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# ASSESSING THE EFFECT OF BINDER PROPORTION AND PARTICLE SIZE ON IGNITION AND BURNING RATE OF PALM KERNEL SHELL BRIQUETTES TOWARDS SUSTAINABLE DEVELOPMENT

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## ABSTRACT

*In many developing countries, briquettes from agricultural waste contribute significantly to the energy mix especially for house hold requirements. In this work, study was conducted to assess the effects of binder proportion, particle size and compaction pressure on burning rate and ignition of palm kernel shell briquettes. the briquettes were produced from palm kernel shall by carbonizing the shell to charcoal followed by the pulverization of the charcoal into different particle sizes and then the addition of cassava starch gel as a binder in different proportions. The samples were compressed into molds using hydraulic press machine at different compaction pressures. The results from the assessment of the sample shows that increased in binder ratio and compaction pressure decrease the burning rate of the samples whereas increased in particle size increases the burning rate of the samples.*

**KEYWORDS:** *palm kernel shell, starch gel, compaction pressure, burning rate*

## 1. INTRODUCTION

In spite of the vast resources, the forests and the accumulated fossil fuels, most developing countries including Nigeria are plagued by energy crises arising from the inadequate availability of power for private and commercial usage. Some of the reasons for the poor energy situation in Nigeria, with its abundant petroleum resources, have been attributed to the technological inadequacy, managerial incompetence and sabotage (Bruce, Perez-Padalla and Albalak, 2000). The prices of petroleum products which are no longer affordable to the majority of Nigerians have remained on the increase. Apart from the price, the products are not always available. One way of addressing the problem is to harness the available fuel resources, getting the different sources to make contribution to the energy mix. Since these resources are widely dispersed, it becomes imperative to obtain them from areas of occurrence and distribute as appropriate.

Agriculture is the main occupation of most Nigerians. It involves a lot of activities. These activities generate so many wastes which are disposed indiscriminately. It has been found out that these wastes can be reintegrated to contribute in solving the energy problem in the country. One way of solving the energy problem is by briquetting of flammable materials (Grover and Mishra, 1996).

Briquetting is a process of binding together pulverized carbonaceous matter, often with aid of binder. The common forms of briquettes are the coal briquettes and biomass briquettes. Biomass briquette originates from mostly agricultural residues which include the charcoal briquettes. Some of the advantages derived from briquettes include:

1. Briquettes provide an easier way of getting energy supply for cooking and ironing of clothes.
2. Briquettes provide cleaner emission than wood and other dried plants usually used for obtaining rural energy supply
3. The raw materials for making briquettes are sourced from materials that would have been chunked and as such it converts waste to energy
4. briquettes can be used in stoves and boilers (Jindapom et al, 2005)

Many researchers have reported on the combustion properties of briquettes fuel for various agricultural waste products such as charcoal briquettes from wood residue, two paired of biomass species, polymeric waste material briquettes, production of fuel briquettes from waste paper and coconut Husk and composite sawdust briquette (Grover and Mishra, 1996; Kuti, 2009)

The understanding of thermal properties of fuel briquettes is pertinent in order to investigate factors affecting the combustion rate and ignition time. Heat is transferred from burning briquette in three different ways: thermal conduction, convection of heat by the flow of volatile gases and radiation within pores inside the solid. The efficient utilization of biomass or agro-waste briquettes as biofuel requires the understanding of combustion such as ignition time and burning rate, moisture content, ash content, density volatile matter, and heating value among others (Olorunnisola, 2007; Olorunnisola, 2009; Ugwu and Agbo, 2011).

The objective of this study is therefore to asses; the optimum compaction pressure, binder proportion and particle size required to produce an acceptable briquettes with best burning rate and ignition time.

## 2. MATERIALS AND METHODOLOGY

The raw materials used in this study were palm kernel shells and cassava starch. The palm kernel shells were collected at Ekwulobia, Aguata L.G.A, Nigeria. The shells were converted into charcoal, pulverized and made to briquettes using cassava starch as a binder. The samples were arranged in block design for the experiments.

### Preparation of Briquette Samples

The palm kernel shells were carbonized by putting them in a metal container perforated underneath. The container was placed on a tripod stand and small amount of kereosine was sprinkled on the shells to facilitate ignition. This was followed by application of heat underneath the container. The shells ignited and were allowed to burn until it turned black. The container was brought down from the stand and was allowed to remain tightly covered for about 6 hours to prevent air from entering it. After this period, the charcoal had formed with no ash

The charcoal was pulverized using a manually operated blender. The particle size distribution was achieved by using Particle Size Analysis Equipment (PSAE) consisting of sieve shaker and tylers sieve of various diameter or particle openings. This equipment vibrated and forced the material through the screens with mesh. For this experiment, sieve sizes corresponding to 0.8, 2.2 and 4.0mm were chosen. Each of the aggregate was subdivided into five equal parts.

The starch gel used as binder was prepared from raw cassava root which was peeled, washed, sun dried and pulverized to gel cassava paste. The paste was added into the boiling water and mixed properly to get the starch gel.

While the starch gel was still warm, it was added gradually to each of the subdivided residue rations of the pulverized palm- kernel charcoal in the ration of 10%, 20% , 30% , 40% and 50% by weight. The mixing process was done using a stirring stick until a thick , black compound was formed prior compaction.

### Experimental Tests

The experimental tests were conducted in Mechanics of Machine Laboratory, Department Of Mechanical Engineering Technology, Federal Polytechnic, Oko, Anambra state, Nigeria. The following tests were carried out on the briquette samples: compaction tests, ignition test and combustion test.

### Compaction tests

The compaction tests on the mixture samples were done using hydraulic press machine (briquetting machine). A cylindrical die of 5cm and 14.5cm diameter and height respectively was filled with known weight of each sample mixture and be compression into briquettes. The piston was actuated through hydraulic pump at the speed of 30mm/min of piston movement to compress the samples compaction pressure used in each of the sample mixtures were 2.0, 4.0, 6.0 and 8.0Mpa respectively. Stop watch was used for timing.

## Ignition Test

One of the briquette sample was placed in a wire gauzed resting on a tripod stand under free flow of air around the briquette. A bunsen burner was placed directly under the wire gauze in a way that the flame will not spread in the transverse directions. The burner was adjusted to blue flame and was left to burn until the briquette was well ignited and had entered into its steady state burn phase. The same test was conducted in each of the remaining briquette samples. In each of the mixture samples, time of ignition was taken and recorded.

## Combustion Test

The combustion test was done to determine the rate at which each of the mixture samples is burnt in air. One of the briquette sample of known weight was allowed to burn in bursen burner and the rate at which the sample was burning was monitored at every 20second throughout the combustion process using stop watch until the briquette sample was completely burnt and constant weight was obtained. The same test was performed in the remaining mixture samples of the briquette. The burning rate was computed in each of the test using the expression below

$$Q_R = \frac{W_1 - W_2}{t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $Q_R$ = Burning Rate in g/min

$W_1$ = Initial weight of sample prior to burning (g)

$W_2$ = Final weight after burning in (g)

t = Total burning time in (min)

# 3. RESULT AND DISCUSSION

## Effect of Particle Sizes on Ignition Time and Combustion Rate

The effect of particle size on ignition time and combustion rate of the palm kernel shell briquette are shown in figures 3.1 and 3.2 respectively. The values of the ignition time and combustion rate are recorded in table 3.1

**Table 3.1: The values of Ignition time and combustion rate with particle sizes of the Briquettes**

| Particle Size (MM) | Ignition Time (Sec) | Combustion Rate (g/min) |
|---|---|---|
| 0.8 | 108 | 1.6 |
| 2.2 | 96 | 2.8 |
| 4.0 | 71 | 4.0 |

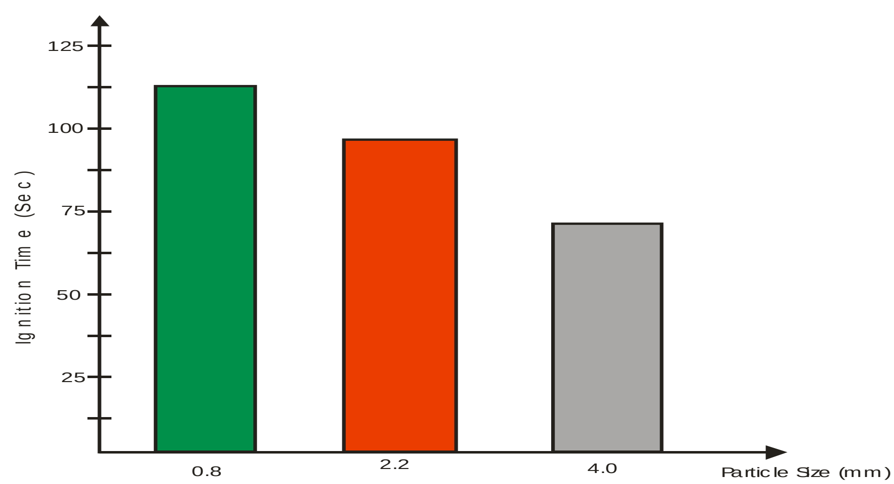


**Figure 3.1: Ignition Time vs Particle Size**

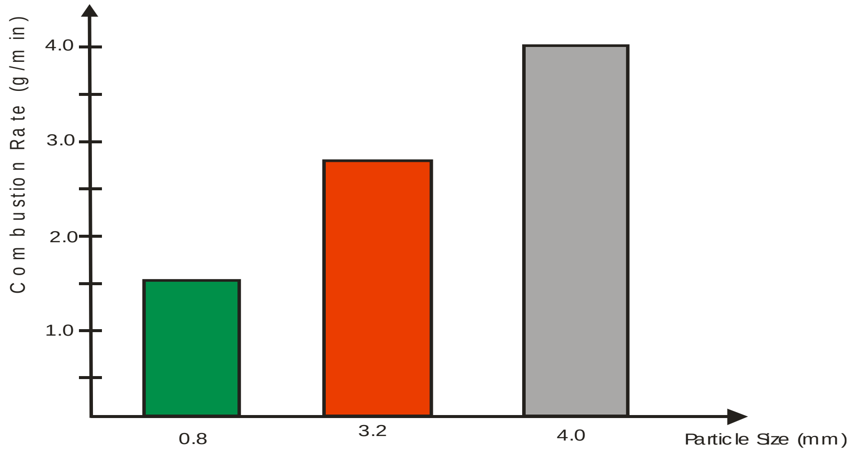


**Figure 3.2: Combustion Rate vs Particle Size**

From the results in figure 3.1, it was obvious that particle size of the briquettes had negative effect on the ignition time of the briquettes as the ignition time decreases with the increased particle size of the briquettes. This is because, the pore volume increases with increased particle sizes thus increases the porosity index of the briquettes which might cause reduction on time taken for the briquettes to ignite. Meanwhile, briquettes for domestic use must be easily ignitable but with low porosity index, low volatile content and low ash content (Olorunnisola, 2009; Vijaya et al, 2004)

On the other hand, the combustion rate of briquettes demonstrated direct relationship with the particle sizes. There is increased combustion rate with increasing particle sizes of the briquettes and decreased combustion rate with decreasing particle sizes of the combustion rate of the briquettes. The increased rate of combustion due to increased particle sizes is attributed to high porosity index exhibited between inter and intra particles which enable easy infiltration of oxygen and outflow of combustion briquettes. Also , the decreased rate of combustion due to finer particle sizes is attributed to lower porosities and this hindered mass transfer, such as drying, DE volatilization and char burning processes due to fewer free spaces for mass diffusion (for examples , water vapour, volatile matter, carbon dioxide outflows and oxygen infiltration). Consequently, its burning rates (i.e briquette weight reduction rate) will be reduced.

## The Effect of Binder Proportion on Ignition Time and Combustion Rate of the Briquettes

Table 3.2 shows the results of the ignition and combustion tests on binder proportion of the briquette samples. Figure 3.3 and 3.4 also show the effects of binder on ignition time and combustion rates of the briquettes respectively.

**Table 3.2 : The Values of Ignition Time and Combustion Rate with Binder Proportion of the Briquettes**

| Binder Proportion(%) | Ignition Time (sec) | Rate of Combustion (g/min) |
|---|---|---|
| 10 | 60.81 | 2.57 |
| 20 | 72.43 | 2.05 |
| 30 | 88.61 | 1.76 |
| 40 | 100.20 | 1.33 |
| 50 | 112.26 | 1.14 |

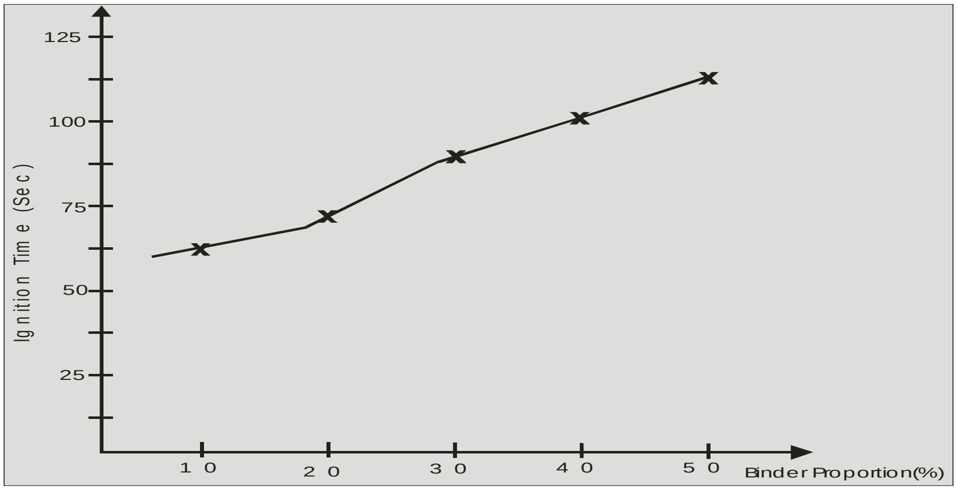


**Figure 3.3 Graph of Burning Rate and Binder Proportion**

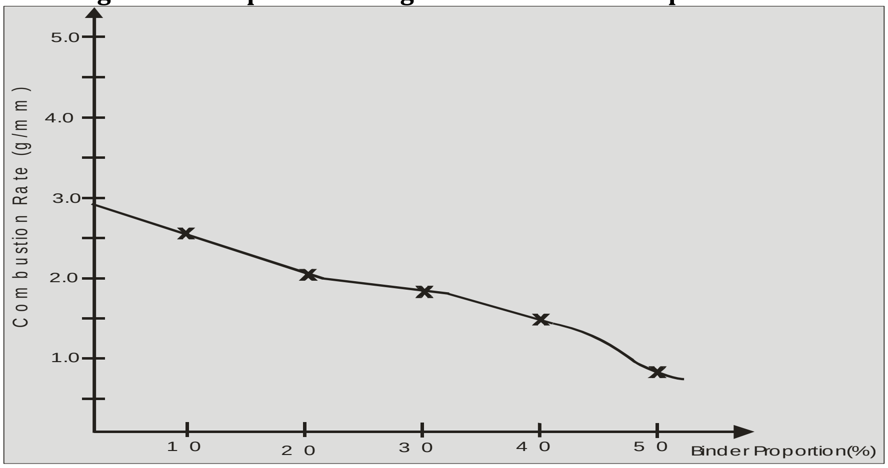


**Figure 3.4 : Graph of Combustion Rate and Binder Proportion.**

Figure 3.3 indicates that ignition time increased with increased binder proportion. The recorded lowest ignition time (60.81 seconds) could be attributed to high porosity exhibited between inter and intra-particles which enable easy percolation of oxygen and out flow of combustion briquettes due to low bonding force.

On the other hand, the effect of binder on combustion rate of palm kernel shell briquettes was studied in figure 3.4 and it shows that the combustion rate of the briquettes decreased with the increased in binder proportion. This means that more fuel will be required for cooking with briquettes produced from lower percentage binder proportion than higher percentage binder proportion. The briquettes produced form 50% binder level had the lowest combustion rate. Kuti (2009) studied the effect of binder on the burning rate of sawdust briquettes with starch gel as binder. The study discovered that the binding of the sawdust by the gel prevented the fast burning of the briquettes, hence experienced reduction in weight loss as the gel content increases.

### The Effect of Compaction Pressure on Ignition Time and Combustion Rate of the Briquettes

The ignition time and combustion rates of the palm kernel shell briquette samples with the compaction pressure are recorded in table 3.3

**Table 3.3 : The Values of Ignition Time and Combustion Rates With Compaction Pressure**

| Compaction (Mpa) | Ignition Time (sec) | Combustion rate (g/min) |
|---|---|---|
| 2.0 | 70.26 | 2.4 |
| 4.0 | 83.89 | 1.8 |
| 6.0 | 89.10 | 1.3 |
| 8.0 | 97.34 | 0.8 |

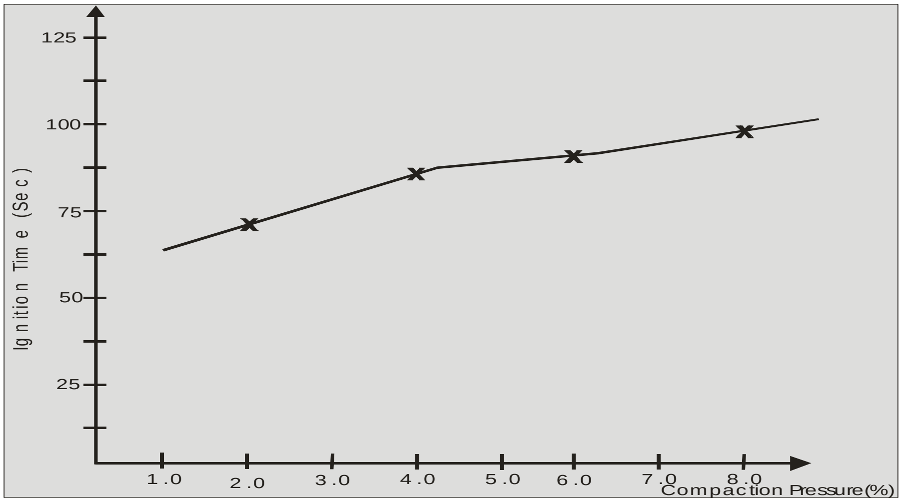


**Figure 3.5 Graph of Ignition Time and Compaction Pressure of the Briquettes**

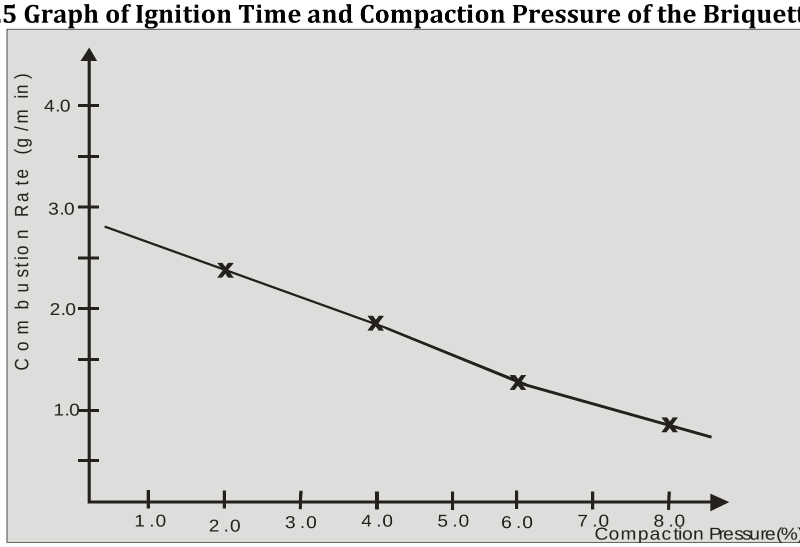


**Figure 3.6 Graph of Combustion Rate Compaction Pressure of the Briquettes**

Figure 3.5 and 3.6 , respectively, show the graphical relationship between the compaction pressure , ignition time and combustion rates of the palm kernel shell briquettes samples. The influence of compaction pressure on ignition time varied from 70.26 to 97.34 seconds as shown in figure 3.5. Increased in compaction pressure consequently, increases the ignition time of the briquette, Furthermore , briquettes compressed to a higher density will tend to have a lower porosity, and thus elongates the ignition time.

On the other hand, figure 5.6 shows that the rate at which the briquettes sample burn increased with decreased compaction pressure. Ugwu and Agbo (2011) studied the effect of pressure on the burning rate of some biomass briquettes, and the study reported that increased densification pressure decreased the burning rate of the briquettes.

## 4. CONCLUSION

In this research, assessing the effect of binder proportion, compaction pressure and particle sizes on the ignition and burning rate of palm kernel shell briquette was carried using cassava starch gel as a binder in the ratio of 10%, 20%, 30%, 40% and 50% by weight. The results suggest that the briquettes produced from mixture of pulverized palm kernel shell and cassava starch gel could be good biofuel than one from pulverized palm kernel shell alone. It has been established in this work that the combustion (burning) rate of the briquettes decreased with increased binder proportion. The implication of this observation is that more fuel might be required for cooking with briquettes produced from smaller percentage of binder proportion than one from higher percentage. The briquettes produced from 50% binder level had the lowest combustion rate and as well, highest ignition time. Increase in compaction pressure caused decrease in the combustion rate but increases the ignition time of the briquettes. Lastly, the increased in particle sizes caused increase in the combustion rate but reduces the ignition time.

## 5. RECOMMENDATIONS

Since increased in binder proportion and compaction pressure reduced the combustion rate of the briquette samples from the experimental tests, it is recommended that biofuel users at homes, industries and even in hospitals should use briquettes with higher binder proportion and compaction pressure in other to save cost.

It is also recommended that the usage of briquettes from mixture of charred palm kernel shell and cassava starch gel could enhance: rural economic development, farm income, market diversification, reduced negative environmental impact, international competitiveness and creation of employment in the areas of production, harvesting and utilization.

## REFERENCES


1. *Bruce N. Perez-Padalla R and Albalak (2000): "Indoor air pollution in developing countries a major environmental and public health challenge". Bulletin of world health organization 78(9): 1078-92*
2. *Grover , P.D and Mishra, S.k, (1996). "Biomass Briquetting Fuel in a Biomass stove under simulated condition" A.U J.T. 12 (4) pp 284-288*
3. *Jindapom, J. chadchawan , P, Aurawan T. and Songchai W, (2005). "Physical properties and combustion performance of briquettes produced from two pairs of biomass species". ENETT 49-137.27-29*
4. *Kuti, O.A (2009) "Performance of composite sawdust briquette fuel in a biomass stove under stimulated condition". AU J.T. 12 94) pp 284-288.*
5. *Nasrin, A.; MA. A.N; Choo, Y.M; Mohama, S: Rohaya, M.H; Azali, and A; Zainal, Z. 2008. Oil Palm Biomass as Potential Substitution Raw Materials For Commercial Biomass Briquettes Production". American Journal of applied Science 5 (3) 179-183*
6. *Ma A.N and Dato , Yusof Basiron, (2005). "Biomass Energy From the palm oil industry in Malaysia". The Ingenieur, Vol. 27 September – November, 2005 pp.18-25*
7. *Mahanama K.R.R (2008). "Cooking or being cooked. Economic reviews": 34 (384) : 18-23*
8. *Ogbuanya, T.C (2005): "Energy and Technology of Home Appliances", Cheston limited , Enugu Nigeria, P102.*
9. *Olorunnisola, A.O (2007). "Production of fuel briquettes from west paper and coconut husk admixtures". Agricultural Engineering international The CIGR E-journal. manuscript EE 06 066 vol. IX*
10. *Olorunnisola , A.O (2009) ."The performance of sawdust briquettes combusted in a convectional coal stove. Journal of forestry".28: 15-18*
11. *Ugwu, K.E and Agbo , K.E (2011). Briquetting of palm kernel shell. J. Appl Sci. Environ . Manage. Vol. 15(3)447-450*
12. *Vijaya, S; Chow, M.C and Ma. A.N. 2004. Energy Database of the Oil palm , MPOB palm oil Engineering Bulletin, 70: 15-22*
13. *Walter , Emrich (1985), Handbook of charcoal making : the traditional and industrial methods, D Reidel for the commission of the European Communities Boston.*