deckle

The mould and deckle in this project is an essential tool for hand-made papermaking. Handmade paper is made with a mould and deckle. The mould is a frame covered with metal or nylon mesh, and the deckle is the frame that sits on top the mould. The paper is formed on the mould and the deckle is used to create straight edges on the paper sheet. The mould is a screened frame that catches pulp to help form a sheet of paper. The deckle is a frame that sits on top of the mould, catching pulp and defining the edge of the paper. A3 size of mould and deckle was produce.

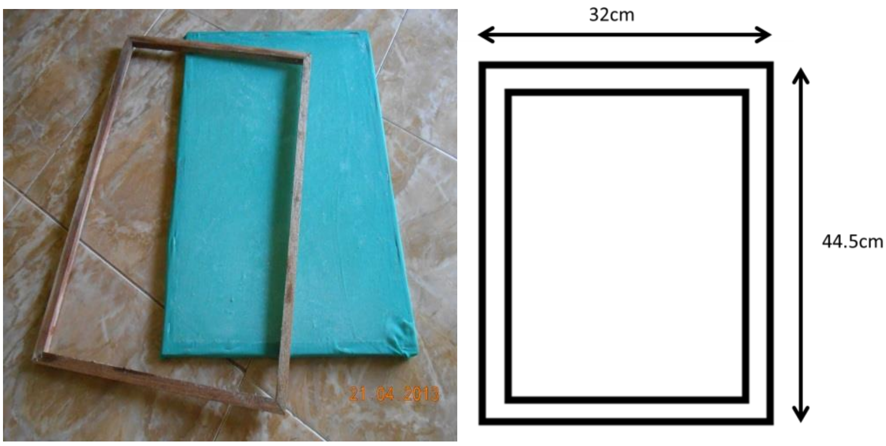
Table 3.2 presents the mould and deckle making process while Figure 3.1 shows the completed mould and deckle as well as their dimension.

Table 3.2: Mould and deckle making process

	Step 1: Collect all the required material 1. 1.1cm × 1 cm wood 2. Measuring tape 3. Saw 4. Fabric 5. Stapler gun
	Step 2: Cut Wood The woods were cut according to the desired length and width. The mould and the deckle need 8 pieces of wood. Four pieces for the mould and the other four for the deckle.
	Step 3: Glue The wood pieces were arranged in a rectangular shape. The pieces were glue together to strengthen the structure.
	Step 4: Staple the edge The edges of the structure were stapled together to make the structure stronger. The purpose also to hold the wood in place.

Table 3.2: (Continue)

	Step 5: Paint the mould and deckle The mould and the deckle were painted with varnish for two layers. The purpose of painted the mould and deckle is to ensure that it will not affect the colour of the paper.
	Step 6: Applying Nylon net After drying the mould and deckle, the netting was wetted and stapled to the frames using staple gun. Nylon was used for the netting and it was pulled as tight as possible.



(a) (b)

Figure 3.1: Mould and deckle (a) and dimension of mould and deckle (b)

PART 2: Producing a Mould for Prototype

The purpose of the project is to replace wood as the packaging material base. To come out with the prototype, a mould was needed. The design of the mould was referred to the design of the existing "Food Container" in the market. Figures 3.2 and 3.3 show the top and bottom view of mould design, respectively. The actual prototype mould is shown in Figure 3.4.

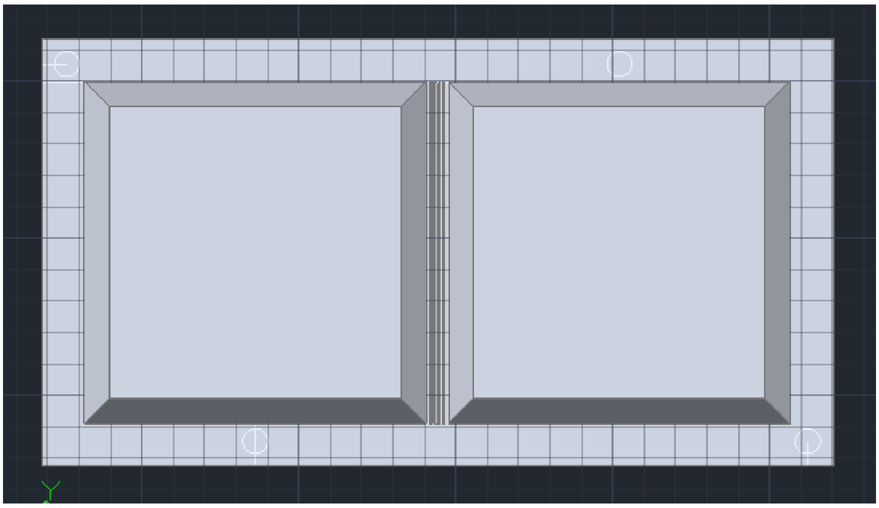


Figure 3.2: Mould design (top part)

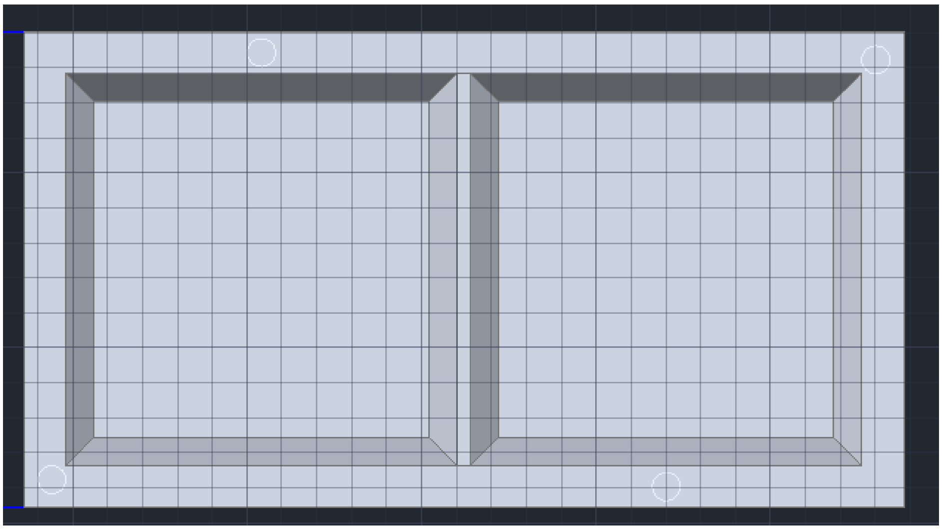


Figure 3.3: Mould design (bottom part)

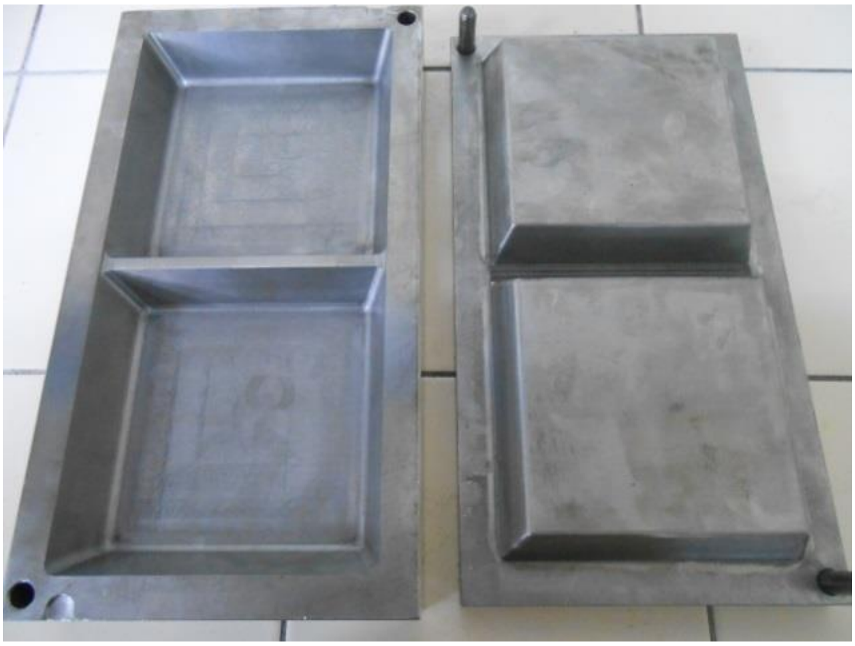


Figure 3.4: Mould

PART 3: Alkali Treatment and Neutralization Process

The compositions of the rice husk are cellulose, hemicellulose and lignin. The purpose of alkali treatment is to remove the lignin from the fibre. Alkali treatment process was based on Biermann's method [21]. Sodium hydroxide (NaOH) is the alkali used for the treatment process. NaOH aids separation of cellulose fibres from lignin and breaks down fibre into pulp. NaOH also helps bleaching paper to the required whiteness and brightness

The rice husk was boiled for 6 to 12 hours to soften the fibre. Next step was soaking the fibre in NaOH for 6 hours. The concentration of NaOH used was 50%. The NaOH concentration plays a significant role in fibre treatment process. In general, high concentration of NaOH solution and shorter soaking time provides better impact strength whereas low and medium concentration of NaOH solution and longer time improves flexural and tensile properties [23].

After soaking for 6 hours, the fibre was washed with water to remove the excessive alkali. The fibre was then treated with 5 ml acetic acid to neutralize the alkali effect. To ensure that the fibre is neutral, the fibre was tested using the pH paper.

PART 4: Grinding the Rice Husk into Small Aggregates

After the fibre dried, grinding process was done on the fibre. The purpose of the grinding process is to lower the void between the particles when the mixture is mixed together. A study found that with the finer particle size, a greater pozzolanic reaction occurred [20]. The small particle could fill the voids of the mixture, thus increasing the strength. For this process, mortar grinder was used to grind the rice husks. Figure 3.5 shows the mortar grinder used in this project. Figure 3.6 and figure 3.7 shows the rice husk inside the mortar grinder and the mortar grinder in the inside respectively. The rice husk is pour into the mortar grinder. The rice husk shown in Figure 3.8 is the raw rice husk and Figure 3.9 shows the rice husk after it was grinded by the mortar grinder.

Figure 3.5: Mortar grinder

Figure 3.6: Rice husk being put inside the mortar

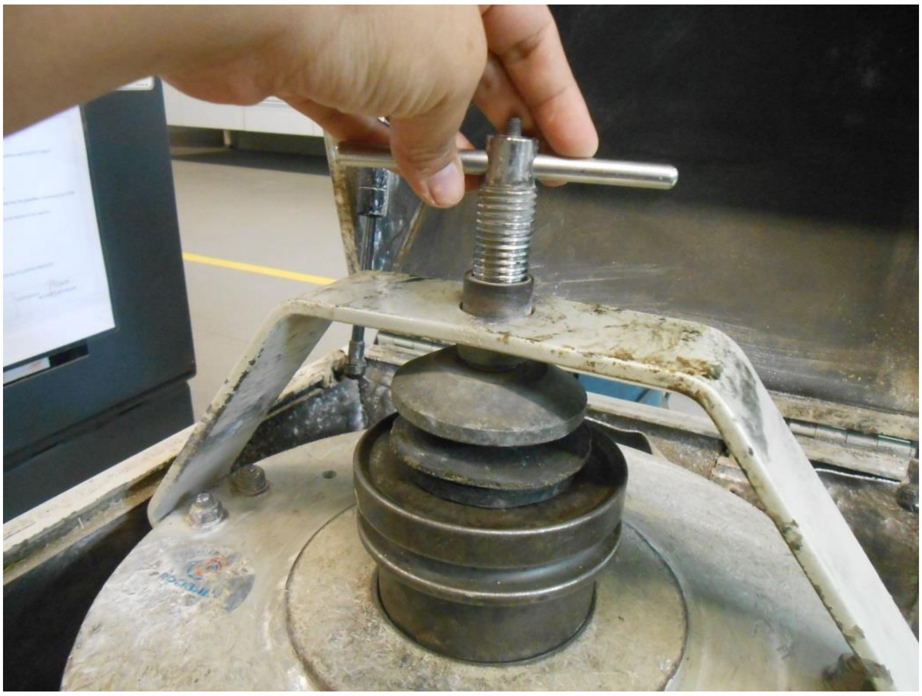


Figure 3.7: Inside the mortar grinder

Figure 3.8: Rice husk before grinding

Figure 3.9: Rice husk after grinding

PART 5: Paper Making Process

The steps for paper making were based on paper making process by Marianne Saddington [22]. The paper making process steps are illustrated in Table 3.3.

Table 3.3: Paper making process

	1. Wash the rice husk to remove the unnecessary particle.
	2. Boil the rice husk with distilled water for 6 hours to soften the fibre of the husk. The temperature is 100ºC.
	3. Soak the rice husk at room temperature with NaOH for 6 hours to remove the lignin from the cellulose.
	4. Wash the rice husk to remove the excessive alkali. 5ml of acetic acid, (CH_3COOH) was added to neutralize the fibre. To test the pH of the rice husk, pH paper was used.

Table 3.3: (continued)

	5. After dry the rice husk using oven, grind the rice husk into small aggregates.
	6. Seize the rice husk particle to get the average size of 600 micron.
	7. Blend the rice husk with corn starch, water, and cinnamon to make the pulp.
	8. Transfer the mixture on the deckle and let the mixture to dry.
	9. Transfer the mixture from the paper into mould to get the required shape.

3.3 Testing

3.3.1 Tensile Test

Tensile testing was conducted to measure the strength of the paper. Universal tensile machine (UTM) with the maximum force of 10 kN was used. Tensile strength test was done according to ASTM D638 standard. Figure 3.10 shows the universal tensile machine used in to conduct the tensile test in this work.

Figure 3.10: Universal tensile machine

Procedures of conducting tensile test were as follows:

1. Each specimen was labelled with a marker pen to indicate the material.
2. An appropriate height of the crosshead was adjusted so that the specimen could be placed.
3. Specimen was placed inside he grips.
4. The position of the grip was set to zero.
5. The parameters of the specimen like length, width and thickness were measured and keyed in the UTM machine.
6. Play button was clicked to start the test.

7. The machine was automatically stopped when the specimen failed.
8. All data such as the force at peak and elongation at break were recorded.

3.3.2 Moisture Absorption Test

Moisture absorption test being conducted to measure the per cent of moisture absorption of the material. The procedure for moisture absorption test is as below:

1. Cut the specimen into 2 cm by 2 cm size. Each composition will have 5 sample of specimen.
2. Measure the weight of the specimen.
3. Place the specimen inside the oven for 12 hours
4. Immediately after taking the specimen off the oven, measure the weight of each of the specimen
5. Calculate the percentage of the weight reduction of the specimen

3.4 Key Milestones and Gantt Chart

Table 3.4 shows the key milestones and the Table 3.5 shows the Gantt chart for this project.

Table 3.4: Key milestone

Milestones	Completion date
Material and tool procurement	13.4.2013
Molud and deckle fabrication	20.4.2013
Alkali treatment and neutralization of the fibre	06.6.2013
Grinding the fibre into small particles (600micron)	16.6.2013
Mould fabrication for prototype samples	17.7.2013
Specimen preparation for testing	23.7.2013
Tensile test	25.7.2013
Moisture absorption test	26.7.2013
Appearance assessment	26.7.2013
Analysis of testing results	30.7.2013

Table 3.5: Gantt chart

	Jan		Feb				Mar				Apr				May				Jun				Jul				Aug			
Project Activities	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4
Research topic and gather data	■	■																												
Title selection		■																												
Futher researh on choosen topic			■	■	■	■																								
Material survey							■	■	■																					
Material and tool procurement										■	■	■																		
Testing facilities survey												■	■																	
Designing mould for prototype												■	■	■	■	■														
Mould for prototype order																	■	■	■	■	■	■	■	■	■					
Fabrication of mould and deckle													■																	
Paper making 1st trial(without grinding)														■	■															
Fiber treatment process																■	■	■	■											
Grinding process																				■										
Paper making 2nd trial(grinding)																					■	■	■	■						
Paper making process for final fabrication																									■	■				
Testing																										■				
Analysis of testing result																										■				
Pre-Sedex and poster presentation																											■			
Draft report submission																												■		
Oral presentation																														■
Dissertation and technical report submission																														■

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this research work, a prototype of rice husk packaging material was produced by using the rice husk particle to replace wood. In this experiment, the variable was the composition of the rice husk particle and binder of the composite. The compositions were, 60% rice husk particle with 40% binder and 70% rice husk particle with 30% binder. The other parameter such as the concentration of alkali, water and temperature were kept constant. Packaging product made from polystyrene foam and paper box were used as the reference. Tensile test and moisture absorption test were done and the result obtained were presented and discussed in this chapter.

4.2 Testing Results

4.2.1 Appearance

After completing the rice husk paper making process, there are a few differences in term of appearance and strength that can be seen. The appearances and results tabulated in the Table 4.1.

Table 4.1: Results for appearance

	Composition	**Appearance**
	70% Rice Husk 30% Corn Starch Grinding size: Coarse	Very bad. The fibre of the rice husk can be seen clearly. The paper is brittle.
	70% Rice Husk 30% Corn Starch Grinding size: 600 micron	The appearance is good. The surface of the paper is smooth but brittle.
	70% Rice Husk 20% Corn Starch 10% Recycled Paper Grinding size: 600 micron	The appearance is good. The surface of the paper is smooth.

The appearances of the rice husk paper with different composition were compared. The results show that the appearance of the rice husk paper before grinding was very bad as the fibre and silica in the rice husk made the paper very hard. The rice husk paper produces a coarse surface which is not good for packaging material.

After grinding the rice husk into fine aggregates, the rice husk paper seems to have better appearance. The surface of the rice husk paper was fine and smooth. The fine size of the rice husk gives a smooth and good appearance for the packaging material. The potential voids of the packaging material could be filled with the fine size of the rice husk, thus increasing the strength of the paper and improving the binding effect. However, the paper seems to be brittle. Corn starch as a binder alone does not have enough strength to hold the rice husk particle together, thus make the paper weak and brittle. To overcome the problem, 10% of recycled paper was added to the mixture. The effect of adding the recycled paper is the rice husk paper becomes stronger.

4.2.2 Tensile Test

After fabricating all the rice husk packaging material with the required composition, tensile test was done to measure the strength. The results were compared to the strength of paper box and polystyrene foam. The test was done according to the ASTM Standard D 638.

To produce a good packaging material, the parameters for example the ultimate tensile strength need to be taken care of. A good packaging materials need to have a suitable strength so that it can protect the goods inside. Figure 4.1 shows the tensile strength result.

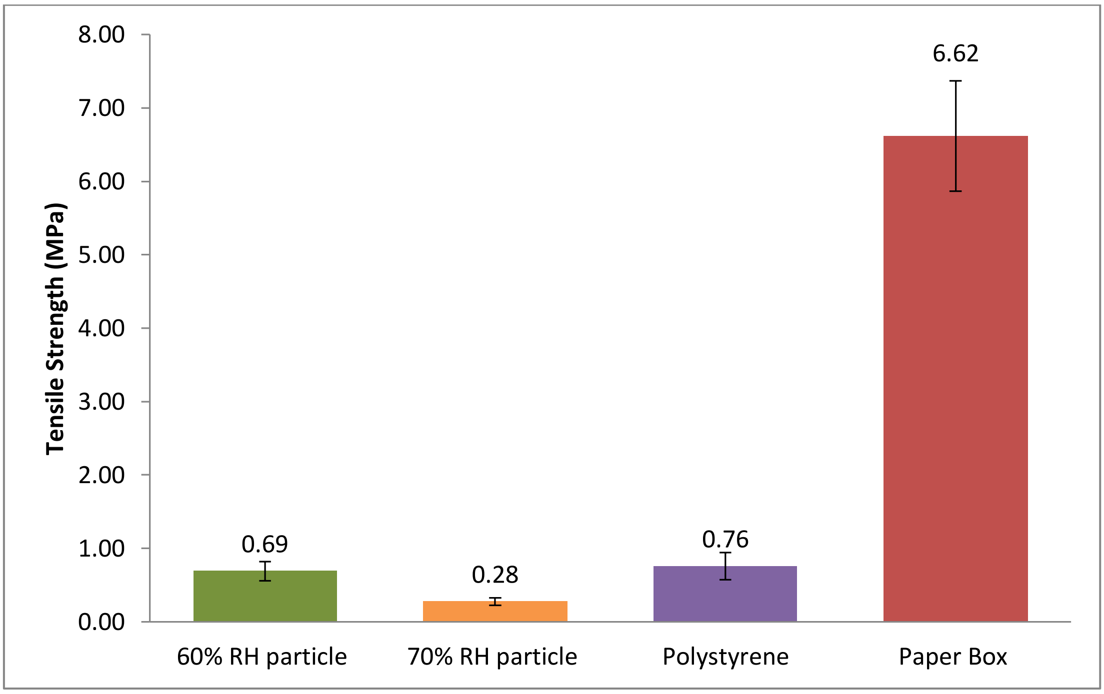


Figure 4.1: Tensile strength of 60% rice husk particle, 70% rice husk particle, polystyrene foam and paper box

It can be seen that rice husk packaging material with 60% rice husk particle has higher strength from rice husk packaging material with 70% rice husk particle. However, the average strength of rice husk packaging material with 60% rice husk particle is 7.8% lower than polystyrene foam. The value depends on a few factors such as the methods of producing the sample and type of binder used. This shows that the 60% rice husk particle paper has the highest tensile strength. Rice husk packaging material with 70% rice husk particle is slightly lower in strength compared to rice husk packaging material with 60% rice husk particle may. This may to the less amount of binder.

However, there was such a big gap between the paper box and rice husk packaging material. The average strength of paper box is 6.61 MPa, which have the difference of 5.92 MPa from the rice husk packaging material with 60% rice husk particle. This may cause by the method of production itself. Packaging material from rice husk and paper box were produce using very different methods resulting in the paper box having much more finer texture rather than packaging material with rice husk. If the same techniques used in making the paper box being applied to packaging material from rice husk, it can be said that the strength of packaging material from rice husk can surpass the strength of paper box. Besides that, the effects of binder also being the important factor that result to the strength of the material. There are much more other type of binders using in industry for example resin and wax. Resin is more complex and can improved binder but the price is more expensive than corn starch.

4.2.3 Moisture Absorption Test

The purpose of moisture absorption test is to provide a means for comparing relative water absorption tendencies between different specimen Water absorption is used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include: type of materials, additives used, temperature and length of exposure. Figure 4.2, 4.3 and 4.4 below shows the specimens and machines used in moisture absorption test.

Figure 4.2: Specimen for moisture absorption test

Figure 4.3: Weighing balance for weight measurement of specimen before and after dry

Figure 4.4: Oven for drying process

Moisture absorption is expressed as increase in weight per cent. Weight of specimen before and after oven dry being recorded.

Percent Moisture Absorption = [(Wet weight - Dry weight)/ Dry weight] x 100

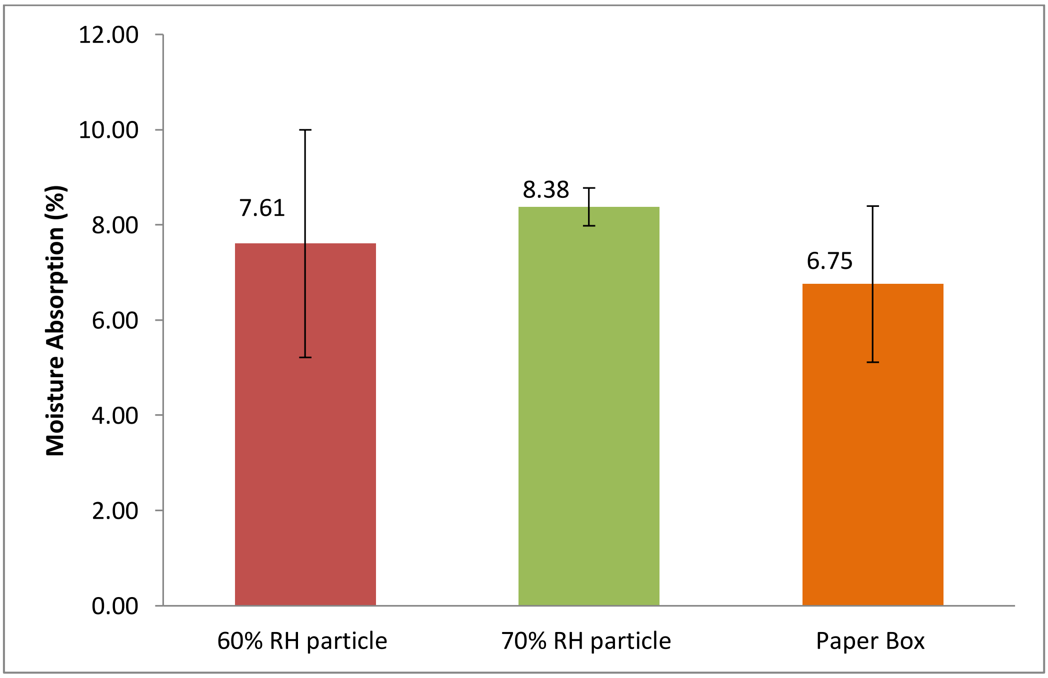


Figure 4.5: Moisture absorption of different material and composition

Figure 4.5 shows the result for water absorption test for different materials and composition of fibre. The experiment being done for rice husk packaging materials with70% rice husk particle and 30% binder, 60% rice husk particle and 40% binder, polystyrene foam and paper box. From the data collected, rice husk packaging material that contains 70%rice husk particle and 30% binder has the highest percentage of moisture absorption which is 8.38% followed by rice husk packaging material with 60% rice husk particle and 40% binder which is 7.60% and paper box which is 6.75%.

Although the moisture absorption of rice husk packaging material is high when compare to paper box, the rice husk packaging material still can be used for dry food such as fried potato and cookies.

CHAPTER 5

CONCLUSION

The packaging materials from rice husk were produced in this research work and the rice husk was chosen due to its wide availability and sustainability. The hard and coarse fibre problem of the rice husk can be solved by grinding the rice husk using mortar grinder. Thus, the appearance of the rice husk paper can be improved.

Two type of packaging material were produced which consist of 60% and 70% rice husk particle. The test results showed that the packaging material with 60% rice husk particle was stronger than the packaging material with 70% rice husk particle. However, the packaging material made from rice husk is weaker than the commercial paper box. In term of moisture absorption, all of the packaging materials have almost similar property. Both papers made from rice husk only increased the absorption ability by 1% for packaging material with 60% rice husk particle and almost 2% for packaging material with 70% rice husk particle.

It can be concluded that the packaging material made from rice husk have a potential to be commercialized since it is comparable to the commercial paper box. However, further study should be done to improve rice husk paper quality in order to be commercialized successfully.

CHAPTER 6

FURTHER STUDY

In order to obtain the optimum amount of strength of the packaging from rice husk, further investigation on the binder effect, grain size, and alkali treatment should be made. This can be done by using the different type of binder such as tapioca starch and recycled paper. The binder does affect the strength of the packaging. Grain size also plays a big role in determining the strength of the packaging material.

The effect of alkali treatment to remove the lignin from the rice husk fibre can be further investigated. By using the chemical pulping alone, the lignin cannot be break completely. Therefore, the effects of concentration and soaking duration of NaOH should be studied further.

REFERENCES

[1] Department for Environment Food & Rural Affairs. (2012, August). Air Pollution from Farming: Preventing and Minimising. [Online]. Available: https://www.gov.uk/reducing-air-pollution-on-farms

[2] Salman Zafar. (2008, September). Waste as Renewable Energy Sources. [Online]. Available: http://www.alternative-energy-news.info/waste-renewable-energy-source/

[3] S, Noor Syuhadah and Rohasliney, "Rice Husk as Biosorbent: A Review," *Health and the Environment*, vol. 3, (1), pp. 89, 2012.

[4] World Health Organization. (2013, June). Environmental Health. [Online]. Available: http://www.who.int/topics/environmental_health/en/

[5] R. Hamid, N. Ibrahim and A. Jamadin, "Influence of Grinding of Rice Husk Ash to the Workability and Strength of Concrete," *International Refereed Journal of Engineering and Science (IRJES)*, vol. 2, (2), pp. 50-54, 2013.

[6] Padiberas Nasional Berhad. (2013, August). Harvesting Calendar. [Online]. Available: http://www.bernas.com.my/index.php?option=com_content&view=article&id=90&Itemid=103

[7] U. Weiting, Y. Lo. Tommy and A.M. Shazim, "Construction and Building Materials," *Microstructure and Reactivity of Rice Husk Ash*, vol. 29, pp. 541-47, 2012.

[8] Green Technology. (2011, February). Strategy and leadership for clean and sustainable communities.[Online]. Available: http://www.green-technology.org/what.htm

[9] D. Klemm, H. P. Schmauder, and T. Heinze. "Cellulose," *Structure and Analysis*. pp 275-287.

[10] Roger C. Pettersen. "The Chemical Composition of Wood," in *The Chemistry of Solid Wood*, Rowell, Roger M, Ed. Washington, DC: American Chemical Society, 1984, pp. 57-126.

[11] A. C. Johnson and N. Yunus. "Particleboards from Rice Husk.". *Jurutera*, pp 12-15, 2009.

[12] H. S. Yang, H. J. Kim, J. Son, H. J. Park, B. J. Lee and T. S. Hwang, "Rice-husk Flour Filled Polypropylene Composites; Mechanical and Morphological Study," *Composite Structure*, vol. 63, pp. 305-12, 2004.

[13] H.G.B. Premalal, H. Ismail and A. Baharin, "Comparison of the mechanical properties of rice husk powder filled polypropylene composites with talc filled polypropylene composites," *Polym. Testing*, vol. 21, (7), pp. 833–839, 2002.

[14] A. Nourbakhsh, F.F. Baghlani and A. Ashori, "Nano-SiO2 Filled Rice Husk/polypropylene Composites: Physico-mechanical Properties," *Industrial Crops and Products*, vol. 33,(1), pp. 183-87. 2011.

[15] Y. Zou, J. S. Hsieh, T. S. Wang, E. Mehnert, and J. Kokoszka. "Rosin Sizing under Neutral-alkaline Papermaking Conditions," *TAPPI journal,* vol 3, (7), pp. 41-59, 1991.

[16] B. W. Crouse and D. G. Wimer, "Alkaline Papermaking an Overview," *TAPPI journal*, pp 152-59. 1991.

[17] P. Ramadevi, D. Sampathkumar, C. V. Srinivasa and B. Bennehalli, " Effect of Alkali Treatment on Water Absorption of Single Cellulosic Abaca Fiber," *BioResources*, vol. 7, (3), pp. 3515-3524, 2012.

[18] Govardhan Goud and R. N. Rao, "Effect of fibre content ad alkali treatment on mechanical properties of Roystonea regia-reinforces epoxy partially biodegradable composites," *Bull. Mater,* vol. 34, (7), pp. 1575-1581, 2010.

[19] Huda, M. S. Lawrence, T Drzal, A. K. Mohanty and M. Misra, *Compos. Sci. Technol*. vol. 68, pp. 424, 2008.

[20] S. Rukzon, P. Chindaprasirt and R. Mahachai. "Effect of Grinding on chemical and physical properties of rice husk ash". *Materials*. Vol 16, (2), 2009. pp242.

[21] Biermann, Christoper J. *Handbook of Pulping and Papermaking*. San Diego: Academic Press. ISBN 0-12-097360-X.

[22] Marrianne Saddington. (1993, December). How to make a Homemade Paper. [Online]. Available: http://www.motherearthnews.com/Do-It-Yourself/1993-12-01/How-To-Make-Homemade-Paper.aspx

[23] Chemicalland21. (2012, December). Caustic Soda [Online]. Available: http://www.chemicalland21.com/industrialchem/inorganic/CAUSTIC%20SODA.htm

APPENDIX

Table A1: Raw data from tensile test

	60% RH particle (MPa)	70% RH particle (MPa)	Polystyrene foam (MPa)	Paper Box (MPa)
Sample 1	1.03	0.36	0.91	6.96
Sample 2	0.92	0.30	0.44	7.69
Sample 3	0.82	0.23	0.82	5.72
Sample 4	0.79	0.26	0.85	6.50
Sample 5	0.69	0.24	0.78	6.20
Average	0.69	0.28	0.76	6.62
STD DEV	0.13	0.05	0.18	0.75

Table A2: Raw data from moisture absorption test

	60% RH particle (%)	70% RH particle (%)	Paper Box (%)
Sample 1	0.05	0.08	0.07
Sample 2	0.05	0.08	0.05
Sample 3	0.10	0.09	0.06
Sample 4	0.09	0.09	0.09
Sample 5	0.09	0.08	0.07
Average	7.61	8.38	6.75
STD DEV	2.39	0.40	1.64

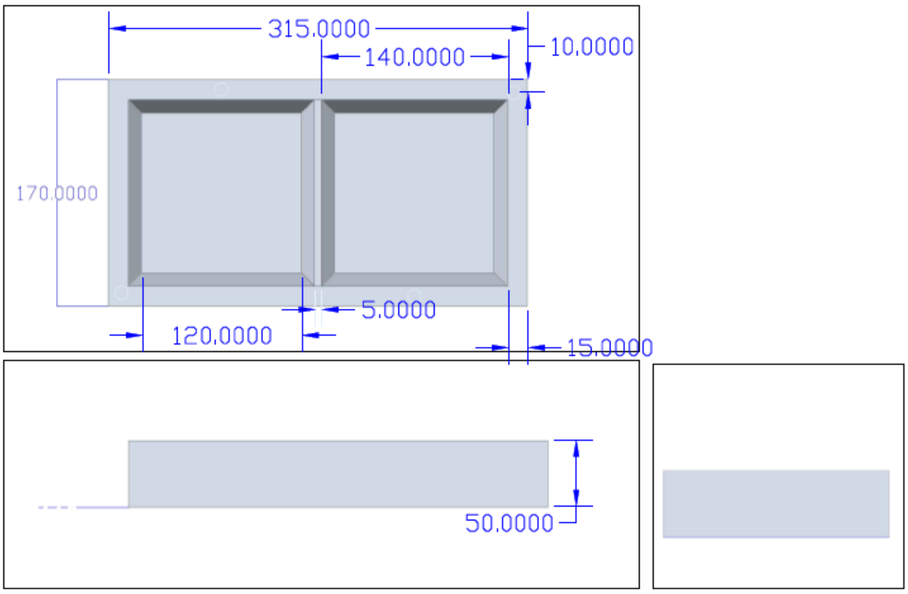
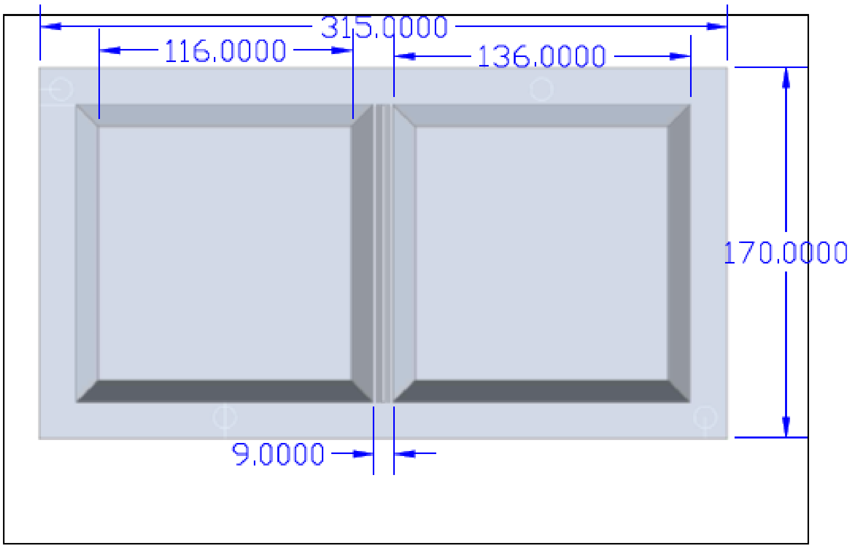


Figure A1: Mould drawing (bottom part)



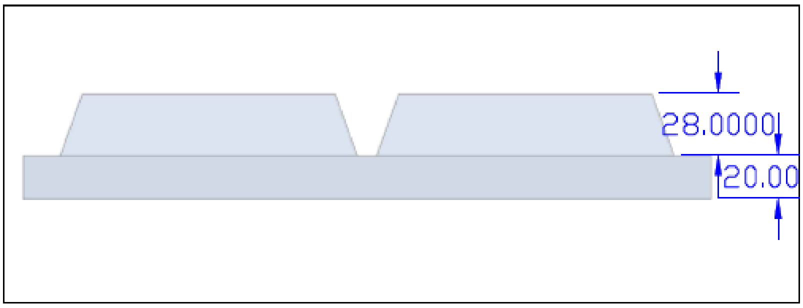


Figure A2: Mould drawing (top part)