Determination of Combustion Characteristics of Compressed Pulverized Coal-Rice Husk Briquettes

Markson, I.E.
Mechanical Engineering Department
University of Uyo
Nigeria

Akpan, W.A.
Mechanical Engineering Department
University of Uyo
Nigeria

Ufot, E·
Mechanical Engineering Department
University of Uyo.
Nigeria

Abstract

This paper investigates the optimal compositions of coal, rice husk and palm oil sludge for energy derivation produced at various compression pressures in the range of 20 to 45Mpa. Their combustion characteristics were tested. Results show that a 5:3:1 ratio by weight of coal, rice husk at a compression pressure of 35 Mpa produces a minimum power loss.

Keywords: Combustion, energy, pulverization, rice husk, coal, briquette compression .

Introduction

Energy is considered the basis for the progress and prosperity of nations and societies. It is also the cornerstone of economic development. The combustion of coal and biomass fuel can decrease emission of fossil $CO_{2.}$ In order to meet an increasing demand, alternative energy sources like biomass must be use effectively. In Nigeria, fuelwood is by far the most widely used household fuel as in other developing countries. Illechie, (2006) et al reported that about 80 – 90% Nigeria’s population, most especially the rural and semi urban dwellers greatly rely on it for their cooking and heating. National forest (1997) estimated that fuelwood demand is about 960 million tonnes annually and will progressively increase as population rises by over 270 million tonnes annually.

Large quantities of agro-residues are produced in the country but they are used inefficiently causing extensive pollution to the environment. The major residues are ricehusk , sawdust, bagasse; and groundnut shells. Hall et al (1998) reported that in developing countries energy from biomass continues to be the main source of energy, mostly in its traditional forms designed to meet the demands of domestic use. It is widely accepted that renewable energy will play a major role in the foreseeing year. It has been reported that over 33 percent of energy consumption for developing countries can be supplied from this kind of energy resource , Sayigh (1999) and Hall e tal (1995). Moreover, the carbon dioxide generated during biomass energy conversion will be compensated by its photosynthesis process. Agricultural residues account for the largest amount worldwide Erikson, (1990). Hence, for developing an agriculture–based country, the utilization of the residues from agricultural sectors as energy is considerably attractive. The residues are available as a free, indigenous and environmentally friendly energy resource.

Briquetting process, has been investigated by several researchers(Grove, et al ,1996; Ajueyitsi, et al, 2003) and Battacharya, et al (2002). The technology may be simply defined as the densification process for improving the biomass fuel – characteristics.

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 a very fine form can be added Ajueyitsi , et al (2003) and Reed, et al (1980) .The important properties of briquettes that may affect the fuel quality are their physical and chemical attributes.

The main objective of this research is to evaluate the effect of compression pressure on the combustion characteristics of pulverized coal – rice husk briquettes.

Methodology

The Various mixture of pulverized coal – rice husk and palm oil sludge were formulated .They were compressed at different pressures for the optimal mixture using an electrically hydraulic compression machine. The physical and mechanical properties of pulverized coal-rice husk briquettes were determined .Samples of the coal-rice husk briquettes were dried in the oven an combustion test data obtained on the combustion parameters of pulverized coal-rice husk briquettes using a briquette stove in water-boiling-tests Statistical tools and mathematical analysis were applied on the combustion data to draw conclusions.

Results and Discussion

Table 1 shows the Mean densities, compressive strength and durability of briquettes at a constant diameter of 4.30cm and length varying with applied compression pressure from 6.32cm to 3.63 cm. Briquette reduced to 3.63cm at a compression pressure of 45 Mpa has the highest density of $1663.5 kg/m^3$ and compressive strength of 565.6 Kpa. The durability index is also at the apex at this compression pressure.

Table 1: Mean Densities, Compressive strength and Durability of Pulverized coal-rice husk briquettes

Compression Pressure (p) Mpa	Weight of briquette	Length of briquette	Diameter of briquette	Volume of briquette	Density of briquette	Mean Compressive strength of briquette in Kpa	Mean Durability Of briquette Cm
20	96.88	6.32	4.3	91.79	1055.44	116.25	61.87
25	92.28	5.59	4.3	81.19	1137.01	429.12	90.17
30	69.90	5.14	4.3	65.21	1379.60	503.15	107.84
35	88.15	4.78	4.3	59.98	1470.01	624.50	121.84
45	87.70	3.63	4.3	52.72	1663.50	765.60	138.50

Tables 2 shows the combustion data of pulverized coal-rice husk briquettes. As the compression pressure increases the time for the briquette combustion increases. The amount of ash formed also reduces. However the weight of unburnt briquette increases. In Table 3 It can be seen that as the compression pressure increases the weight of charcoal produced increases. Combustion with low weight of ash and high weight of charcoal is an indication of efficient combustion and is desirable.

Table 2: Mean Combustion data of pulverized coal-rice husk briquettes

Compressive Pressure(P) Mpa	Time of combustion Test (t_c) Min	Initial Ambient Temperature T_C $°C$	Weight of briquette Loaded (W_X) kg	Weight of burnt briquette (W_y) kg	Weight of unburnt briquette $(W_X W_y)$ kg	Weight of ash produced kg
20	16.20	30.30	3.0	2.8	0.20	0.07
25	18.90	29,60	3.0	2.58	0.42	0.0075
30	21.05	30.70	3.0	2.37	0.63	0.0037
35	23.50	30.50	3.0	2.22	0.78	0.0023
45	23.55	31.50	3.0	2.21	0.79	0.002

Table 3: Mean Combustion data of pulverized coal-rice husk briquettes

Compressive Pressure(P) Mpa	Weight of charcoal produced (W_c) kg	Weight of boiled water produced (W_{bw}) kg	Weight of pot used (P_p) kg	Initial temperature of water (T_{iw}) $(°C)$	Final temperature of water (T_{fw}) $(°C)$
20	0.0004	4.00	0.65	30	98.5
25	0.36	4.00	0.65	32	98.4
30	0.48	4.00	0.65	31	98.2
35	0.58	4.00	0.65	30	98.5
45	0.61	4.00	0.65	31	98.5

As presented in Tables 4 and 5, the very low charcoal formation rate of 0.000025kg/min, low percentage charcoal formation of 0.014%, higher ash formation rate of 0.00143kg/min and higher percentage ash formation of 2.5% obtained at a compression pressure of 20MPa can be explained by the high porosity and low density of the burn briquettes. From Table 1, the compression pressure of 20MPa corresponds to a briquette density of 1055.44kg/m^3. Very low charcoal formation rate and percentage charcoal formation represent loss of energy. Higher ash formation rate and percentage ash formation reduces fuel deficiency of the briquettes and imposes fire management problems such as frequent ash removal from the stove and frequent attention to fire. Therefore to ensure high fuel efficiency, pulverized coal-rice husk briquette should not be produced of 20MPa. The low fuel efficiency of the briquettes can be traced to: High power losses sustained by the briquettes and Lack of baffle in the stove combustion chamber, which would exploit the energy of the volatile produced during the combustion of the briquettes. The high power losses sustained by the briquettes can also be traced to the low performance of the briquette stove used in this work.

Table 4: Mean combustion parameter of pulverized coal-rice husk briquettes

Compression pressure(p) Mpa	Burning rate Kg/min	Specific fuel consumption (SFC) kg/min	Fuel efficiency (FC)	Charcoal formation rate (CFR)	% charcoal formation (PCF)
20	0.173	0.70	2.15	0.000025	0.014
25	0.137	0.65	2,27	0.019	13.95
30	0.113	0.59	2,50	0.023	20.25
35	0.095	0.56	2.72	0.025	26.18
45	0.094	0.55	2.69	0.026	27.60

Table 5 Mean combustion parameter of pulverized coal-rice husk briquettes

Compression pressure(p) Mpa	Ash formation rate (AFR) Kg/min	Percentage ash formation(PAF) %	Power dissipated (Pd) KW	Power output (Po) used for boiling KW	Power loss (Pl) KW
20	0.00430	2.5	57.53	1.23	56.28
25	0.00040	0.29	45.43	1.03	44.40
30	0.00018	0.16	37.41	0.94	36.48
35	0.00010	0.10	31.47	0.86	30.62
45	0.00008	0.09	31.23	0.84	30.92

Conclusions and Recommendations

The research shows that sufficient energy can be obtained from rice husk with appropriate formulation with additives like coal and palm oil sludge .The optimum energy formulation of coal, rice husk and palm oil sludge is obtained at a ratio of 5:3:1 with a calorific value of 19.97MJ/kg. Compression pressure increases the density of the briquette while decreasing its porosity. The Highest fuel efficiency is obtained at a compression pressure of 35MPa .With the increase of compression pressure the rate of ash formation decreases leading to minimum power loss of 30.62 KW and 30.96KW at compression pressures of 35 MPa and 40 MPa respectively. Further studies should be extended to different types of biomass from agricultural and forest sources to obtain energy capabilities for briquetting processes.

REFERENCES

Ajueyitsi, O.N.A. and Adegoke ,C.O.(2003). Optimum Proportion of Starch binder and paper Waste Additive in the Formulation of Coal Briquettes for Domestic Cooking. Nigerian Journal of Mechanical Engineering.Vol.6,No.2,pp 67-71

Battacharya , S.C; Leon,M.A. and Rahman, Md.M.(2002). A study on improved biomass briquetting. Energy for Substainable Development. Vol. 6, No.2

Eriksson, S. and Prior, M(.1990). The briquetting of agriculture wastes for fuel. Food and Agricultural Organization, Environmental and Energy paper 11, Food and Agriculture Organization of United Nations, Rome, pages 131

Grover , P.D. AND Mishra, S.K.(1996).Biomass Briquetting: Technology and Practices.Regional Wood energy Development Programme in ASIA. Field document No.46, Food and Agriculture of the United Nations, Bangkok, Thailand pp10-12

Hall, D.O. and Rossillio, C.F.(1998) Biomass for Energy and Industry. The 10th European Conference on Biomass for Energy and Industry, Wurzburg, Germany

Hall, D.O. and House, J.(1995).Biomass: A Modern and Environmental Acceptable Fuel. Solar Energy Materials and Solar cells.Vol.39pp.521-542

Ilechie, C.O., Omoti, U., Bafor, M.E., Ogblechi, S.R., Aibangbee, G.F. and Amiolemhen (2006). Palm Waste Briquette-Substitute for Fuelwood. Proceedings of 2nd Annual Conference of IRDI Science and Technology Forum, November 22-23, 2006. Vol. 2, No. 8, pp 6 – 9.

National Forest Conservation Council of Nigeria (1997). Report on the Enlightenment and Awareness Campaign on Coal Usage as Substitute to Fuelwood.

Reed, T.B; Trefek; G. and Diaz, L.(1980) Biomass Densification Energy Requirements in Thermal Conversion of solid Wastes and Biomasss. American Chemical society. Washington D.C

Sayigh, A.(1999). Renewable Energy-The way Forward. Applied Energy Vol.64. pp15-30