ECO-BRIQUETTES USING WASTE NEWSPAPER AND COCONUT HUSK

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This report is submitted in partial fulfillment of the requirement for the award of Diploma of Mechanical Engineering

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‘ I hereby declare that this report is the result of my own work except for quotes as cited in the references.”

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“I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Diploma of Mechanical Engineering.’

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Date:……

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ABSTRACT

Briquetting is the process of conversion of agricultural waste and municipal waste into uniformly shaped briquettes that are easy to use, transport and store. Briquettes were discovered to be an important source of energy during the first and second world wars for heat and electricity production using simple technologies . Malaysia has abundant supplies of biomass resources, particularly agro-forestry residues and municipal solid waste, whose potentials are yet to be fully tapped for energy generation. The study was undertaken to investigate the properties of fuel briquettes produced from a mixture of a municipal solid waste and an agricultural residue which is waste newspaper and coconut husk particles. Briquettes were made manually using coconut husk and waste newspaper mixing ratios by weight which is 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 ratio. Results obtained showed that briquettes produced using 100% waste newspaper and 90:10 waste newspaper and coconut husk ratios respectively has the largest heat transfer when tested with rocket stove and the temperature recorded using thermocouple.

ABSTRAK

Briquetting adalah proses penukaran sisa pertanian dan sisa perbandaran ke dalam briket berbentuk seragam yang mudah untuk digunakan dan menyimpan. Briket telah ditemui untuk menjadi sumber tenaga yang penting semasa perang dunia pertama dan kedua bagi penjanaan haba dan elektrik menggunakan teknologi mudah. Malaysia mempunyai sumber biomass yang banyak, terutamanya sisa agro-perhutanan dan sisa pepejal perbandaran, yang berpotensi belum dimanfaatkan sepenuhnya untuk penjanaan tenaga. Kajian ini telah dijalankan untuk menyiasat sifat-sifat briket bahan api yang dihasilkan daripada campuran sisa pepejal perbandaran dan sisa pertanian yang dihasilkan menggunakan sisa akhbar dan sabut kelapa. Briket telah dibuat secara manual menggunakan sabut kelapa dan sisa akhbar dengan nisbah mengikut berat iaitu 100: 0, 90:10, 80:20, 70:30, 60:40 dan 50:50 nisbah. Keputusan yang diperolehi menunjukkan bahawa briket yang dihasilkan menggunakan 100% sisa akhba dan 90:10 sisa akhbar dan nisbah sabut kelapa masing-masing mempunyai pemindahan haba terbesar apabila diuji dengan dapur roket dan suhu yang dirakam menggunakan penyukat suhu.

CHAPTER 1

INTRODUCTION

1.0 Introduction

A briquette is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, coconut husk, or paper used for fuel and kindling to start a fire. The term comes from the French language and is related to brick. Briquetting is the process of conversion of waste materials into uniformly shaped briquettes that are easy to use, transport and store. The briquetting of biomass improves its handling characteristics, increase the volumetric calorific value, reduces transportation costs and makes it available for a variety of application. Briquettes were discovered important during the first and second world wars for heat and electricity production using simple technologies.

Charcoal Briquette is viewed as an advanced fuel because of its clean burning nature and the fact it can be stored for long periods of time without degradation. Hence, this study focused on providing eco-briquettes using waste newspaper and coconut husk as alternative to wood charcoal. Newspaper and coconut husk briquettes can be used to heat boilers in manufacturing plants, and also have applications in developing countries. This briquettes are a renewable source of energy and avoid adding fossil carbon to the atmosphere. Many companies have switched from furnace oil to biomass briquettes to save costs on boiler fuels. Use of newspaper and coconut husk briquettes can earn Carbon Credits for reducing emissions in the atmosphere.

Many people make their homemade briquettes and there are a wide range used by backpackers and survivalists. Eco-briquettes using waste newspaper and coconut husk is simple to make, low cost, and performs admirably in the field.

1.1 Project background

This project is focus on designing, fabricating and testing a waste newspaper and coconut husk briquettes which is environmental friendly, more efficient and concentrated. To accomplish this project, proper research and preparation needs to be done and a few recommendations need to be considered.

First step of this project is to looking for the idea of a well-designed briquettes and turn it into a simple sketch. Then, the suitable materials needed need to be collected in order to make a briquettes using waste newspaper and coconut husk.

After the briquettes is made, the briquettes needs to be run in a few tests to make sure it is functioning while achieving the required characteristics including high efficiency and high burning rate. The briquettes has to be modified if it does not meet the wants and needs. Eventually, we can make a conclusion by stating whether this briquettes is successful after the test and modification is completed. If the test run shows positive respond, then we can conclude that this briquettes can be accepted.

1.1 Problem statement

Improvised briquettes are common all around the world and come in numerous designs. The common briquettes is made up of poor design and low which is not effective and has low heat transfer. This will leads to ineffective burning and heat distribution that produce low amount of heat. Furthermore, many briquettes does not consider the emission of harmful gas which causes the high production of carbon dioxide which leads to poor air quality.

1.2 Objective

The objectives of this project are:

i. To design and fabricate different ratio of eco-briquettes using waste newspaper and coconut husk.
ii. To analyse the process of combustion of briquettes.

1.3 Scope of project

i. To design a briquettes using waste newspaper and coconut husk which has high burning rate.
ii. To fabricate and identify the efficiency of different type of ratio of newspaper and coconut husk eco-briquettes.
iii. To analyse combustion process and heat distribution process.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The material that was related or was used in this project based research and reference done during finishing this project. The function and the application for the material will be explained in this chapter. The information was obtained from journal, article and searching through the internet.

This research is focus on development of eco-briquettes as alternative way for heating, cooking fuel and electricity generation. Eco-briquettes are built with material that not degrade the environment, waste newspaper and coconut husk will replace other commom material in briquettes that will harm the environment. It contained 100% of waste materials. The research is to determine the most efficient eco-briquettes made from different ratio of waste newspaper and coconut husk.

2.1 Briquetting

Briquetting is a process in making the briquettes. This section will cover the principle and technology using in the briquetting process and the characteristic of bio-briquettes. Bio-briquettes is can be used either for heat generation in households and small scale home industries, or even for power generation in large industries (Kettunen and S. Foster Wheeler, 2004).

Principle and Technology

Densification or briquetting is a mechanical treatment to upgrade the loose biomass into a higher density and uniform solid fuel via compaction. It has higher density and energy content and less moist compared to its raw material (A.B Nasrin *et al.* 2008). The briquetting process will increase the physical, chemical and combustion

properties over of the raw material and easy to handle. There are two technologies that can be used in the process which is screw extrusion and piston pressing where both can be done with or without binder. The central hole incorporated into the briquettes produced by a screw extruder helps to achieve uniform and efficient combustion and, also, these briquettes can be carbonized (Grover. P.D and Mishra. S.K, 1996).

Another type of briquetting machine is the hydraulic piston press. This is different from the mechanical piston press in that the energy to the piston is transmitted from an electric motor via a high pressure hydraulic oil system. It is compact and light. Because of the slower press cylinder compared to that of the mechanical machine, it results in lower outputs. This machine can tolerate higher moisture content than the usually accepted 15% moisture content for mechanical piston presses.

Pelletizing is closely related to briquetting except that it uses smaller dies so that the smaller products are called pellets. The pelletizer has a number of dies arranged as holes bored on a thick steel disc or ring and the material is forced into the dies by means

of two or three rollers. The two main types of pellet presses are which is flat and ring types (Eriksson, S. and M. Prior, 1990). The flat die type features a circular perforated disk on which two or more rollers rotate. The ring die press features a rotating perforated ring on which rollers press onto the inner perimeter. Pellet press capacity is not restricted by the density of the raw material as in the case of piston or screw presses (Grover. P.D and Mishra. S.K, 1996).

There are different forms of compressed materials. These forms are cubes, pellets and crumbles. American society of Agricultural Engineers (ASAE, 1991) defined these forms as follow:

i. Cubes: An agglomeration of ungrounded ingredients. The configuration of the agglomeration may take any form.

ii. Pellets: An agglomeration of individual ground ingredients, or mixture of such ingredients, commonly used for animal feed.

iii. Crumbles: Palletized feed reduced to granulate form. The best known forms of the compressed materials are pellets and briquettes. In general there is no difference in properties between them. The small-length pressed materials are called pellets and the course materials are called briquettes. The use of briquetting for the conversion of agricultural residues is comparatively recent. Briquetting makes these wastes easier to transport, to handle and to store.

Figure : Piston press technologies in the production of palm biomass briquettes

Source: MPOB Information Series. ISSN 1511-7871, Jun 2010.

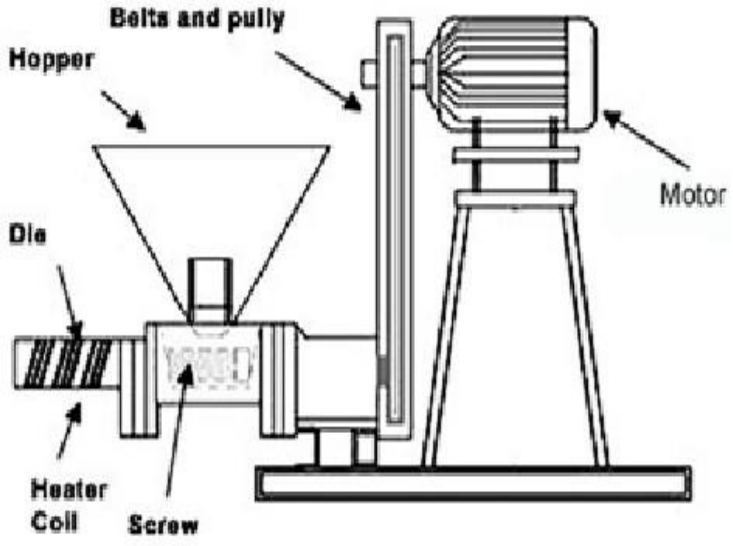

Figure : A typical commercial screw extrusion set-up

Source: MPOB Information Series. ISSN 1511-7871.Jun 2006

CHARACTERISTICS OF BIO-BRIQUETTES

Moisture content

The moisture content is expressed as the mass of moisture per unit mass of wet or dry material. In the wet-mass method of measurement, the moisture in a sample is expressed as a percentage of the wet mass of the material; in the dry mass-method, it is expressed as a percentage of the dry mass of the material (Peavy, Howard S., Environmental Engineering Book). Equation for the calculation of wet-mass moisture content:

$$\text{Moisture Content } (\%) = \left(\frac{a-b}{a}\right) \times 100 \qquad \text{.....Equation 2.1}$$

Where a = initial mass of sample as delivered

b = mass of sample after drying

The moisture content in bio-briquettes should be as low as possible, generally in the range of 10-15 percent. Problems will occurred in grinding and excessive energy will required in drying process if high moisture content is in the bio-briquettes**.** If the feed moisture content is around 8-10% and the resulting briquettes after compaction process will have 6-8% moisture content**.** The significant of bio-briquettes having more moisture contents, the solid fuels result in easily cracks, poor and weak and the operation is erratic. Excess steam is produced at higher moisture content leading to the blockage of incoming feed from the hopper, and sometimes it shoots out the briquettes from the die. Therefore, it is necessary to maintain optimum moisture content (Grover. P.D and Mishra. S.K, 1996).

2.2 Renewable energy

Renewable energy sources are those resources which can be used to produce energy again and again, e.g. solar energy, wind energy, biomass energy, geothermal energy, etc. and are also often called alternative sources of energy (Rathore NS, Panwar NL, 2007). According to the world energy council projections, if the adequate policy initiatives are provided, in 2005, 30% of direct fuel use and 60% of global electricity supplies would be met by renewable energy sources (M.P Koh and W. K. Hoi, 2003). For the other renewable energy sources such as wind and solar, its have limitation due to the form energy that they produces. Biomass energy is versatile because it can be produced in gaseous form (gas and biogas), liquid form (alcohol) and solid form (charcoal and briquettes) by adding value to commercialization. Furthermore, biomass energy system is not site specified so it can be established in any places where the plants are grown and animal waste are available. Renewable energy is a clean or inexhaustible energy like hydrogen energy and nuclear energy and it can decrease of environmental pollution.

Table : Main renewable energy sources and their usage

Energy Sources	Energy conversations and usage options
Hydropower	Power generation
Modern biomass	Heat and power generation, pyrolysis, gasification, digestion.
Geothermal	Urban heating, power generation, hydrothermal, hot dry rock
Solar	Solar home system, solar dryers, solar cookers
Direct solar	Photovoltaic, thermal power generation, water heaters
Wind	Power generation, wind generators, windmills, water pumps
Wave	Numerous design
Tidal	Barrage, tidal stream

Source: Kralova I, Sjöblom J, 2010

2.3 Biomass

Biomass is refers to the organic matter which can be used as a renewable energy source in a number of different ways. Biomass also can be defined as all renewable organic matter including plant materials, whether grown on land or in water, animal products and manure, food processing and forestry by products, and urban wastes (Kitani and Hall, 1989).

The term biomass covers a large number of materials with highly different properties which can be used as fuels. These materials can be classified into a few main categories, each of which can be divided into several types:

i. Wood from forestry
ii. Residues from wood and food industries
iii. Agricultural residues
iv. Energy crops (Madsen, 1994)

Biomass generally contains a lower percentage of carbon and a higher percentage of oxygen than fossil fuels. The result is a lower heating value per unit mass of biomass compared with fossil fuels. This means that more biomass fuel must be handled and processed to obtain an equivalent unit of usable energy (Unger, 1994).

2.4 Coconut husk

Coconut husk known as which extracted from the outer surface of coconut. Coconut Husk provides useful products and this is also one of the good product from the coconut tree. Coconut tree is another miracle tree and this tree produces the greater production to entire market. Coconut husk has great capacity to produce various important products to the modern market. Coconut husk offer good solution for greenhouse production as a raw material of soil. Coconut husk are also used as a bio fuel and this also a source of charcoal too. So according to above facts coconut husks are considered as the best natural organic growing medium in world. Since the product from coconut husks are 100% natural most of these product can easily recyclable.

Figure shows Coconut Husk

Most of coconut husk producer produce this very attractive type of these coconut husks form the raw materials. Normally these coconut base husk are a form of chips which is small part of outer shell and these Coconut chips are produced by cutting coconut husk in the small piece of slices. Coconut growing mediums such as coconut husks and coconut chips has larger market share in natural growing medium market and this is also environment friendly growing production. Coconut husk is a suitable material to produce a stable briquettes with other materials such as newspaper and it is a better alternative to charcoal.

2.5 Newspaper

A newspaper is printed on thin paper made from a combination of recycled matter and wood pulp, and is not intended to last very long. Newspaper is the major contributor of solid waste by either weight or volume. One of the most common items recycled all across the globe is old newspapers. Hundreds of tons of waste paper is collected daily from homes and offices. There was a time when they were disposed by burning or dumping them in landfills. Nowadays, the best and most eco-friendly way to get rid of old papers is to reuse them so that they can used again for different purposes. It is highly recyclable and can be manufactured into some other materials.

Newspaper is the major contributor of solid waste by either weight or volume. Yet it is highly recyclable and can be manufactured into some other materials. Thus, newspaper briquettes was introduced as an alternative for charcoal. Also, it will not destroy our forests and ravage mother earth but instead, this will help minimize solid waste and reduce forest denudation due to charcoal making (The Central Echo, 2011). Waste newspaper briquettes are made by soaking papers overnight and forming it into fist size balls which are left to dry in the sun. Waste newspaper briquettes serves as a good alternative fuel for cooking. Encouraging the use of waste newspaper briquettes as an alternative for fuel is a good practice. Waste papers that would otherwise end up in landfills are given new use as cooking medium. This will also help reduce dependence on forest wood for cooking. Since this is made out of used paper materials, this is inexpensive and can be done by every household anytime. It does not produce soot like ordinary charcoals. A few pieces of these paper charcoals can be used for cooking and is very ideal to use during the rainy season (OISCA, 2012). Aside from its environmental benefits, it will also help families with their budget since waste newspaper briquettes can easily be made and the materials to be used are widely available. Waste newspaper briquettes may function differently than charcoal but it is very resourceful and eco-friendly.

2.6 Water

Water is a chemical substance with the chemical formula H_2O. Its molecule contains one oxygen and two hydrogen atoms connected by covalent bonds. Water is a liquid at ambient conditions, but it often co-exist on earth with solid state, ice and gaseous state, water vapor or steam. Water is a tasteless, odourless liquid at standard temperature and pressure. The color of water and ice is, intrinsically, a very slight blue hue, although water appears colorless in small quantities. Ice also appears colorless and water vapor is essentially visible as a gas. The purpose of water used in briquettes is to break down the newspaper into soft particles and create soup like mixture of water and newspaper so that the newspaper can be molded and shaped easily. In addition, an excessive amount of water will affect the tightness of the briquettes. The water that used in mixing must be clean and free from oils, alkalis, acids, and organic materials. Water for drinking is the most recommended to be used.

2.7 External additives

The briquetting process does not add to the calorific value of the base biomass. In order to upgrade the specific heating value and combustibility of the briquette, certain additives like charcoal and coal in very fine form can be added. About 10-20% char fines can be employed in briquetting without impairing their quality (Grover. P.D and Mishra. S.K, 1996). The variety of biomass had been used to improve the mechanical strength and the energy content like calcium carbonate, beach sawdust, ash chipping, nut shell, rice shell, huskus of grape-vine and cuttings of grape-vine (Mitic and Nesic, 1997) and the result revealed that the briquettes are compact, no crumbling, no cracking in drying phase, and it is possible to cut and engrave them (Jankovic. S, 1997).

2.8 Ash content and composition

Biomass residues normally have much lower ash content (except for rice husk with 20% ash) but their ashes have a higher percentage of alkaline minerals, especially potash. These constituents have a tendency to devolatalise during combustion and condense on tubes, especially those of super heaters. These constituents also lower the sintering temperature of ash, leading to ash deposition on the boiler‟s exposed surfaces (Grover. P.D and Mishra. S.K, 1996). The ash content of different types of biomass is an indicator of slagging behavior of the biomass which is the greater the ash content, the greater the slagging behavior. But this does not mean that biomass with lower ash content will not show any slagging behavior. The temperature of operation, the mineral compositions of ash and their combined percentage determine the slagging behavior. If conditions are favorable, then the degree of slagging will be greater. Minerals like Silicon Oxide (SiO) are more troublesome. Many authors have tried to determine the slagging temperature of ash but they have not been successful because of the complexity involved. Usually slagging takes place with biomass fuels containing more than 4% ash and non-slagging fuels with ash content less than 4%. According to the melting compositions, they can be termed as fuels with a severe or moderate degree of slagging (Grover.P.D and Mishra S.K, 1996).

Table : Ash content of different biomass type

Biomass	Ash content (%)	Biomass	Ash content (%)
Corn cob	1.2	Coffee husk	4.3
Jute stick	1.2	Cotton shells	4.6
Sawdust (mixed)	1.3	Tannin waste	4.8
Pine needle	1.5	Almond shell	4.8
Soya bean stalk	1.5	Areca nut shell	5.1
Bagasse	1.8	Castor stick	5.4
Coffee spent	1.8	Groundnut shell	6.0
Coconut shell	1.9	Coir pith	6.0
Sunflower stalk	1.9	Bagasse pith	8.0
Jowar straw	3.1	Bean straw	10.2
Olive pits	3.2	Barley straw	10.3
Arhar stalk	3.4	Paddy straw	15.5
Lantana camara	3.5	Tobacco dust	19.1
Subabul leaves	3.6	Jute dust	19.9
Tea waste	3.8	Rice husk	22.4
Tamarind husk	4.2	Deoiled bran	28.2

Source: P.D. Grover & S.K. Mishra, 1996.

CHAPTER 3

METHODOLOGY

3.0 Introduction

Methodology shows the flow of project from the beginning until this project is accomplished. There will be explanation on methodology used to achieve the project objectives and finish this project. This chapter was done by referring to the information obtained from the literature review. In addition, the procedure of the setup of the project and the test will also be explained in this chapter. Based on the procedure the test was done and the result was recorded.

3.1 Materials

The materials used in manufacturing of eco-briquettes in this research are coconut husk, newspaper, and water. Raw materials available in the recycle centre and farm.

3.2 Flowchart process

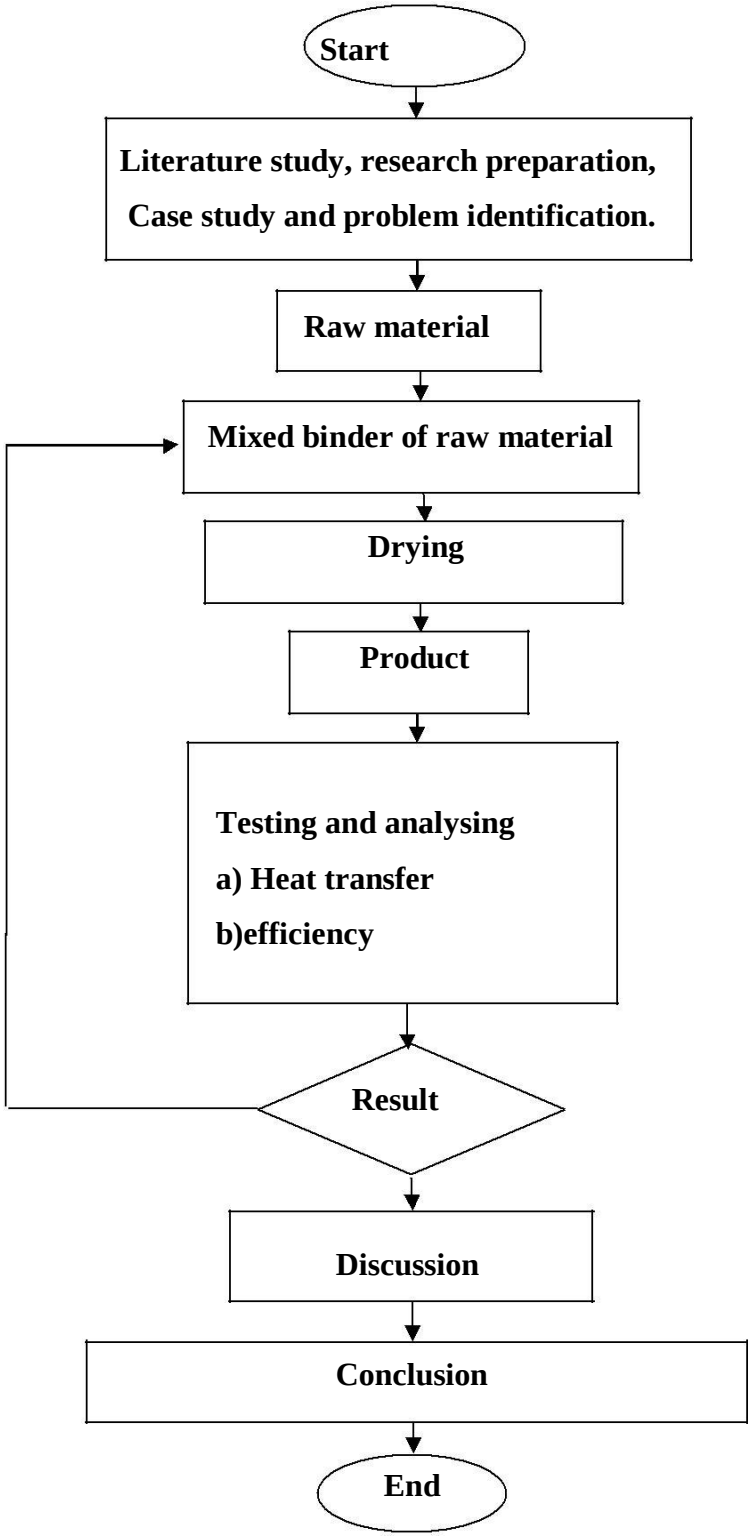

Figure : Flowchart of project

Figure shown the final year research process. In this project, start with literature study, research preparation case study and problem identification. After that we gather all raw materials. Start the making briqquettes with the standard of procedure. Than we need go through the drying process to become product. Product will undergoes the testing. If get the best and fulfill briqquettes specification the heat transfer test will run. Final gathers all data from experiment for result, analysis, discussion and conclusion.

3.3 Composition of raw material

Sample	Ratio		Original mass of briquette with water (g)	Mass of briquette after drying (g)						
	Coconut Husk	Waste Newspaper		12 hrs	24 hrs	36 hrs	48 hrs	60 hrs	72 hrs	84 hrs
A	100	0	100	69	51	42	29	18	14	14
B	90	10	100	65	50	39	27	15	9	9
C	80	20	100	61	49	37	25	17	13	13
D	70	30	100	70	39	23	19	16	14	14
E	60	40	100	81	50	34	26	21	16	16
F	0	100	100	73	63	48	33	26	20	20
G	10	90	100	71	60	49	35	23	18	18
H	20	80	100	78	65	50	38	29	24	24
I	30	70	100	93	47	32	26	22	18	18
J	40	60	100	72	62	41	33	27	23	23
K	50	50	100	95	64	51	35	29	24	24

3.4 Process of manufacturing

- **Collecting wastes and preparing them**

All the wastes are firstly cleaned out thoroughly with water to remove dirt and are dried on open top for few days. Primary Samples are ready after they are completely dried out. The dried samples were cut into small pieces (about ½ inch). The samples were soaked in different buckets for 24 hours. After 24 hrs. the samples were filtered using a mesh and partially dried for few minutes.

- **Preparing Briquetting sample**

The water filtered sample is then mixed with the binder. Both are mixed well. Then the mixture is kept into mould which is placed on a round container. After putting all the prepared mixture, the mould is closed with lid and kept under fitted and tightened to apply pressure. The pressure is applied for about 24 hours.

- **Drying**

After 24 hrs. the mould should be carefully removed. A round briquette with high moisture content is obtained. Then it should be dried enough to obtain a rigid briquette. . During drying, the briquette , which would have formed, changes from a semi-solid to a solid form, thus holding the particles together.

- **Firing of the samples**

The samples were fired in an rocket stove and the heat distribution is recorded using thermocouple and pico log software. Finally, the most efficient briquette sample will be identified.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.0 INTRODUCTION

In this chapter, the results of the different types of test are obtained and are explained. There are figures and tables provided show the results that already obtained. At the end of this chapter, the result will be explained based on their specifications, advantages and disadvantages. The discussion is explained at testing with the proof and achievement stated.

4.1 Result

The result of the test is shown by two aspects which are by heat transfer and flame. Thermocouples is used to view the result in terms of heat transfer while for flame, the result is taken by observation using naked eyes.

4.1.1 Heat transfer

Thermocouples and thermocouple data logger together with Pico Log data logging software is used to measure the heat distribution around the pot gap in between the chimney and bottom of pot. The picture of thermocouples and thermocouple data logger as well as Pico Log data logging software are shown in Figure 4.1 and Figure 4.2 respectively.

Figure : Thermocouples and thermocouple data logger

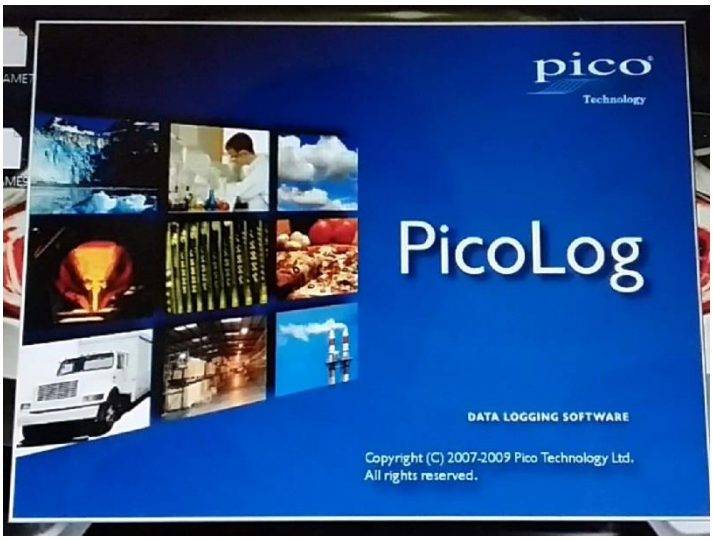

Figure : Pico Log data logging software

Pot skirt of the fabricated rocket stove is drilled 90° to each other to make four holes in order to make way for thermocouples to enter the area that the

temperature to be taken. The hole is made to leave a gap of approximately 1 millimetre above the top of stove. Afterwards, four thermocouples are inserted to the holes that have been made as shown in Figure 4.3.

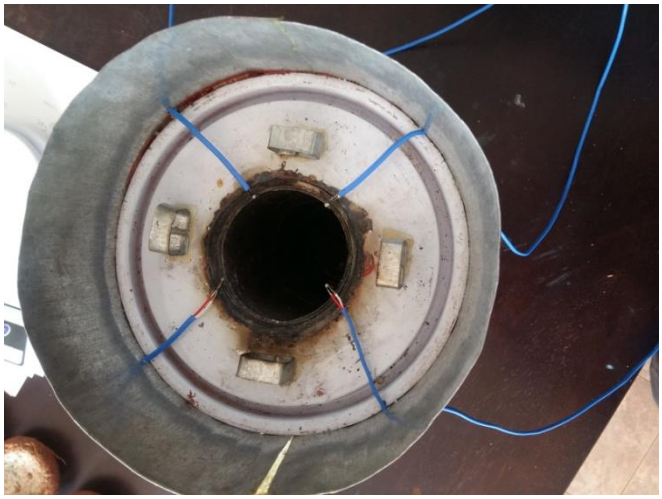

Figure : Location of thermocouples

Pico Log data logging software is opened after thermocouples are connected to data logger and data logger is linked to a laptop. The sampling interval is set to 300 seconds which is equivalent to 5 minutes and the software is set to stop taking data after 3 samples were taken. The software is started right after the briquette in rocket stove was lightened. The data obtained is shown in Table 4.1 while a graph of temperature versus time is plotted as shown in Figure 4.4.

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	53.95	65.15	59.82	62.79
300	395.68	382.25	401.93	398.27
600	448.49	461.82	462.94	458.48
900	553.40	548.39	534.26	530.53

Table : Data of ratio of waste newspaper to coconut husk which is 100:0 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	51.85	63.35	57.84	60.59
300	373.67	372.84	368.59	368.98
600	438.47	441.85	432.74	438.88

900	513.40	508.39	504.26	510.53

Table : Data of ratio of waste newspaper to coconut husk which is 90:10 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	53.75	58.15	55.82	60.73
300	365.36	362.68	361.32	358.54
600	418.49	422.34	416.76	420.24
900	493.20	488.15	484.74	490.68

Table : Data of ratio of waste newspaper to coconut husk which is 80:20 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	52.35	63.15	53.82	55.79
300	345.68	352.25	351.93	349.27
600	408.39	401.56	402.74	411.44
900	476.40	479.39	474.26	470.46

Table : Data of ratio of waste newspaper to coconut husk which is 70:30 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	53.05	55.75	59.55	62.46
300	343.24	339.52	341.08	338.79
600	398.78	401.43	412.90	408.76
900	453.46	458.21	455.67	459.47

Table: Data of ratio of waste newspaper to coconut husk which is 60:40 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	50.96	51.11	52.10	49.25
300	355.68	352.25	351.93	353.27
600	388.49	381.82	382.94	378.48

900	423.08	418.93	404.62	410.35

Table: Data of ratio of waste newspaper to coconut husk which is 50:50 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	43.95	55.15	49.82	52.79
300	293.68	292.65	291.58	298.33
600	344.49	361.28	362.94	358.48
900	421.49	418.09	412.26	410.53

Table : Data of ratio of coconut husk to waste newspaper which is 100:0 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	52.22	55.75	50.63	53.78
300	303.64	307.82	301.45	305.32
600	350.36	357.79	355.01	354.21
900	428.40	432.39	430.89	427.35

Table : Data of ratio of coconut husk to waste newspaper which is 90:10 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	52.59	62.24	57.46	60.26
300	325.68	322.13	319.37	328.29
600	368.49	361.82	362.03	358.48

900	433.08	438.93	440.16	436.34

Table: Data of ratio of coconut husk to waste newspaper which is 80:20 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	52.95	61.25	57.26	60.43
300	358.68	352.75	357.25	360.73
600	396.78	399.46	397.12	396.58
900	440.54	446.89	445.36	449.04

Table: Data of ratio of coconut husk to waste newspaper which is 70:30 using thermocouples

Time (sec)	Channel 1 (°c)	Channel 2 (°c)	Channel 3 (°c)	Channel 4 (°c)
0	53.09	64.72	59.33	62.64
300	395.68	382.25	401.93	398.27
600	413.78	418.24	411.05	419.94
900	456.77	452.45	454.98	453.71

Table: Data of ratio of coconut husk to waste newspaper which is 60:40 using thermocouples

4.1.2 Flame

In this test, the smoke emitted only can be seen in the cold start phase, which is the early phase of combustion. After several minutes of combustion, there is no visible smoke seen flowing out from the pot gap and the picture is shown in Figure 4.5. Moreover, long flame is seen in the combustion chamber as shown in Figure

.

Figure : Flame in rocket stove

4.2 Discussion

The data obtained shows that the temperature increase rapidly in the first 300 seconds and the rate of temperature increase after the time of combustion exceed 300 seconds. This is because the body of stove absorb some heat form the combustion and some heat from flame is used to raise the temperature of an area on the briquette surface to some depth into the briquette. Moreover, the heat also boils and evaporates the water in the briquette when the briquette’s surface temperature approaches 100 degrees Celsius.

There are some different in temperature for each of the four thermocouples at certain time of combustion. However, the heat can be considers distributed equally beneath the pot as the range of temperature is not too big. The small difference in measured temperature is due to the uneven cross sectional area of the hot gases path as there is little difference in height of four different pot rest which disturb the flow of hot flue gases. Moreover, the other reason that leads to unequal temperature of four different points is natural convection of air.

Based on the results that have been explained above, we can conclude that this project has reached and completed the goals that have been set earlier. So the main idea to create a briquette that is the most efficient is succeeded. The main factors that make all the test is succeed without any failure are the materials used, and the details of the idea in making this project runs well. The functionality is important to make sure that this briquette can be used for a long term and capable to give the advantages to the users to use it. Hence, it can be concluded that this waste newspaper and coconut husk briquette is able to perform and replace coal and charcoal.

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

The conclusions that can be drawn from this study and research are briquettes produced from only waste newspaper which is 100:0 ratio and mixture of waste newspaper and coconut husk which is in ratio 90:10, 80:20, 70:30, and 60:40 have high quality, more efficient, highly storable and durable than the briquettes that contain more coconut husk than waste newspaper.