International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 7, July - 2013

Comparative Briquetting Of Residues From Corncob, Groundnut Shell And Their Mixture

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Abstract

The use of biomass as an alternative source of energy became imperative as a result of depletion of fossil fuels and the attendant hazards to both human and ecology. Production of briquettes from agro-residues can help to solve the problem of energy shortage in the world. Therefore, this work investigated the briquetting of corn cobs and groundnut shells as well the mixture of the two residues.

An existing briquetting machine was used for compaction. The residues were milled and sieved having an approximate uniform size. The maximum density, relaxed density, density ratio, relaxation ratio and compaction ratio were determined for briquettes from each residue and their mixture. The energy values of the briquettes were also determined.

The initial moisture contents of corn cob and groundnut shell were 16% and 12% respectively, while the corresponding final moisture contents were 13% and 9.11%. The maximum and relaxed densities were 842.7 kg/m^{3}and 492.57 kg/m^3 for briquettes produced from corn cob respectively, while the corresponding values of maximum density for briquettes produced from groundnut shell and their mixture were 986.8 kg/m^{3}and 1129.9 kg/m^3 respectively. For the relaxed densities, the values 672.57 kg/m^3 and 959.7 kg/m^3 were obtained for groundnut shell and the mixture respectively. The density, relaxation and compaction ratios for corn cob, groundnut shell and the mixture were respectively (0.584, 1.71, 5. 44); (0.695, 1.44, 7.05) and (0.849, 1.17, 7.66).

Briquettes produced from these residues would make good biomass fuels, with briquettes from their mixture having an edge over the briquettes produced from each of the residues.

Keywords: Agricultural residues; Biomass; Briquettes; Corn cob; Groundnut Shell; Mixture.

Introduction

Energy is very important to every aspect of the economy and its relevance to a nation's development cannot be overemphasized [1]. This is because energy is the cornerstone of economic and social development [2]. The existing source of energy, especially the fossil fuels may not be adequate to meet the ever increasing energy demands as they are depleting very fast and will one day be exhausted [3]. However, there is a problem of energy worldwide and this is mainly due to increase in population and growth in industrialization and technological advancement. This had brought energy demand under an increased pressure [4].

According to Kaygusaz and Turker (2002) [5], 86% of the energy being used comes from fossil fuels and its application is very convenient and efficient. However, as good as fossil fuel is for energy application, it has some flaws and drawbacks, which make it less desirable. Notable among these flaws are environmental pollution, fluctuation of price, high cost, disruption in supply and more importantly it is non-renewable [6]. Hence, there is the need for alternative generation of energy, especially on renewable basis. Biomass from plants can serve as an alternative renewable and carbon-neutral raw material for the production of energy. Wood fuels, agricultural straws, and grasses are the most prominent biomass energy sources. Straw from crop production and agricultural residues existing in the waste streams from commercial crop processing plants have little inherent value and have traditionally constituted a disposal problem. In fact, these residues represent an abundant, inexpensive and readily available source of renewable lignocellulosic biomass [7]. It can significantly reduce net carbon emissions when compared to fossil fuels. For this reason, renewable and sustainable fuel is considered a clean development mechanism (CDM) for reducing greenhouse gas (GHG) emissions [8]. Biomass, if properly managed, offers many advantages, the most important being a renewable and sustainable energy feedstock. However, one of the major limitations of biomass for energy purposes is its low bulk density, typically ranging from 80–100 kg/m^3 for agricultural straws and grasses and 150-200 kg/m^3 for woody biomass, like wood chips [9]. The low bulk densities of biomass often make the material difficult to store, transport, and use. Low bulk density also presents challenges for technologies such as coal co-firing, because the bulk density difference causes difficulties in feeding the fuel into the boiler and reduces burning efficiencies. Briquetting is one promising option for overcoming these limitations.

Briquetting can be defined as the process of compaction of residues into a product of higher density than the original raw materials. Wilaipon 2007 [10] also defined briquetting as densification process. Briquetting makes agricultural residues easier to transport, handle and store [11]. Other notable advantages of briquettes are the ease of charging the furnace, increased calorific value, improved combustion characteristics, reduced entrained particulate emissions, uniform size and shape. In addition, furnaces that use other solid fuels can use briquettes also. The main disadvantage of using biomass briquettes or pellets in industrial furnaces is ash slagging due to the alkali content in briquettes made from biomass [12]. During densification, biomass is mechanically compressed, increasing its density about tenfold [13]. Appreciable amount of research on briquetting technology has been conducted. Examples of such agro-residues are rice husk [14], waste paper plus admixture of coconut husk [15], rattan furniture waste [16] and maize cob plus coal particles [10].

The materials chosen for this study are corn cob from maize (*Zea mays*) and groundnut shell. These materials were selected because they are available in abundance and most often, these residues are dumped or flared resulting in wide spread fire hazards and environmental pollution. The aim of this study was to characterize briquettes produced from each of the residues and mixture of these two residues with a view to establishing their energy potentials.

Materials and Methods

The corncobs and groundnut shells were procured from crop processing mills and they were sun-dried in order to reduce the moisture content as much as possible. Each of the samples was ground separately in order to increase the surface area. A briquetting machine (Plate 1), which is capable of producing four briquettes at a time was designed and fabricated for compaction process. The machine consists of four lower rectangular moulds (where biomass feedstock were placed), which were welded together. These moulds were placed upon a base plate, which moves up and down in vertical guide. This plate is also capable of horizontal movement by sliding on a pair of rails, which was made from angle bars. The vertical motion of the plate along with the moulds is made possible through a manually operated jack, while their horizontal motion is achieved by manual pulling or pushing. The hydraulic jack rests directly under the moulds on a rigid frame made from angle bars. The design of the machine is based practically on hydraulic principle, although the loading of the biomass feedstock was purely a manual process [17]. A restraint is put to ensure that the hydraulic jack does not move laterally. By this arrangement, the force from the hydraulic jack is always centrally applied to the base plate holding the moulds.

Design calculations were done to ensure that the briquetting machine does not fail under load during the briquette production process. The two possible failures which were taken care of are the mould and compactor. They were tested for failure and buckling respectively. A cassava starch gel was used as a binder. Both residues (Plates 2 and 3) were mixed with the starch and they were manually fed into the moulds and compaction was effected through a hydraulic jack. A dwell time of ninety seconds was observed after which the briquettes were ejected. The ejected briquettes (Plates 4 - 6) were later sun-dried.

The maximum density of briquette from each specimen was determined immediate after it was ejected from the mould by computing the quotient obtained by dividing the mass by the volume of the compressed briquette. The mass was obtained by using a digital weighing scale, while the volume was determined by taking the linear dimensions of the briquettes by a standard vernier calliper. The relaxed densities of the two briquettes formed were determined in dry condition. Relaxation ratio was calculated as the ratio of maximum density to relaxed density, while the compaction ratio was determined as the ratio of maximum density to the initial density.

Plate 1- Experimental Briquetting Machine

Plate 2- Ground Sample of Groundnut Shells

Plate 3- Ground Sample of Corn Cob

Plate 4: Corncob briquette

Plate 5: Groundnut shell briquette

Plate 6: Briquette from the mixture

Results and Discussion

The results of the determination of densification characteristics of briquettes produced from corn cob, groundnut shell and the mixture are shown in Tables 1and 2.

Table 1: Physical characteristics of briquettes produced from corn cob, groundnut shell and their mixture

Parameters	Unit	Values		
		Corn cob	Groundnut shell	Mixture
Mass	kg	1.5	1.5	1.5
Initial Length	m	0.153	0.155	0.153
Final Length	m	0.159	0.158	0.16
Initial Breadth	m	0.14	0.14	0.145
Final Breadth	m	0.145	0.143	0.143
Initial Height	m	0.083	0.07	0.08
Final Height	m	0.088	0.069	0.082

Table 2: Density related and fuel characteristics of briquettes produced from corn cob, groundnut shell and their mixture

Parameters	Units	Values		
		Corn cob	Groundnut shell	Mixture
Initial density	kg/m^3	155	140	147.5
Maximum density	kg/m^3	842.7	986.8	1129.9
Relaxed density	kg/m^3	492.57	672.57	959.7
Density ratio	-	0.584	0.695	0.849
Relaxation ratio	-	1.71	1.44	1.17
Compaction ratio	-	5.44	7.05	7.66
Energy value	kJ/kg	17,348	18,634	21,887

The values 842.7kg/m^3, 492.57 kg/m^3 and 1.71 were obtained for maximum density, relaxed density and relaxation ratio respectively for briquettes produced from corncob, while the corresponding values for briquettes from groundnut shell and the mixture of the two residues in the order listed above were (986.8kg/m^3, 672.57 kg/m^3, 1.44) and (1129.9kg/m^3, 959.7 kg/m^3, 1.17) respectively. The maximum densities obtained in this work are better than densities of notable biomass fuels such as melon shell, cassava and yam peels briquettes-561 kg/m^3, 741.13kg/m^3 and 911.45kg/m^3[11]; coconut husk briquette 630 kg/m^3 [15]; banana peel-600 kg/m^3 [13] and rice husk briquette-534 kg/m^3 [14]. Furthermore, the low values of relaxation ratios obtained for briquettes in this study when compared with the ones of between 1.80 and 2.25 obtained by Olorunnisola (2007) [15] for coconut husk briquettes and between 1.65 and 1.80 obtained by O'Dogherty and Wheeler (1989) [18] for hay wafer briquette are indications of more stable briquettes. This implies that the briquettes would experience minimum relaxation and this is a very good attribute as briquettes would not crumble with time, especially during transportation and handling. The values of density and compaction ratios were 0.584 and 5.44; 0.695 and 7.05; 0.849 and 7.66 for briquettes produced from corn cob, groundnut shell and their mixture respectively. The high values obtained for the density and compaction ratios is a pointer to the fact that the residues examined in this study lent themselves easily to process of densification. This is because; the nearer the density ratio is closer to 1, the better the densification process [11].

Conclusion

Based on the results obtained and the findings of this study, the following conclusions could be drawn:

(1) Good quality and highly storable briquettes can be produced from the blend of corncob, groundnut shell and the mixture with cassava starch gel.

(2) Briquettes produced from the mixture have more positive attributes of biomass fuel followed by that produced from groundnut shell.

(3) The high value of relaxed density obtained in this study suggests the briquettes could be transported over a long distance without disintegration.

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