The Viability of Refuse-Derived Fuel As A Green Household Cooking Fuel

Collins N. Nwaokocha, Haribhau G. Phakatkar, Solomon O. Giwa, Abayomi T. Layeni, Sandip A. Kale

Abstract*: Rice husk and sawdust are waste generated freely in many developing countries in the cause of rice production and wood processing respectively. This large biomass volume can be useful as an energy resource useful in numerous processes other than being dumped or flared in the farms, thereby causing health risks and having severe environmental consequences. Biomass combustion is known for the release of pollutants such as particulate matter and carbon monoxide. In this study, rice husk and sawdust were prepared with starch and spent oil as binders. The characteristic behavior of the biomass materials was investigated. The properties of the new fuel derived from sawdust showed moisture content of 0.93%, ash content of 16.5%, higher heating of 7808.1 kJ/kg and tensile strength of 576.8 N/mm^2 were obtained and that for rice husk, moisture content, ash content, higher heating value, and tensile strength of 0.908%, 11.5%, 6160.7 kJ/kg and 508.7 N/mm^2 respectively, were obtained also. These results propose that the refuse derived fuel produced in this work from rice husk and sawdust is viable as a green fuel which will help reduce the global greenhouse gas content.

***Index Terms*: Cooking fuel, Climate change, Derived Fuel, Environment, Green Energy.**

I. INTRODUCTION

An attempt at increasing energy independence should be a key concern that should be sourced by substituting fossil fuels with green energy resources [1]. Today Liquefied Petroleum Gas (LPG) has become the major source of cooking fuel. Because of increasing with the price of crude oil, the LPG prices are continuously increasing. In many countries the government is providing subsidies on LPG. Ultimately, it is increasing dependence on other crude oil supplying countries and affecting the economy of any nation at significant levels [2]. Fig. 1 shows the World LPG domestic consumption for the year 2015 [3]. It is showing that many countries are consuming LPG significantly. The demand for energy keeps rising from the time of the primitive man who needed very little daily energy consumption, to today, when the need for energy is vast, yet increasing [4].

Energy remains an important catalyst for industrial, economic, technological, social and sustainable development [5]. Many developing countries have a vast natural resource, especially arable and forest land, with many of its households relying on solid biomass like firewood and charcoal as cooking fuels [6]. Biomass combustion is a significant contributor to environmental pollution [7]. The continuous demand and use of firewood and its allied fuels has led to desertification, deforestation and emission of pollutants which has a close correlation with global warming and health disorder amidst other related problems. Bio-waste as an alternative fuel for cooking in developing countries is still in its infancy and hence the need for this research [8].

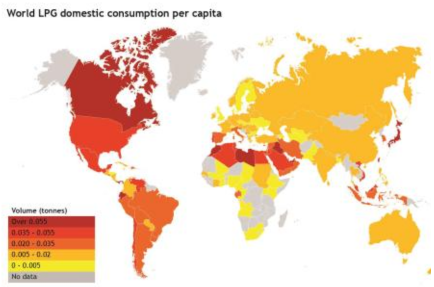

Fig. 1. World LPG domestic consumption [3]

Modern energy availability and consumption rate is an economic index for ascertaining developmental parameter of a nation. In developing and underdeveloped countries, access to reliable energy is a major issue for both urban and rural dwellers. The challenge is more significant with the rural communities where a little below 10% of the population mix has access to adequate electricity. Inadequate energy supply is a major hindrance to business and revenue growth [4]. Hence, the need for a green fuel substitute is essential [9, 10]. Another alternative energy source will abound to replace the

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dependence on fossil fuel in the future exists, such as biomass, hydro, solar, tidal, wind and ocean thermal energy. Advances in biotechnology and Bioengineering, have considered waste resources as a new form energy resource. [11-14]. Biomass pellets are produced from organic wastes such as agricultural

wastes, sawdust, etc. and are a suitable substitute for fossil fuels. Biomass pellets are green energy resource that will help reduce the release of fossil-derived carbon to the atmosphere, thus earning carbon credits which is a critical target of the Sustainable Development Goals (SDGs) program [15, 16].

This study majors in the production of Refuse Derived Fuel (RDF) from Municipal Solid Wastes (MSWs) such as sawdust and rice husk. These wastes constitute environmental nuisance leading to environmental pollution with the release of harmful substances to the atmosphere. In many developed and undeveloped countries, rural inhabitants and urban dwellers mainly use firewood, charcoal and fossil fuels as their energy source for cooking and heating. Consequently, these sources cause deforestation; environmental pollution and it also result in high cost of living [17].

Rice husk and sawdust are waste generated freely in many developing countries in the cause of rice production and wood processing respectively. This large biomass volume can be useful as an energy resource useful in numerous processes other than being dumped or flared in the farms, thereby causing health risks and having severe environmental consequences. Biomass combustion is known for the release of pollutants such as particulate matter and carbon monoxide. In this study, rice husk and sawdust were prepared with starch and spent oil as binders.

II. RESULTS & DISCUSSIONS

A. Fabrication of Handheld Compressible Device

A handheld device was fabricated to help provide an easy means for compressing ground materials into pellet form without the stress or cost associated with the expensive pellet making machine. It is a compact hand operated press, that allows for mobility within the laboratory (Fig. 2). The pellet hand compressible metal produces uniform pellets in a mold and then it is ejected smoothly on a plane surface without danger of contamination. The hand compressible metal is a standalone accessory of 500 cm, which weighs 120 kg; customs in between sizes are available upon request. The hand device produces a compression force to help increase mechanical advantage steadily to a ratio of approximately 50 to 1 at the end of the press. A pressure of 250 N/m^2 is applied to the device which develops approximately 1000 in/min on the press ram adequate enough to produce firm pellets from powdered materials with binders.

Fig. 2. Handheld Compressible Device

B. Pre-Treatment of Waste Materials

The pre-treatment of the waste materials (sawdust and rice husk) was done mechanically, to reduce the biomass size by means of grinding or shredding. The size reduction by means of a mechanical process (grinding) facilitates handling, increases surface area, decreases crystallization and improves the efficiency. The pre-treatment process helps improves the energy density of the biomass, allowing it to be efficiently stable at the point of use. For the pre-treatment of the spent oil, a sieve of 4cm was used to remove the particles away from the spent oil before the point of use.

C. Preparation of Mixture

Before mixing the raw materials, which comes after the pretreatment of the sawdust, the ash content and moisture content were determined. Thereafter, the binder (starch) was boiled to solidify it before mixing it with the biomass (sawdust and rice husk) and a little quantity of waste engine oil in a bowl, to produce a crude unfinished material. The quantity of biomass was less than that of the binder before mixing them in the bowl. After which a pellet mixture of approximately 12 g was produced.

D. Procedure for Producing Refuse Derived Fuel

Pellet formation follows the following order. The biomass (sawdust and rice husk) and binders (starch and engine oil) were mixed by weight ratio and blended manually in a mixing bowl. Varying ratios of binders (38.5 g and 31.3 g) to waste biomass (50 g) of different types were then mixed to produce unfinished products. The crude mixture (approximately 12 g) was placed inside newspaper wrapping, and the ends were folded down so that both ends of the wrapping were covered. No adhesive was used till the crude mixture was compressed. This raw pellet was then transferred into the mold - a short length of PVC with one end sealed. The diameter of the PVC pipe is 12.5 mm and length 101.6 mm. The mold is to assist the pellet product retain a cylindrical shape, while a short metal rod of slightly smaller internal diameter was inserted into the open end of the mold to compress the pellet. Pressure (approximately 250 psi) was applied manually for a period of 15 seconds to to reduce the pellet size and also allow the binders to permeate the materials, thereby forming a single firm unit. Note that this form of production is only for laboratory experiments and commercial production is automated. After production of the pellets, they were sun–dried for 3 – 5 days to reduce the moisture content, thus allowing for a good mechanical durability. Randomly selected pellets

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were then taken to the laboratory for characterization as fuel.

E. Characterization of RDF

The combustible fraction, consisting of rice husk, sawdust and other non–biodegradable fractions of solid waste are processed as refuse derives fuel, which usually has a high calorific value. The composition of RDF and Municipal Solid Waste (MSW) varies in line with the origin of waste material and the process of separation.

This in turn greatly influences the properties of RDF such as moisture content, ash content, and higher heating value.

III. RESULTS AND DISCUSSION

Table I gives the fuel properties of the raw materials used in the production of RDF on a laboratory scale. The moisture content of rice husk that went into the production is 5.72 %, which is relatively lower than that of sawdust (15 %). Whereas, the ash content of sawdust (10.23 %) prior to the RDF production is moderately lower than that of rice husk (17.14%). Table II depicts that the moisture content of the pellets decreased after processing the raw materials into the final products. This is as a result of the raw materials, adjusting to the surrounding relative humidity. The pellets gain mechanical strength as the moisture content reduces, same for ash content. Biomass has a higher heating value due to high oxygen content and lower moisture content. The results from the analyses of pellets are summarized in Table 2. It is obvious that all the properties of sawdust pellet are higher than the properties of rice husk pellet. The resultant energy values are sufficient to produce the needed heat for domestic cooking and cottage industrial applications.

Table I: Fuel properties of the biomass (rice husk and sawdust) before production

Types of fuel	Moisture content (%)	Ash content (%)
Sawdust	15	10.23
Rice husk	5.72	17.14

Table II: Fuel properties of the biomass (rice husk and sawdust)

Types of fuel	Moisture content (%)	Ash Content (%)	Higher heating value (kJ/kg)	Tensile strength (N/mm^2)
Sawdust	0.93	16.5	7808.1	576.8
Rice husk	0.908	11.5	6160.7	508.7

The pellet is made from biomass (sawdust and rice husk), they are categorized by their heating value, moisture content, ash content and dimensions. The pellets can be used as fuel for power generation, commercial or residential heating and cooking. Table II also shows that the pellets are extremely dense and can be produced at low moisture content below 10%, thus allowing them to burn with very high combustion efficiency. Further, the advantage of the pellet geometry size is that it can be fed to a burner by hand or pneumatic conveying. The sample picture of a pellet is shown in Fig. 3.

Fig. 3. Sample picture of the pellets.

IV. CONCLUSION

The result of this study indicates that pellets produced from the two biomass residues are good biomass fuels. However, findings show that sawdust pellets are better than rice husk pellets. This study confirms the possibility of utilizing the two biomass residues as fuel for domestic and industrial application, thus a good substitute and supplements to firewood and kerosene. Of note is that the energy quality of biomass briquettes as a correlation with the type of original residue and type of binders used.

V. CONFLICT OF INTEREST

The author states that there is no conflict of interest.

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