Optimum Efficiency of TCT Honeycomb Briquettes about Its Firepower and Smoke Emission

Mr. MUNYANEZA Jean de Dieu, Mr. NZABONIMANA Gilbert, Mr. RURANGIRWA Martin, Mr. MAJYAMBERE Eugene

Abstract— Around the world, we found many municipal waste or waste biomass that we can use to fabricate beehive briquettes instead of causing hygienic issues and fire hazardous during the dry seasons causing extensive damage to the forest areas [5]. This study found evidence of capability that honeycomb briquettes had for cooking and heating activities where one beehive briquette burnt in the time ranged between 60 -90 minutes by using an insulated metal stove heats 3-10 litres (from about 22°C -92°C at 2052m altitude) of water and also depend on raw materials were made. Smoking test showed that these beehive briquettes are smokeless. Results indicated all six types of beehive briquettes tested had 5,000 watts as average firepower; our research study was limited to the fabrication of beehive briquettes from six wastes biomass with the use of clay soil (25% of clay soil and 75% of powder of waste biomass).

Index Terms— carbonization, honeycomb briquette, firepower and smoking test.

I. INTRODUCTION

An estimated 2.4 billion people globally rely on solid fuels such as coal and biomass for their energy needs, burning 2 million ton of biomass each day (Rehfuess, 2006; Rehfuess et al., 2006). This has consequences for both the environment and human health [2]. Incomplete combustion of these fuels and poor ventilation result in high indoor concentrations of health-damaging pollutants including particulate matter and carbon monoxide (Jetter and Kariher, 2009; Rehfuess, 2006) [1]

Regionally in East African Community (EAC) countries and DRC, the figures on wood fuel reliance are similar: Uganda 98%, Tanzania 96%, Kenya 90%, and the Democratic Republic of Congo (DRC) 95% (UNDP, 2009b). Wood fuel contributes 86% to the primary energy balance and about 97% of Rwandan households are dependent on wood for cooking (NISR, 2008b). [3].

According to recent reports, out of the 95,000 tonnes/year of MSW generated in Kigali 40% is not being collected. It is therefore assumed this is allowed to accumulate on the streets, eventually to be washed away by heavy rains into nearby

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Mr. MUNYANEZA Jean de Dieu, Alternative Energy Department, Tumba College of Technology, Kigali, Rwanda

Mr. NZABONIMANA Gilbert, Alternative Energy Department, Tumba College of Technology, Kigali, Rwanda

Mr. RURANGIRWA Martin, Alternative Energy Department, Tumba College of Technology, Kigali, Rwanda

Mr. MAJYAMBERE Eugene, Alternative Energy Department, Tumba College of Technology, Kigali, Rwanda

rivers and streams. It is estimated that Waste Collection Associations set up by NGO's will collect and process 40,000 tonnes of MSW per year to supply the briquetting factory. [4] Therefore the fabrication of honeycomb briquette can reduce the number of households that are dependent on wood for cooking and reduce sanitation issue which caused by huge biomass deposited in different areas of Rwanda. The main purpose of our study is to turn rejected organic wastes into cooking fuel called "honeycomb briquette".

Heavy dependence on traditional sources of energy such as fuel wood, animal dung and agro- forest residues causes deforestation, soil erosion, floods, climate change and global warming. Among many alternatives, briquetting of waste or residual biomass to produce biobriquette is one reliable option. Biomass briquetting can use a wide range of waste biomass such as agricultural residues, agro-industrial residues, forest waste, etc. Waste biomass especially forest residues such as pine needles, leaves are fire hazardous during the dry seasons causing extensive damage to the forest areas. Therefore, utilization of these waste materials for briquetting can prevent and reduce the damages of the forest areas. Briquetting technology based on the use of waste biomass has been practiced successfully in many developing countries in Asia and Africa [5].

Hardwood woody biomass charcoal briquettes with 20% clay content would produce about 18 MJ/kg or about 9 MJ/briquette. In practice this would heat 2 litres of water in 15-20 minutes using the insulated (one briquette) metal stove (from about 20°C - 98°C at 1300 m altitude). The total burning duration of this briquette is about 1.5 hours. Forest and agricultural waste charcoal briquettes, also with 20% clay, would produce about 12 MJ/kg or 6 MJ per briquette, depending on the composition of the charcoal. In practice this would heat 2 litres of water in 30-45 minutes, using the single briquette stove. The total burning period of one briquette would be about 1 hour [6].

II. MATERIALS AND METHODS

This study carried out is followed by the scientific literature review in biomass briquetting, scientific literature such as journal articles, conference papers, books and documents, including research/project reports, and test/analysis reports. As well, first hand information collected during field visits, interactions and discussion with the briquette entrepreneurs were also part of this paper. The observations and experience of long time affiliation involvement with energy sector through different projects also served as supportive materials for the study. Research findings while conducting different studies related to biomass briquetting also served as the basis of this paper.

A. Study area

This study was carried out in Tumba College of Technology (TCT), Department of Alternative Energy where they made honeycomb briquettes from different raw materials. Tumba College of Technology is a public higher learning technical institution established to train highly skilled technicians needed for the social-economic development of our country. TCT is a dynamic and forward-looking College, vibrant and lively; established in 2007 under the cabinet decision, to produce highly skilled workforce to meet industry and social needs. Currently we offer three courses leading to an advanced diploma (A1) namely: Alternative Energy (AE), Electronics and Telecommunication (ET), and Information Technology (IT) [7].

Since 2008, we have started briquetting technology in Alternative Energy department where we took charcoal dust as raw material, many people rejected this in compost pit as organic waste and we produced a honeycomb briquette which is used as fuel for cooking process and heating. As long we have continued the study on briquetting technology, we have adapted carbonization system of some waste materials like eucalyptus leaves, pine needles, dry banana leaves, and papyrus and forest killers by using charring drum so as to produce honeycomb briquettes and we tested its smoke emission and firepower in TCT Biomass laboratory.

B. Data used for the analysis

This research project was focused on fabrication of beehive (honeycomb) briquettes from different raw materials such as charcoal dust, eucalyptus leaves, pine needles, dry banana leaves, and papyrus and forest killers; then after we got six beehive briquettes from six organic wastes. We tested firepower and smoke emission of each type of beehive briquette. We took also about burning time of each type. During the fabrication of honeycomb briquette, we need to dry raw material so as to reduce moisture content upon 12% to 20%. After carbonizing each type of organic waste; we got charcoal dust to be grinded into powder. This powder will be mixed with binding material (binder) so as to get wet beehive briquette.

We have varieties of binders in TCT biomass laboratory such as Clay soil ratio: 25%-30%, Ceramic clay ratio: 1 unit of clay+ 4 units of water and mix completely, then 1 unit of the mixture is added to 4 units of the charcoal dust, cassava flour ratio: 10%-15%, CMC ratio 5-10%, wheat flour ratio: 15%, corn flour 15% the remaining percentages are for the charcoal dust. During this first study of TCT honeycomb briquettes, we have analyzed six types of beehive briquettes depend on raw material is made but only one type of binder is used in different experiments which is clay soil at 25% of mixing ratio. Apart from laboratory experiments, we have analyzed the information of five cooperatives which did the training on beehive briquetting production.

III. RESEARCH APPROACH AND METHODOLOGY

This research project, we fabricated and tested beehive briquettes done manually, the production process involves partial carbonization of biomass in a charring drum, mixing of char with 25 percent clay soil, followed by compaction in a steel mould. The following are the steps that we have used during manually production of honeycomb briquettes:

- Collection of loose biomass such as charcoals dust/ wastes, eucalyptus leaves, pine needles, dry banana leaves, papyrus, forest killers. This had different moisture content some of them had 80%, only charcoal dust had low moisture content which was between 13% to 22% depend on stored place.
- 2. To dry the loose biomass so as to reduce moisture content upon to 12% to 20%
- 3. Carbonization of biomass on charring drum. This process took different time depend on the type of raw material, the higher contains solid matter the higher time uses to be dried, during our experiments the average time for carbonization process was 25 minutes.

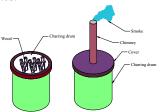


Figure 1: Carbonization of biomass on charring drum

- 4. Grinding of charcoal (Manually and Electric Grinder)
- 5. Mix up the fine particles of charcoal and clay soil.
- 6. Compaction in a steel mould

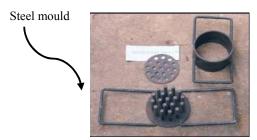


Figure2: Compaction in a steel mould

7. Drying of wet beehive briquettes to the sun during 10 days so that they could use for cooking or heating activities One beehive briquette has 12 cm of diameter and 12 cm of height, it weighs also 800 to 1,000 grams when it is completely dried. After burning completely, the remaining ash is ranged between 250-300 grams.



Figure 3: Place the beehive briquette for sun drying

As we have produced six beehive briquettes from also six raw materials while we conducted test of firepower and smoke emission of each type, we have taken randomly three pieces of beehive briquettes from each type, therefore the below table showed the average result found on each case:

S/N	Type of beehive briquette	Average Firepower of briquette burnt(watts)	Average Smoking test result(readi ngs on filter paper)	Average Time spent in burning process(in minutes)
1	BHB from charcoal dust	5,200	0-1	90
2	BHB from eucalyptus leaves	5,050	0-1	75
3	BHB from pine needles	5,102	0-1	80
4	BHB from dry banana leaves	4,800	0-2	60
5	BHB from papyrus	4,898	0-2	65
6	BHB from forest killers	4,950	0-1	70

Table 1: Result of firepower and smoking test via burning time

This is an example of how we have calculated firepower of BHB briquettes where its mass varies between 800 to 1000 grams depends on manually pressure of Compaction in a steel mould.

BHB from charcoal dust has 985 grams

Firepower =
$$\frac{\text{CV x MFU}}{\text{Time taken to turn x 60 occ}} \text{ (watt)} = \frac{\frac{283072 \times 0.985 \text{ kg}}{\text{kg}} \times 0.985 \text{ kg}}{70 \times 09}$$
$$= \frac{28,072.5 \text{ kj}}{8400 \text{ Sec}}$$

= 5.1986kj/sec = 5198.6 watts

Where CV is the heating value or calorific value of charcoal (KJ/kg) and

MFU is mass of fuel used (kg)

The heating value or calorific value of charcoal = 28,500 kJ/kg

During the testing phase where we wanted to know the capacity of water in litres to boil using the insulated (one briquette) metal stove (from about 22°C up to 92°C at 2052m altitude). We tested in different batches because the insulated (one briquette) metal stove is very small and can hand only a saucepan of 3 litres.

S/N	Type of beehive briquette	Average Time spent in burning process(in minutes)	Average time taken to boil 3 litres but for starting time there is a delay of 5 to 10 minutes of ignination.	Average capacity of water in liters to boil using the insulated (one briquette) metal stove (from about 22°C - 92°C at 2052m altitude)
1	BHB from charcoal dust	90	Starting time = 30 min WhileBHB was ready = 22min(22-30 min)	10 litres in 4 batches
2	BHB from eucalyptus leaves	75	Starting time = 38 min WhileBHB was ready = 30min(30-38 min)	6 litres in 2 batches
3	BHB from pine needles	80	Starting time = 35 min WhileBHB was ready = 28min (28-35 min)	7.5 litres in 3 batches
4	BHB from dry banana leaves	60	Starting time = 45 min WhileBHB was ready = 33min (33-45 min)	3 litres in 1 batch
5	BHB from papyrus	65	Starting time = 43 min While BHB was ready = 30min (30-43 min)	4 litres in 2 batches
6	BHB from forest killers	70	Starting time = 40 min While BHB was ready = 30min (30-40 min)	6 litres in batches

Table 2: Result of average capacity of water to be boiled for each type of BHB

Apart from laboratory experiments, we have visited and gathered the information of five cooperatives which did the training on beehive briquetting production in TCT Campus. Those five cooperatives are C.F.M of Nyamasheke district, TERIMBERE KARAMBO (Rulindo), TWITEZIMBERE (Rulindo), COOJEC (Rulindo), TUZAMURANE (Rulindo) and their members have appreciated the positive impact of using beehive briquette in daily life such as;

- To save energy,
- To improve its combustion efficiency,
- To make handling more convenient,
- To save time,
- To be free from diseases such as headache, lung diseases, eye problems.

These people showed also a few demerits of beehive briquettes such as;

- It is used once, no way to use more than one time,
- Not easy to ignite as way it has nineteen holes that help beehive briquette to burn well.

IV. RESULTS AND DISCUSSION

A. Firepower and smoking test via burning time

Results indicated all six types of beehive briquettes tested had 5,000 watts as average firepower and smoke emission is 0-1 reading on filter paper as showed by table 1 which means beehive briquettes are smokeless and environmental friendly. Among those types of beehive briquettes, the best are those from charcoal dust, pine needles and eucalyptus leaves.

B. Capacity of water to be boiled for each type of BHB

Table 2 displays average capacity of water to be boiled for each type of BHB where beehive briquette from charcoal dust is able to boil 10 litres in 90 minutes whereas beehive briquette from dry banana leaves is able to boil 3 litres in 60 minutes using the insulated (one briquette) metal stove (from about 22°C - 92°C at 2052m altitude).

CONCLUSIONS

The study found evidence of capability that honeycomb briquettes had for cooking and heating activities where one beehive briquette burnt in the time ranged between 60 -90 minutes by using an insulated metal stove heats 3- 10 litres (from about 22°C - 92°C at 2052m altitude) of water and also depend on raw materials were made. Smoking test showed that these beehive briquettes are smokeless. Around the world, we found many municipal waste or waste biomass that we can use to fabricate beehive briquettes instead of causing hygienic issues and fire hazardous during the dry seasons causing extensive damage to the forest areas [5]. Our research study was limited to the fabrication of beehives briquettes from six wastes biomass with the use of clay soil (25% of clay soil and 75% of powder of waste biomass). Further studies are therefore necessary to determine the effects of a variety of binders to the quality of honeycomb briquettes.

ABBREVIATIONS

BHB: Beehive briquette

CMC: Carboxyl methyl cellulose sodium salt DRC: Democratic Republic of Congo

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MJ: Mega joule

MSW: Municipal Solid Waste

NGO: Non-governmental organization

NISR: National Institute of Statistics of Rwanda

TCT: Tumba College of Technology

UNDP: United Nations Development Program

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MUNYANEZA Jean de Dieu was born December 23, 1983 in Musanze, Rwanda. He received, in 2011, the advanced



diploma in Alternative Energy with first class from Tumba College of Technology, Rwanda. In 2014; he received the B.S. degree as engineer in electrical engineering from University of Rwanda/ College of science and Technology with second class honours, upper division. He is

currently Assistant Lecturer in Alternative Energy at Tumba College of Technology, Rwanda. Since 2012, he was the Managing Director of Muneza Biomass Engineering Ltd which focused on the design and construction of biomass technology and design and production of briquetting technology.

Some academic achievements are: He is Author of academic paper titled "Firewood-Stove Made in Rwandan Rock" reviewed and published by Global journal inc. (USA), *GJRE* (2015) Volume 15 Issue 4: 25-29. Category: For Code: 091599 · Added: Jun 01, 2015 and he is among of the authors of academic paper titled "Design of Automatic Irrigation System for Small Farmers in Rwanda" Received 7 February 2015; accepted 28 February 2015; published 6 March 2015 Copyright © 2015 by authors and Scientific Research Publishing Inc. Since 2011, his current research interests at

Tumba College of Technology include the performance of Energy saving stove and briquetting technology.

NZABONIMANA Gilbert was born in March 1978 at Huye, Rwanda. He received in 2013 the Diploma in Technical



Education from Kenya Technical Teacher's College, Nairobi, Kenya. He also received B. Sc. Degree in 2007 from Kigali Institute of Science and Technology (KIST) in 2007, Option of Electrical Engineering.

In 2010, he joined Tumba College of Technology (TCT), Rulindo, Rwanda; He is currently Assistant Lecturer in

Alternative Energy at Tumba College of Technology, Rwanda.

His current research interests concern Optimum efficiency of TCT honeycomb briquettes about its firepower and smoke emission.



RURANGIRWA Martin was born in Rwanda on November 02, 1980. He received the B.S degree as engineer in electrical Engineering from Kigali Institute of Science and Technology. From May 2008-October 2009: He was

Director Manager for Real Time Engineering s.a.r.l in charge of construction and installation of Communication towers in Rwanda. On June 2008: Employed as permanent Assistant Tutor in Tumba College of Technology (Alternative Energy Department). From November 15th, 2009 - December 03rd, 2009: He was trained in Nepal on Renewable Energy (MHP, Solar Systems, biomass and biogas).

On January 2012: He contributed in research on domestic biogas plants for Models Rw1 and Rw2 organized by EWSA. From February – March 2012: He was Project Manager of the trial cost reduction initiative training for the construction of four domestic biogas plants in (Masaka, Rusororo, Rutunga and Gahanga). In July 2013: he participated in regulations of Domestic biogas plants in Rwanda, organized by RURA.

From February - August 2012: He was Project manager of construction of 200m3 biogas plant at Nyakiriba prison. He is currently Assistant Lecturer in Alternative Energy at Tumba College of Technology, Rwanda. From September 2014 - November 2014: He was Project supervisor during the Construction of 50 m³ biogas plant and 18 latrines at GS. APAPEUC BUNGWE and construction of 50m³ biogas plant at GS. APAPEC MURAMBI. From November 29th - December 26th 2014: He was a trainer on Rehabilitation works and maintenance of biogas countrywide offered by EDCL ltd at APENA NASHO, RWANDA.

From April 10th - 25th, 2015: He was Project Manager of the Consultancy services related on Installation of 400 solar energy kits in 400 households located in Gisagara, Ruhango, Gakenke and Gatsibo Districts. From January 01st - 01st July, 2016: He was Project manager for the construction of 400m³ biogas plant at MAGERAGERE Prison, RWANDA.

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MAJYAMBERE Eugene was born March 03, 1982 in Gisagara, Rwanda. He received, in 2009, the B.S degree as engineer in Civil Engineering from Kigali Institute of Science and Technology. He is currently Assistant Lecturer in Alternative Energy at Tumba College of

Technology, Rwanda.

From November 01 - 30 2011:He was trained in Institut Bisnis dan Ekonomi Kerakyatan (IBEKA), Panaruban, Subang, West Java, Republic of Indonesia (Micro-Hydro Power Design). Since 2013, his current research interests at Tumba College of Technology include the design and construction of domestic biogas plant.

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